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ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS (INDIA) MYSORE - 570 013

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- Promotion of research, development and training in the science, Technology and Engineering of Food.
- To provide a forum for exchange, discussion and dissemination of knowledge and current developments, especially among Food Scientists and Technologists as well as the Public and Society at large.

Major Activities :

- Publication of 'Journal of Food Science and Technology' (bi-monthly) and 'Indian Food Industry' (bi-monthly).
- Holding symposia/conventions on different aspects of Food Science, Technology and Engineering.
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Dr. C.L. NAGARSEKAR

PRESIDENT

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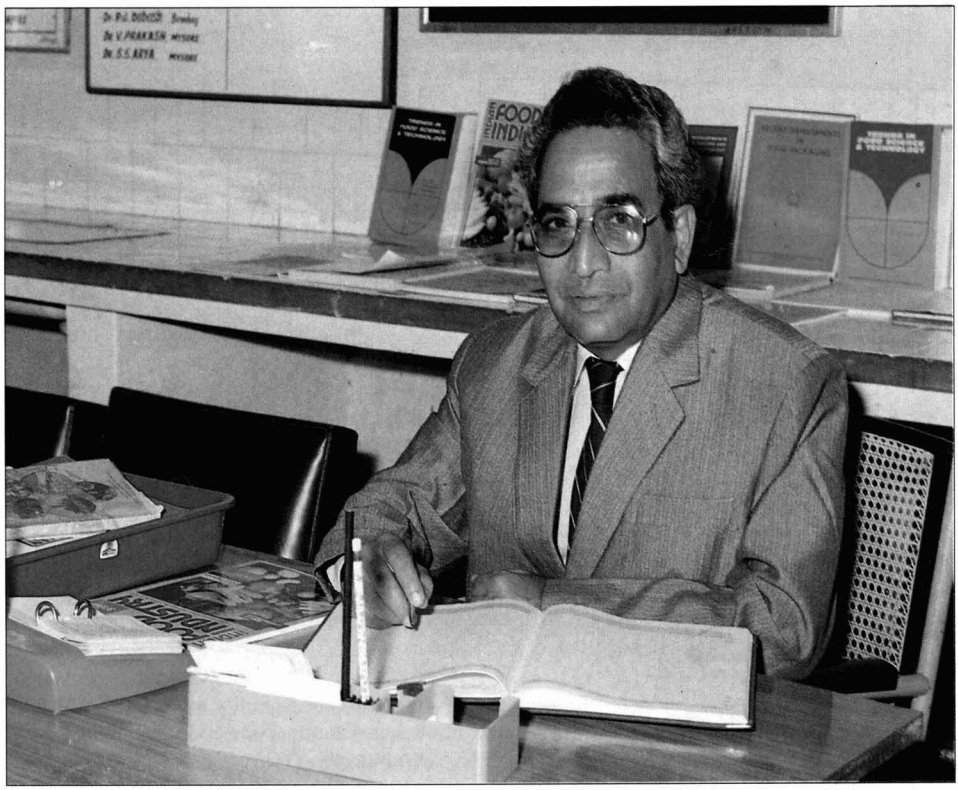
FOR THE YEAR 1996-97



Helms of AFST(I) in the Strong and Yet Persuasive Hands of a Dynamic and Distinguished Food Consultant of International Recognition

Dr. C.L. Nagarsekar, Food Consultant (Dr. Nagarsekar Associates, 2/202, Mehta Park, Mahim, Mumbai - 400 016), has assumed the total responsibility of the Association of Food Scientists and Technologists (India) as President for the year 1996-97, along with a dedicated team of a Central Executive Committee. The Presidentship of AFST(I) was handed over to him at the Annual General Body meeting held on September 7, 1996, after the annual Convention & Colloquium on Food Safety and Quality, organized in the IFTTC Auditorium, Central Food Technological Research Institute, Mysore.

Soon after his induction, Dr. Nagarsekar in his presidential address, placed on record the excellent contribution of the former CEC (1995-96) and stressed the need to make cohesive efforts by the new CEC for taking the AFST(I) to greater heights. He particularly emphasised the need to strengthen the ties between AFST(I) and Food Industries and regulatory bodies of the Government. He further said that all his endeavours will be to fulfil his dream of making AFST(I) indispensable to food industry as well as the Government agencies and requested the cooperation and support of all the AFST(I) members in achieving this goal.

Now, it is my honour and privilege to introduce Dr. C.L. Nagarsekar to the readers of the *Journal of Food Science and Technology.*

Dr. Chandrasekar Laxman Nagarsekar, born on December 18, 1940 at Canacona, Goa, had his early education in the beautiful and serene atmosphere of Goa, followed by higher education in Mumbai, the industrial capital of the country. It is probably the result of this optimal blend of the environment, which has ultimately made him a dynamic, gentle and warm person, with several achievements and international distinctions. He had a brilliant academic career starting with: (a) B.Sc. (Hons.) in Chemistry and Physics from St. Xavier's College, Bombay University in 1961, (b) B.Sc. (Tech.) in Food Technology at University Department of Chemical Technology, Bombay University in 1963 and (c) Ph.D. (Tech.) in Food Technology of Bombay University in 1970 at University Department of Chemical Technology on "Amino Acid Metabolism in Microorganisms", under the guidance of late Dr. D.V. Tamhane, an outstanding food and fermentation technologist of India.

The goal of being an excellent food consultant was probably set forth during his higher education days by Dr. Nagarsekar, due to realization of the poor state of Indian Food Industry during the 60's. Accordingly, he planned and moulded his career in the right way to emerge as an eminent food consultant, with diverse experience and knowledge in various aspects of food processing.

After initially serving as lecturer in food technology at the University Department of Chemical Technology, Bombay University, which equipped him with knowledge about all the facets of the multidisciplinary subject, Dr. Nagarsekar moved to Wallace Flour Mills in Mumbai and later on had a stint for 3 years in Fiji during 1970-84 to rise to the position of General Manager. From 1985-87, he was the Executive Director of Protein Foods and Nutrition Development Association of India and later joined Tasty Bite Eatables Ltd., Mumbai, as the Chief Executive during 1987-89. During this period, he acquired a wide experience in milling, baking and pasta products, retort pouch foods and IQF frozen foods. After this experience of over 20 years in academia and senior managerial positions in various food industries in the area of food technology, production, R&D, quality control, labour and personnel management, marketing, sales, finance, machinery maintenance and liaison with Government agencies as well as industries, Dr. Nagarsekar is now a full-fledged consultant to food processing industries.

Currently, he is consultant to several food industries in India and abroad, including some multinational corporations. He has developed production processes for a variety of traditional and convenience foods. The credit for development and introduction of a total enteral nutritional product for the first time in India goes to Dr. Nagarsekar. In spite of the busy time schedules in the consultancy assignments, Dr. Nagarsekar has kept himself in contact with academia. He is a visiting faculty at UDCT, SNDT University and Indian Institute of Packaging, all in Mumbai, and is also an examiner for B.Sc. (Tech.), M.Sc. (Tech.), Ph.D. (Tech.), M.Sc. (Home Science) and Ph.D. (SNDT University). Yet another favourite mission of Dr. Nagarsekar is the dissemination of information about food science for removing misconceptions amongst consumers through media, including newspapers, magazines, AIR and TV. He is also responsible for editing the Newsletter of Mumbai Chapter of AFST(I) and bringing it to its present attractive format.

Dr. Nagarsekar has served as ISI(BIS) committee member, was on the selection committees for various posts of Bombay University, CFTRI and various industries. Dr. Nagarsekar is a Professional member of Institution of Food Technologists, USA and a former member of the National Association of Bakery Industries, India.

Dr. Nagarsekar has been actively involved in organisation and participation in a large number of national and international seminars, symposia and workshops. Dr. Nagarsekar has travelled widely in India and abroad. His travel to Fiji, Japan, Hongkong, Singapore, New Zealand, Australia, Nepal, France, Germany, Italy, Belgium and Switzerland, as well as interactions with the experts in these countries, not only put him on a sound footing in his consultancy but also gave him international status.

Dr. Nagarsekar has been closely associated with AFST(I) in the past several years and served in various capacities, such as Honorary Secretary and President of Mumbai Chapter, Vice-President, AFST(I) and trustee of AFST(I) Educational and Publication Trust. He has been an active fund raiser for strengthening both the Mumbai Chapter and AFST(I), Headquarters.

I wish him success in all his endeavours.

B.K. LONSANE

Editor-in-Chief

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Carob Bean in Food and Feed: Current Status and Future Potentials - A Critical Appraisal

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Carob bean is the fruit of *Ceratonia siliqua* L, an evergreen sclerophyllous perennial and long-producing tree, which naturally grows on barren, rocky and dry regions of the Mediterranean basin and other parts of world, with similar climate. Deseeded carob pod (husk), although rich in water-soluble sugars (mainly sucrose), has a very low protein content, and high levels of tannins (mainly condensed), which minimize the nutritional value of carob beans. The present review attempts to appraise the current status and future potentials of the carob bean in food as well as feed industry and environment upgrading.

Keywords: Carob, Carob tree, Carob bean, Carob sugars, Carob tannins, Carob powder, Carob uses, Carob varieties.

Since ancient times, low income groups of population have been consuming baked carob beans and aqueous carob extract (syrup, carob honey). The use of carob husk in processed confectioneries has increased greatly in the last 50 years. Carob husk powder is also used particularly as an effective agent in the treatment of acute infantile diarrhoea. More extensive use of carob beans is for animal feeding. Carob seed endosperm (locust bean gum) has been the most valuable carob product. However, the use of alternative gums (e.g., tragacanth) has reduced the interest in the carob fruit. Although several studies have been carried out on the valorization of the carob beans, the commercial price of this agricultural product remains very low. This, in combination with the development of other sectors of economy, notably industry and tourism, are responsible for jeopardizing the carob industry. In spite of these situations, the carob tree certainly deserves to be preserved, as a valuable component to the Mediterranean environment and therefore, higher prices need to be offered for its fruit. Of course, carob bean in order to continue to be harvested as a crop, some aspects of present carob practice's should be improved or even changed. This can be achieved through a) identification of alternative and valuable uses not only of the galactomannans, but also of the husk material and b) changes in current carob agronomic aspects (proper carob varieties, new system of carob cultivation and fruit collection) and other aspects.

Carob tree

Name: In carob tree history , this tree has been named as *keratea* (from Greek word *keration* = horn), *keratonia* and *ceronia* (Mitrakos 1968). Latin name of the carob tree is *Ceratonia siliqua* L. The name of the tree and its fruit in different languages are: carob tree-carob bean (English), *caroubier-caroube* (French), *carruba-carrubo* (Italian), *carube* (German), *algarroba* (Spanish), all of which have originated from the arabic word *kharrub*, which indicates the cultivation of the plant and the use of carob beans during the middle ages (Mitrakos 1968). In Greek, the official names for tree and its fruit are *xylokeratea* and *xylokerata*, respectively.

Characteristics: The tree attains a mature height and spread of 6-12 and sometimes more than 20 metres, with branches extended to ground level (Fig. 1). The twice pinnately compound leaves bear 3-5 pairs of 4-5 cm long leaflets, which are darker green on the upper side than on the under side (Fig. 2). The root system is well developed, as it should be for a xerophytic tree (Diapoulis 1950).

Distribution: Carob tree is an evergreen sclerophyllous plant, which naturally grows on barren, rocky and dry regions. Of course, carob

Fig 1. Carob Tree

* *Corresponding Author*

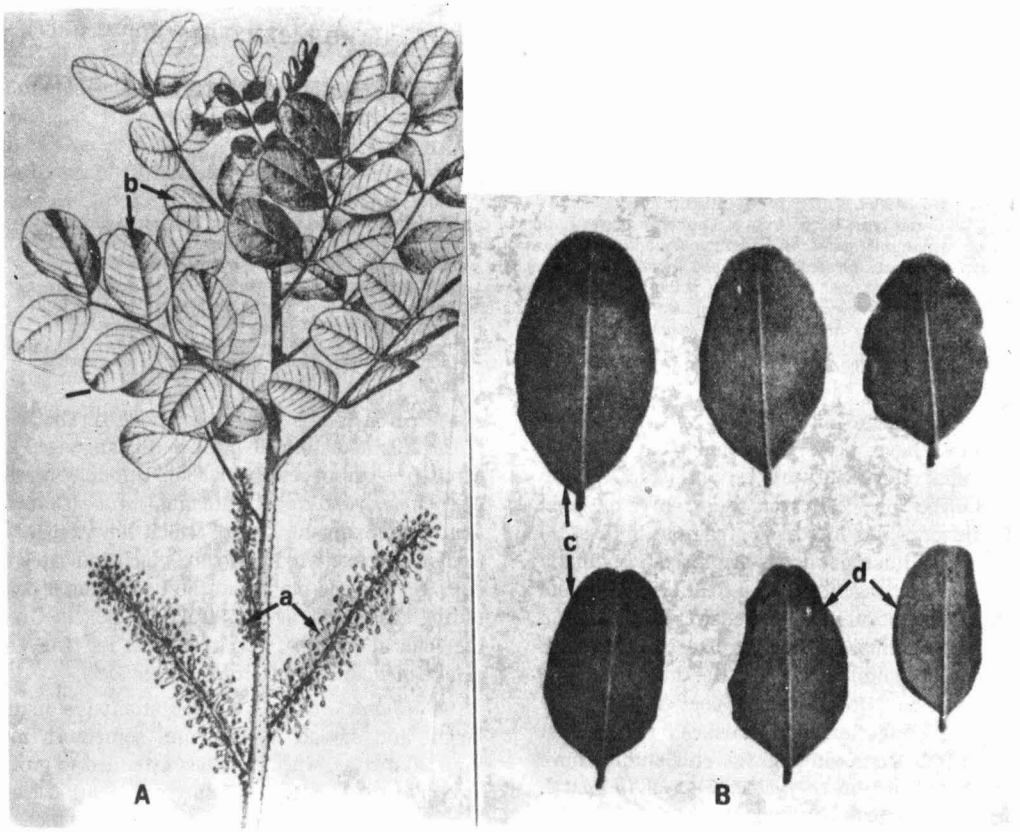


Fig 2. Carob flowering branch (A) and individual leaves (B). Flowers (a), leaves (b), upperside (c), underside (d).

trees can be grown or cultivated in any soil, except in marshes and on very wet soils. It can withstand a certain amount of salinity and prefers soils rich in calcium. Naturally, the tree is more prolific in soils, which have higher fertility.

It is accepted that *C. siliqua* L. is a native plant of Syria or the Northern coasts of Africa (Morocco, Tunisia, Algeria) (De Candolle 1825; Gennadius 1900; Tous et al. 1996). Later, the plant spread to Middle East (e.g., Israel), Greece, etc. Today, the carob tree grows in the warmest regions of the Mediterranean, mainly near the coasts and at an altitude not higher than 500 m (Diapoulis 1950; Mitrakos 1968). Diapoulis (1950) has reported that carob trees do not occur in areas, where the minimum winter temperature is lower than 3° to 4°C. He has opined that *Ceratonia* grows in areas, which are characterized by simple yearly fluctuation in rainfalls i.e., one maximum in winter and one minimum in summer. Other countries, where the carob tree is known to grow on a small scale include Jordan, Yemen, India, China, New Zealand, Rhodesia, Australia, Chile, part of USA (California-Arizona) and Mexico (Imrie and Vlitos 1975; Esbenshade 1987).

Carob tree species and varieties: Ceratonia siliqua L. belongs to the sub-family *Caesalpinioideae* of the leguminosae (Ball 1968). The family is generally characterized by its fruit (carob bean), which is legume or pod. The carob tree is polygamous, i.e., there are female trees, male trees and trees, which have both male and hermaphrodite flowers (Mitrakos 1968).

The genus *Ceratonia* was thought to consist of only one species. *C. siliqua*, until 1979, when Hilcoat et al (1979) described a new carob species, *C. oreothauma* from Arabia and Somali Republic. On the other hand, the species of *C. siliqua* include many varieties (Colt 1967; Orphanos and Papaconstantinou 1969; Secmen 1973; Tous 1985; Marakis et al. 1987; Gaitis et al. 1994). Over 50 world carob varieties, which include traditional

varieties from the Mediterranean and new selections from California have been identified (Esbenshade and Wilson 1986).

So far, several criteria [colour of young shoots, number of leaflets per leaf dimensions and venation of the leaflets, flower characteristics and structure, morphology and chemical composition of the fruit (Coit 1967; Orphanos and Papaconstantinou 1969; Tous 1985)] have been used for recognizing carob varieties. However, neither a clarity, as for the importance of some of the above mentioned criteria, nor an hierarchical order of the criteria has been proposed. Marakis et al (1987) suggested that carob seed's role in the bean weight and the fruit morphological as well as chemical characteristics should contribute to a better understanding of the evaluation of the carob varieties, in general. Thereafter, Kalaitzakis et al (1987); Marakis et al (1993 a, b) and Gaitis et al (1994), based on these criteria, have distinguished and described 8 ungrafted and 7 grafted Greek carob varieties.

It is to be noted that, reports published so far, except those of Marakis et al (1987; 1993 a, b) and Gaitis et al (1994), are purely agriculturally oriented, but no information is available on the evaluation of the different varieties from the species type. This actually is largely obscured, at least in some countries, in spite of the long cultivation of the carob tree (Hillcoat et al. 1979). The available information about the genetic stock of *C. siliqua* is insufficient, both in terms of quantity and quality. For some countries, there is no information available on the cultivated carob tree varieties, whereas for other countries (Spain, Italy, Portugal), the information is inadequate. Thereafter, the research has been focussed on the recognition of the varieties. In recent years, some countries (Spain, Italy, Portugal, etc.) have started surveys of native material and to collect as well as conserve carob genetic diversity in collections and genepools (Tous et al. 1996). Barracosa et al (1996 a, b) have characterized and assessed the phenotypic polymorphism of cultivars of carob tree from Portugal by combination of fruit morphometric studies with isoenzymatic and PCR-RAPD (polymerase chain reaction - random amplified polymorphic-DNA) studies of the genetic polymorphism.

For practical purposes, the main relevant characteristics of the carob trees and their fruits, for the evaluation of carob varieties are as follows:

a) Characteristics of carob bean cropping: yield; regulation of production; precocity; pollination (flowering/fruit setting); size of tree; sensitivity to frost, fog, wind, pests and microbial activity; pruning needs; and response to irrigation/fertilization. b) Characteristics of carob husk: flavour (aroma taste); tannin contents; water-soluble sugar (total, individual) contents; lignocellulosic contents; other chemical characteristics and nutritional value, and c) Characteristics of carob seeds: seed's role in bean weight; locust bean gum (LBG) contents; and LBG quality.

Life span of trees and carob bean yield: *C. siliqua* is a perennial and a long-producing tree. Age, at which flowering and fruit set of carob commence, varies with carob variety, budding techniques and environmental conditions, but generally ranges from 5 to 8 years after budding (Graca 1996). Diapoulis (1950) has reported that a 5-6 years old tree gives 4-5 kg carob beans per year. This yield increases with age, so that, at the age of 20 years, it gives about 40 kg and at full production at 100-150 years, it might even give 500 kg. An exceptional carob yield 727-818 kg/tree has been reported by Esbenshade and Wilson (1986) for Portugal carob bean production. Sometimes, trees of 200 years old, give a good yield.

From the report of Gennadius (1900), a yield of 15-20 kg/tree for non-irrigated and about 50 kg/tree for irrigated trees in Cyprus, have been recorded Higher yields have been reported by Goor et al (1958) for Israel carob trees (30-50 kg/tree for non-irrigated and 60-80 kg/tree for irrigated areas). Graca (1996), using shield-budding or patch-budding grafting techniques, succeeded in achieving an average fruit production of 11.2, 19.9 and 39.0 kg/tree at 5th, 6th and 7th year, respectively, after tree grafting.

Carob bean yield is determined by several factors (Brito de Carvalho 1987). The more important among these are i) pollination, flowering and fruit set, ii) sensitivity to frost and fog (mainly for regions with cold winter), iii) sensitivity to pests and diseases, iv) sensitivity to wind, v) response to irrigation/fertilization and vi) grafting compatibility. Most of the above mentioned factors have been studied by several workers (von Haselberg 1996; Yakir 1996; Ferreira 1996; Lips 1996; Graca 1996). von Haselberg (1996) reported that the variation in flouring intensity and pod yield were influenced by climatic conditions and endogenous factors. Thus, unfavourable environmental factors significantly reduce the yield by diminishing fruit set.

Carob fruit (bean)

Bean morphology and weight: The carob bean (Fig. 3) is chocolate-brown in colour, lustrous and varies in weight (5-30 g) and size, as per the variety and the growth conditions (pollination level and fruit set). The bean size reaches in some cases 25 cm in length and 4 cm in width and are bent like a horn (hence named as *keration* =horn) (Mitrakos 1968; Marakis et al. 1987; 1993 a,b; Gaitis et al. 1994). Both the dorsal and ventral edges are proved, while the flattened sides are sunken and wrinkled.

By cutting the pod parallel to the flattened sides, a series of oval holes appears (Fig. 4). Each hole bears one obovate, dark red or brown, lustrous seed, about 9 mm long (Figs. 4, 5). Each pod bears several seeds, depending on the carob variety. The fruits of ungrafted trees (Fig. 3a) are thinner, shorter and more woody, as compared to those of the grafted ones (Fig. 3b). Seven Greek (Marakis et al. 1987; 1993 a, b; Gaitis et al. 1994) and two Cypriot (Orphanos and Papacontantinou 1969) ungrafted varieties have been reported so far.

Seed weight levels in carob bean weight: The contribution of the seed weight in bean weight ranges between 8-37%, depending on the carob variety and the country of origin (Noukon 1987; Orphanos and Papacontantinou 1969; Secmen 1973; Calixto and Canellas 1982; Amaral-Collaco et al. 1987; Marakis et al. 1987; Gaitis et al. 1994). In Greek carob varieties, seed contribution in bean weight is significantly higher in the ungrafted varieties (16-37%), than in the grafted ones (8-12%). So far, percentages of seed contribution, ranging from 30 to 37%, have been reported for the first time and only for the Greek ungrafted varieties 'u-1' and 'A-1', respectively (Marakis et al. 1987; Gaitis et al. 1994). Varieties with seed contribution percentages similar to ungrafted Greek carob varieties ('u-1', 'A-1'), possibly exist in other countries as well, but these varieties have not been detected yet, mainly because of the researcher's interest having been confined on the grafted varieties and the carob bean price is based on the deseeded carob pod (husk) from the last 10 years, Thus, carob varieties with high husk percentages have attracted more attention of the farmers.

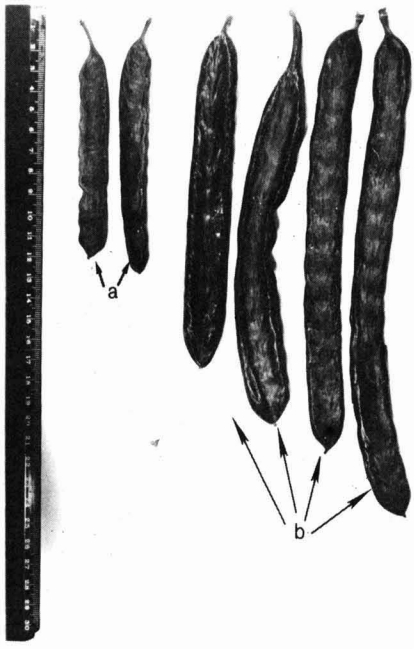


Fig 3. Carob beans : ungrafted (a), grafted (b).

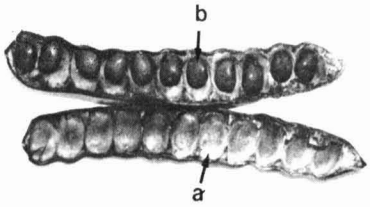


Fig 4. Longitudinal section of carob bean. (a) oval holes, (b) seeds.

Resistance to environmental conditions and diseases: Carob trees are drought resistant, but tolerate only light frost. Sensitivity to frost is the most serious problem in this crop, mainly in countries, where this meteorological phenomenon occurs frequently. The carob tree is, normally, free from insects and diseases. However, a few carob

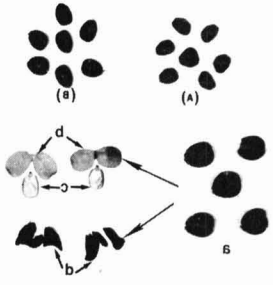


Fig 5. Carob seeds of ungrafted (A) and grafted (B) varieties. Seed treated with soda solution (a) → endosperm halves (galactomannans (b), embryo (germ) (c), perisperm (hull) (d).

varieties are damaged by some insects (e.g., *Zeuzera pyrina*) (Martorell 1987; Tous et al. 1996). Carob pods of many varieties, sometimes, become infested by a small carob moth (*Ectomyelois ceratoniae* Z). *Oidium ceratoniae* C attacks pods, leaves and twigs in different periods of the year, mainly in spring and autumn (Graniti 1959; Martorell 1987; Tous et al. 1996). Charpentie and Marakis (1980), and Marakis and Diamantoglou (1990b) have isolated several pathogenic fungal strains from carob beans and carob leaves, respectively.

Quality of carob beans: The carob bean quality should be most appropriately evaluated, in relation to the use of this fruit components. Brito de Carvalho (1987) has reported that carob bean quality depends on the value of the deseeded carob pod (husk), percentages of seed weight contribution in bean weight, locust bean gum (LBG) contents, LBG quality and ease of processing. It is reasonable to deduce that carob husk composition (water-soluble sugar, tannin, lignocellulosic etc) and seed components play a significant role in the evaluation of carob beans.

Chemical composition of ripe carob husk: Several researchers have dealt with the chemical analyses of the carob husk (Charalambous and Papaconstantinou 1966; Coit 1967; Orphanos and Papaconstantinou 1969; Imrie and Vlitos 1975; Thomson 1971; Marakis 1980; Marakis et al. 1987; Caja et al. 1987; Puchades et al. 1987; Mulet et al. 1987 a, b; Gaitis et al. 1994; Marakis et al. 1996 a, b). So far, there has been no complete study on the chemical composition of carob bean (husk and seeds separately). Table 1 presents the main constituents of deseeded carob pods from different countries. From the results of these chemical analyses, two basic conclusions can be deduced, i.e., a) the chemical composition of the carob husk varies, depending on the carob variety, producing country and district (soil - climatic and cultural conditions), and b) the main husk constituents are water-soluble sugars 32-62% fibres 3.7-35.2%, tannins 3.8-24.9% and proteins 2.3-6.7% (Table 1). Interesting data on inorganic constituents have been given by Charalambous and Papaconstantinou (1966) as well as Puchades et al (1987) for Cyprus and Spain (Valencia district) carob beans, respectively (Table 2).

Water-soluble sugars: The sugar contents (total and individual) of the husk depend on the carob variety (Marakis et al. 1987; Gaitis et al. 1994), tillage of the trees (irrigation, fertilization, ploughing, etc) and the soil-climatic conditions (Tous et al. 1996). Marakis et al (1996 a, b) reported that ungrafted varieties were poorer (<40%) in total water-soluble sugars than the grafted ones. This might be possibly due to the higher amounts of tannin-lignocellulosic materials in ungrafted varieties (Marakis et al. 1987; 1993 a, b; Gaitis et al. 1994).

Although the carob sugar profiles, reported by several researchers, present significant variations, the experimental data clearly indicate that carob husk contains sucrose, fructose and glucose, independently of the variety and the country of origin (Angelidis 1954; Wallenfels and Lehmann 1957; Vardar et al. 1972; Imrie and Vlitos 1975;

TABLE 1. MAIN DESEEDED CAROB POD COMPONENTS (g/100 g DRY WEIGHT) FROM DIFFERENT COUNTRIES

Country	Water soluble sugars	Crude proteins	Tannins	Fibres	Crude fat	Ash	References
Greece	32-60	3.3-6.7	4.2-13.3	3.7-15.9	0.3-0.9	2.3-2.9	Marakis et al (1987; 1993 a, b; 1996 a, b) Gaitis et al (1994)
Spain	41-48	2.9-5.1	3.8	7.0-9.0	1.5-2.3	2.5-2.7	Calixto and Canellas (1982) Puchades et al (1987) Mulet et al (1987 a, b)
Portugal	50-58	3.3-6.3	1.9-24.9	27.6-35.2	0.2	2.4	Amaral-Collaco et al (1987) Wursch(1987)
Cyprus	44-56	3.3-4.6	-	4.8-8.2	0.18-0.40	2.6-4.1	Orphanos and Papaconstantinou (1969)
California-Arizona	35-62	2.3-6.6	-	4.2-9.6	0.46-1.46	1.5-2.9	Coit (1967) Thomson (1971)

TABLE 2. INORGANIC CONSTITUENTS (ON DRY MATTER BASIS) OF CAROB HUSK FROM CYPRUS AND SPAIN

Chemical elements	Cyprus*	Spain**
K, %	0.60-1.30	0.74-0.86
Ca, %	0.09-0.21	0.27-0.34
Mg, %	0.10-0.20	0.04-0.08
Cl, %	0.14-0.25	-
N, %	0.43-0.99	-
P, %	0.04-0.08	0.031-0.068
S, %	0.08-0.24	-
Na, ppm	600-800	-
Zn, oom	5.6-14.0	5.2-12.4
Cu, ppm	1.2-0.8	1.7-2.6
Fe, ppm	20.0-59.5	3.3-10.5
Mn, ppm	7.6-15.2	8.5-13.5
Co, ppm	Nil-0.77	-
B, ppm	12.1-23.4	-

* From Charambous and Papaconstantinou (1966)

** From Puchades et al (1987)

Kalaitzakis 1979; Amaral - Collaco et al. 1987; Marakis 1992; Marakis et al. 1996 a, b).

Sucrose is the major constituent, its level being 16.2-47.3% on husk dry weight (Marakis et al. 1996 a, b) and comprises 50-80.7% of the total water-soluble sugars (Imrie and Vlitos 1975; Esbenshade and Wilson 1986; Marakis 1992; Marakis et al. 1996 a, b). Sucrose and fructose contents were higher in the grafted varieties, as compared to those in the ungrafted ones (Marakis et al. 1996 a, b). On the other hand, the glucose contents were higher in the ungrafted varieties. Except for the three sugars mentioned above, several researchers have reported that deseeded carob pods contain maltose, trehalose and a non-identified sugar (Marakis et al. 1996 a, b); xylose, kestose, ceretose and primverose (Imrie and Vlitos 1975; Wallenfels and Lehmann 1957). The sugar profile variation could be attributed to different carob varieties or to different methods of extraction and sugar determination.

Tannins: A few studies on the determination of total and individual carob tannin contents have been carried out (Nachtomi and Alumot 1963; Tamir et al. 1971; Marakis 1980; Marakis et al. 1987; 1993 a, b; 1996 a, b; Mulet et al. 1987 a, b; Amaral Colaco et al. 1987; Wursch et al. 1984; Gaitis et al. 1994). The tannin percentages 1.4-13.3% (on husk dry weight) have been reported by these researchers. Wursch (1987) reported that tannin contents of deseeded carob pods from Italy, Portugal and Cyprus ranged from 20 to 27% (on husk dry weight), which could be considered too high. No other researcher has reported such a high carob tannin content, so far. The observed fluctuations of the carob husk tannins should be due to various factors such as the carob variety, the producing country or the methods used for tannin extraction and determination.

Although the structure of condensed tannins had not been fully investigated, due to the lack of the suitable methodology. Betts et al (1967), Tamir et al (1971) and Marakis et al (1993 a, b), employing thioglycolic acid to degrade the tannins from common heather *(Callus vulgaris)* and carob pod, respectively, gave a profile of the condensed tannins. Tamir et al (1971) studied the structure of the carob condensed tannins, but the authors did not mention the carob variety from which tannins were isolated. The most detailed carob tannin analyses were carried out by Marakis et al (1993 a, b), using paper chromatography and Marakis et al (1996 a, b) using RP-HPLC. These researchers reported, for the first time, the tannin profile of 17 Greek carob varieties.

The results reported by the above workers, suggested that the main constituents of carob polyphenols were condensed tannins, containing the flavan nucleus. These tannins are composed of flavan-3-ol and flavan-3,4-diol subunits. (+) catechin and (-) epicatechin gallate esters were found to be the ethyl acetate - soluble thioglycolic acid degradation products, for all 9 cretan carob varieties (Marakis et al. 1993 a, b). Tamir et al (1971) have identified (-) epicatehin gallate, (-) epigallocatechin gallate and (-) epigallocatechin as the products of thioglycolic acid degradation of ethyl acetate soluble tannin fraction. By mineral hydrolysis with hydrochloride acid (2M), carob tannins gave delphinidin pelargonidin and cyanidin (Tamir et al. 1971; Marakis 1933 a, b, 1996 a, b). These compounds may be derived from the polymeric catechin, the copolymer of catechin and leucoanthocyanidin, or polymeric leucocyanidin.

Ungrafted (wild) varieties are richer in total tannins than the grafted ones (Marakis et al. 1993 a, b; 1996 a, b). This possibly indicates the protective role of tannins in the natural wild carob varieties, against microbial attack and herbivores. The same authors reported that rats were preferably eating the carob beans and tree bark of some carob varieties, while they were avoiding other adjacent carob varieties. This preference of the rats was shown to be due to the different relative astringency (r.a) of the greek carob varieties (Marakis et al. 1993 a, b, 1996 a.b). Bate-Smith (1973) defined the relative astrigency as the ratio of the

concentration of the tannic acid to the concentration of tannin, which caused the same degree of protein precipitation. The r.a determination of the 17 Greek carob varieties (Marakis and Marakis 1996 a, b) revealed that a) the r.a was generally higher in the ungrafted carob varieties than the grafted ones, b) the r.a values of the varieties preferred by rats, were about 4-fold smaller than those of the other unpreferred carob varieties. Marakis et al (1993 a, b) reported that this might be due to the highly polymerised tannins of the varieties readily eaten by rats, because the more highly the tannins are polymerized the lower is the r.a, as in grape tannins (Harvalia and Bena-Tzourou, 1982).

The growth of micro-fungal species presented a significant differentiation in media containing, carob tannis of all Greek carob varieties and Mimosa tannins (catechols) as sole carbon sources (Marakis et al. 1993 a, b; 1996 a, b). So, a limited number of fungal species, with high tanninolytic ability, exihibited lower growth in tannins of ungrafted varieties, in general. On the other hand, a higher number of fungal species, grew in media, containing tannin of grafted carob varieties. It is also possible that the absence of (-) epicatechin from some of the Greek carob varieties and the low lignin contents of these varieties attracts the preference of rats (Marakis et al. 1993 a, b).

Crude Proteins : The protein contents of carob husk range between 2.3 and 6.7% on dry matter basis (Table 1). Carob protein fluctuations are not significant among the carob producing countries. Marakis et al (1987) and Gaitis et al (1994) found that the husks of the ungrafted varieties were poorer in proteins, compared to those of the grafted ones. Nevertheless, the carob husk is poor in proteins. This is a fact that minimizes the nutritional value of carob pods. The information concerning the quality and amino acid profile of the carob proteins is limited, except for what has been reported by Charalambous and Papaconstantinou (1966) for the amino acid profile (glycine, alanine, valine, leucine, proline, tyrosine, phenylalanine and one non identified) of Cyprus carod pod.

Crude fibres (cellulose, hemicelluloses A, B, lignin) : As for husk fibre content, the existing information is quite confusing. Table 1 shows the fibre contents of the carob husk in carob bean from several producing countries. The high fibre percentage found in Portugal carob husk, could be due to the fact that Almaral-Collaco et al (1987) considered the sum of lignin + cellulose + hemicelluloses, as fibre. Marakis et al (1987) and Gaitis et al (1994) reported that the husks of the ungrafted varieties were richer in cellulose than those of the grafted ones. The carob lignin contents [12.5-14% for 'cretan' carob pods (Cumming 1974; Marakis 1980) and 25.9-30.3% for Portugal ones (Amaral-Collaco et al. 1987)] were higher than expected for the fruit of the legume, which has no extensive visible lignification. On the other hand, Gaitis et al (1994) reported that carob husk from Greek island Lefkada was poorer in lignin contents (2.9-6.4% on husk dry weight), compared to carob husk of 'cretan' varieties. The cellulose contents present a reverse trend. Gaitis et al (1994) found that lignin contents of ungrafted varieties were higher, compared to those of grafted ones. It is noteworthy that all carob pods with low lignin contents were soft and usually preferred by rats.

Lipids : Chemical analyses of carob husks have shown that this fruit is poor (0.18-2.3%) on dry matter basis) in total lipids (Table 1). Orphanos and Papaconstantinou (1969) and Marakis et al (1987) found that husks of ungrafted varieties were richer in lipids than those of the grafted ones. A detailed fatty acid analysis of the pod lipids for distinguishing carob varieties was carried out for the first time by Marakis et al (1987). They found 6 individual fatty acids in lipids of 8 'cretan' carob varieties. Palmitic and stearic acids, constituting about 50-70% of the total fatty acids in the different varieties are predominant. All carob varieties show no qualitative differences in these fatty acids. Interesting differences among different varieties are observed in the unsaturated fatty acids (palmitoleic, oleic, linoleic and linolenic). Palmitoleic was found only in one variety, which, therefore, can be differentiated from the other 7 carob varieties. Therefore, qualitative and quantitative fatty acid composition of lipids depend on the carob varieties.

Ash : The ash content of carob husk ranges between 1.5 and 4.1% on dry matter basis. From the nutritional point of view, the carob pod ash contents are considered to be acceptable, because ash levels must be low, normally less than 5% in a compounded feed (Forage 1978).

Structure and chemical composition of the carob seeds

Seed structure : Examination of the cross section of a carob seed (kernel) under the microscope, allows 3 parts to be distinguished, a) the seed coat (hull or perisperm), b) the endosperm, in which galactomannans are located and is divided into two

halves and c) a yellow embryo or germ (Fig. 6). Generally, the percentages of these three seed parts are different among carob varieties and producing countries. Marakis et al (1987) and Gaitis et al (1994) found higher endosperm percentages (47-59%) in the Greek carob varieties, compared to those (42-46%) reported by Noukon (1987). Marakis et al (1987) have reported that perisperm of the ungrafted varieties is higher to that of the grafted ones. Gaitis et al (1994) have found that the ratio of perisperm dry weight/embryo dry weight distinguishes the grafted from the unfrafted carob varieties from island Lefkada. On the other hand, Marakis et al (1987) have reported that the endosperm dry weight/embryo dry weight ratio distinguishes grafted from ungrafted 'cretan' varieties.

Chemical composition : The endosperm's principal constituent is a reserve edible polysaccharide (galactomannan), containing a backbone of (1→4)-ß-D- mannopyranosyl units with attached (1→6)-a-D-galactose units (Dey 1978), the ratio of mannose/galactose (M/G) varying between 2.7:1 and 4.2:1 (Winer 1980; Marakis et al. 1987; Fernandes et al. 1991 a, b; Gaitis et al. 1994; Tous et al. 1996). Mannose residues form a long extended backbone chain, to which single galactose units are attached as side chains (Fig. 7). Other constituents of endosperm are: arabinose (1.3-2.1%), xylose (0.5-1.1%), glucose (3.2-4.1%), cellulose (3.54%), proteins (4-6%) and mineral substances (Marakis et al. 1987; Esbenshade and Wilson 1986; Gaitis et al. 1994). Marakis et al (1987) observed small differences in the M/G ratio, in contrast to the variation on the total sugar contents of the endosperm in the 'cretan' carob varieties. Obviously, a variety with a higher galactomannan content in its endosperm will be preferred by the industry. Esbenshade and Wilson (1986) reported that it is not certain as to how much the variation in carob seed gum content is reflected by differing soils, climatic conditions or management. On the other hand, Brito de Carvalho (1987) and Tous et al (1996) reported that LBG content and its quality (viscocity grade, gel strength, etc) vary with climate, soil and cultivar. Embryo is protein-richer (45-47% on dry matter basis) part of carob seed (Winer 1980), and therefore, the production of embryo flour would constitute a protein-rich food (Louca and Papas 1973).

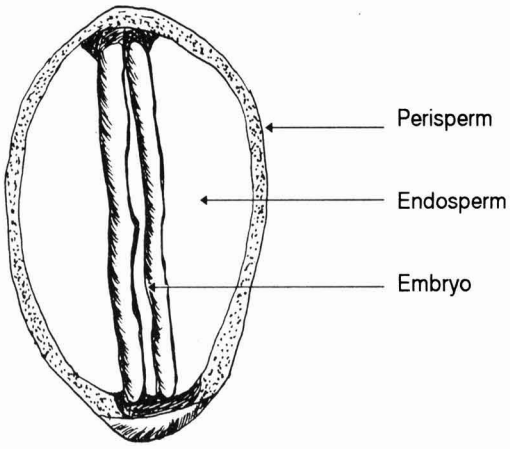


Fig 6. Cross section of carob seed

Uses of carob beans

Since ancient times, low income groups have been eating baked carob beans. This use of carob beans was more during wars and other difficult periods. In Greece, the use of carob beans for eating was especially more during the first and second World Wars. Another use of carob beans is the aqueous extract (syrup, carob honey), obtained from carob husk. Still more extensive has been the use of carob beans for animal feeding. Anyway, the carob beans can be used both directly or indirectly. Only the husk can be consumed directly. Indirect consumption of carob beans requires the intervention of a technical process to alter physical or chemical state of this agricultural product. So, the carob seeds must be mechanically or chemically dehulled to allow separation of the endosperm from embryo (Fig.5), to take advantages of the andosperm galactomannans and embryo proteins. A list of protential products is given in Table 3.

The details of utilization of the carob components are briefly described :

Animal feeding : The ripe carob pod, although rich in water-soluble sugars, has very low calorific

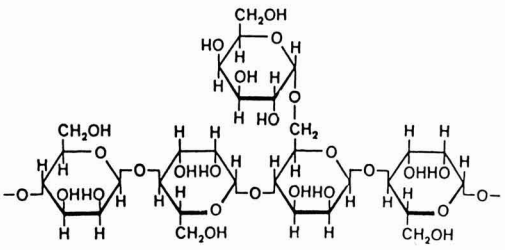


Fig 7. Chemical structure of carob galactomannan

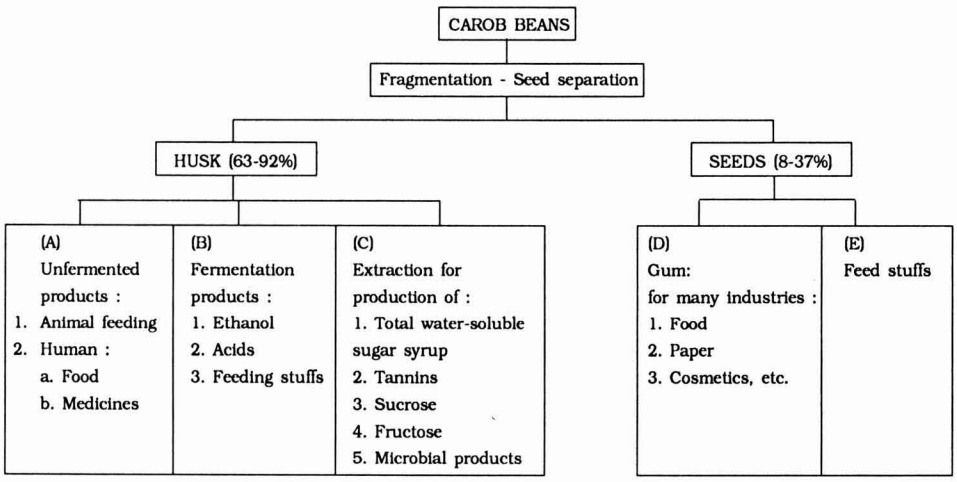
value (Esbenshade and Wilson 1986; Marakis, personal data) and protein contents, but high levels of total tannins, mainly condensed, which minimize the nutritional value of carob bean (Vohra et al. 1996; Tamir and Alumot 1970). The digestibility of carob pod is generally very low. This, in addition to the low protein content, qualifies the carob as a mainly carbohydrate concentrate of low digestibility. The digestibility is better in case of treated seeds and germs. Carob husk has a lower nutritional value than the oats (Obratovich 1966).

Some workers tried to improve the nutritional value of carob, using several treatments (autoclaving, boiling, etc). Borstein et al (1963) found that autoclaving of the kibbled carob failed to retard its growth inhibitory effect, when used as a feed, but when the carob pod was subjected to a hot water treatment, a marked improvement in its nutritional value occurred. Both treatments removed tannins from the carob pod, but autoclaving resulted in an increase in the apparent tannin content of carob pod (Cumming 1974), perhaps by depolymerizing condensed tannins and therefore, it could be a harmful procedure, if tannins were inhibitory to animal growth.

Carob pods are traditionally fed to most livestock, as sweetener and with results, similar to molasses. Jaffa and Albro (1919) have reported that carob pod is generally considered to have a feeding value equivalent to barley. The direct substitution of equivalent amount of barley by weight of carob pods has apparently been widely practised, but little substantive data have been generated until recently to encourage more commercial uses. In Mediterranean regions, carob beans are frequently allowed to fall upon the soil during autumn, thereby, providing a source of freely-harvested fodder for livestock. While carob pods are fed to cattle, horses, goats, sheep, etc, the seeds are not digested by them. These animals also browse upon the lower leaves and branches of carob trees, although these are of relatively low nutritive value, compared to the pods. It is certain, however, that carob pods, leaves and branches, combined with grasses growing among the trees, are a common browse source in the Mediterranean countries. Animal nutritioninsts have yet to solve problems on the specific proportions of carob pod to be added to livestock feeds to reduce observed growth depressions during laboratory experiments, which are most likely caused by either condensed tannins (Tamir and Alumot 1970) or the relatively low calorie content in pods. These problems have been reported, when animals, especially poultry, have been fed with diets containing a high proportion of carob pod. Normally, diets for large animals have usually been reported not to exceed 20% proportion of carob pod (Gohl 1975). Louka and Papas (1973) reported that carob pod meal, constituting up to 30% of the diet, had no depressing effect on the growth rate of calves and kids as well as the performance of dairy goats. It was stressed that the calves and kids could compensate for the lower calorie content of carob pod by increasing their feed intake.

In Portugal, carob husk powder, at the levels

TABLE 3. POTENTIAL PRODUCTION DERIVABLE FROM CAROB BEANS



of 5-10% on total feed basis, is used for animal feeding (Vicente da Cruz et al. 1988). Numerous reports of animal feeding trials need reexamination in the light of current knowledge, such as a) the ability of carob tannins to form complexes with other organic compounds (proteins, polysaccharides, b) the strong inhibition of enzymes (proteases, lipases, amylases, cellulases, etc) by carob tannins (Tamir and Alumot 1969, 1970), c) the preference of rats to eat carob pods with low relative astringency (Marakis et al. 1993 a, b; 1996 a, b). Carob lignin content plays a significant role in the nutritional value of carob pod as well (Marakis and Diamantoglou 1990a) and hence a detailed study is needed.

Due to high ratio of carbohydrates to proteins in the deseeded carob pods, additional roughage and proteineous materials must be fed to animals. An alternative is the enrichment of carob husk by microbial protein of good quality.

Fermented carob pod : Aiming at upgrading of the nutritional value of carob husk, several studies have been carried out. Cumming (1974) produced afermented carob pad with reduced tannin content, containing 27% (on dry matter basis) crude proteins. Marakis and Diamantoglou (1990a) reported significant enrichment (25% on husk dry weight basis) in true protein and tannin reduction (95% on initial tannin content) of carob pod, by mixed culture of the high tanninolytic strains of *Aspergilus carbonarius* and *Penicillium glabrum* in carob slurries. Both amino acid profile and nutritional indices of this fermented product were equivalent to those of soybean (Marakis and Diamantoglou 1990a). The protein content (25%) of the fermented carob pod is higher, than that (7%) of fermented carob pod crude protein, reported by Kokke (1977). From the nutritional standpoint, it is important that the percentages of ash (4.2%), nucleic acids (4.8%) and tannin level (0.4%) are low for being acceptable for animal feeding (Marakis and Diamantoglou 1990a).

Human food-medicinal uses : Beyond the traditional consumption of raw carob pods, as sweet fruit by Mediterranean people, use of carob husk in processed confectioneries has greatly increased during the last 50 years. The carob husk is milled to kibbles, which, after roasting is finely ground into carob powder. This treated carob is used in various industries (confectionery, beverages, bread and macaroni making, etc) Mitrakos 1968; Vicente da Cruz et al. 1988).

Many health professionals and others have expressed concern regarding the effects of caffeine and theobromine, present in cocoa and chocolate products, on human health (Graig and Nguyen 1984). They reported a reduction in caffeine and theobromine contents in cocoa products and drinks, when a quantity of cocoa was replaced by equal quantity of carob powder. This is due to the fact that carob husk does not contain caffeine and theobromine (Antonetti 1978). Thereafter, carob powder is used both as a substitute and extender for cocoa in many chocolate products; and for its own flavour in drinks, cakes and bread. The use of carob powder is advantageous because of the cocoa price. So, as market price of cocoa increases, the less expensive carob powder, mainly in carob producing countries, can be used to replace up to 50% of cocoa in baker's formulae (Esbenshade and Wilson 1986).

In pharmacy, carob beans are popularly termed as 'Fructus ceratoniae'. The carob powder is used as a particularly effective agent in the treatment of acute infantile diarrhoea (Wursch 1987). Milling of the whole carob bean (husk + seeds) results in a higher protein content than that in husk powder. Winer (1980) reported that the germ flour, produced from milling the seeds alone, contained 17-65% proteins. This is possibly a nearly sugar-free product, with the highest protein content found in vegetable kingdom. Greenstock (1977) has reported that carob germ flour is easily digested by invalids and especially by diabetics.

For carob powder, with the above mentioned uses, it is important to determine is microbial flora. Vicente da Cruz et al (1988) reported a microbial flora, consisting of bacteria = 1-3 x 10^2 cells/g and fungi + yeasts = 2 x 10^2 colonies/g. Thirteen species of microfungi and 20 yeast species have been isolated from carob pods (Marakis 1980; Marakis and Karagouni 1985).

Alcohol, acids, and feeding stuffs : Due to the low cost of carob pod and its high content of water-soluble sugars (up to 60%), it is the first among horticultural crops used as feedstock for the production of industrial alcohol by fermentation, mainly in carob producing countries. Since the main fermentable sugar is sucrose, carob pods can be handled by the same extraction procedures as sugar beets or sugar cane (Schwartzberg 1980). As Winer (1980) has reported, carob alcohol is produced by a simple fermentation process. A theoretical yield of 215.8 l of alcohol solution (7%) per tonne of carob pods, containing 40% (by weight) sugars,

has been calculated (Espenshade and Wilson 1986). Alcohol solution (11.41) of 10-12 % concentration was produced from 45.4 kg carob pods (40% of total sugars by weight) (Rimini 1926). The spent carob, generated during alcohol production, must be processed immediately by microbial conversion to higher protein feeds. Alternatively, if dried, the spent carob can be fed to livestock directly, when mixed with the high protein supplements. The use of spent carob as a fertilizer has also been suggested (Maymone and Battaglini 1953; Imrie 1973). Despite these figures, negligible quantities of alcohol are produced in the Mediterranean countries, mainly because of more readily available products or by-products (maize, sugar beet molasses, etc) than carob pods.

The use of carob pod for industrial alcohol or liquid fuel and acids (acetic, lactic, citric, itaconic) production may be succeeded in the near future.

Total water-soluble sugar syrup-Tannins : For the production of carob syrup, both large and small technologies should be available. The colour, due to the tannin content of the syrup, will reveal the level of technology used. Using a small scale system suitable for a village level processing, the syrup (poor quality) will retain its natural deep brown colour and even at this simple level, 70 g sugar can be extracted from 100 g husk (Hillis 1980). At a more complex level, the productivity of a virtually colourless and odourless syrup has been demonstrated, mainly at the laboratory scale.

Marakis and Marakis (1996 a, b) obtained a clear decolourized and odourless syrup of good quality, after removal of tannins by microfiltration procedure, which is a low-cost intensive procedure compared to the high-cost chemical procedures (Vuataz et al. 1959). Such syrup is obtained by other methods using ion exchange resins (Ninnis and Birbili-Ninni 1951). Tannins, obtained by microfiltration method, can be used for leather tanning, as these tannins are resistant to attacks of microorganisms and animals (e.g., rats) Marakis et al (1993 a, b, 1996 a, b) have reported that tannin tolerance to microbial activity depends on their polymerization level and subsequently on tannin astrigency. So, tannins occurring in carob pods of some Greek varieties, e.g., 'u-5', 'g-4', 'H-1' and 'H-4', are not recommended for leather tanning, because of their high polymerization level. While the tannins of 'u-1', 'u-2', 'u-3', 'u-4' and 'g-3' carob varieties could be used for these purposes, because these tannins indicated similar and in some cases, superior resistance to microbial attack in comparison to the Mimosa tannins used for leather tanning at the present time (Marakis et al. 1993 a, b).

Sucrose production : Taking into account the high (up to 47% on husk dry weight basis) sucrose content of carob and the low commercial price of carob beans, one could suggest the use of this agricultural product for the sucrose extraction. In the past, sucrose extraction from carob pod was undertaken by several workers (Oddo 1928, 1936; Buccar 1946; Kriaris 1957), but sucrose crystallization from aqueous carob extract failed, because of the interference of reducing sugars, present in carob. Marakis (1992) realized a sucrose syrup production by micro-selective consumption of carob reducing sugars by a mixed culture of *Rhizopus oilgosporus* and *Saccharomyces rouxii* (invertase negative). This syrup is suitable for several uses (sucrose extraction, pullulan production, sweetener for confectionery products or tin-preserved fruits, etc).

As Marakis (1992) has discussed, sucrose extraction from carob pod appears to have an advantage over the sugar production from beets, for many reasons : 1. Carob pod is an inexpensive agricultural product. 2. Carob pod sucrose content is about 4-fold higher than that of sugar-beets. 3. The cost of carob sucrose isolation from culture filtrate should be lower, than that of sugar crystallization from diffusion-juice of beets, because culture filtrate is a very clear liquid, while diffusion-juice has a number of properties, which impede sucrose extraction by direct evaporation and crystallization, without preliminary purification. 4. Treatment cost of aqueous carob extract (microbial cultures), so as to remove the reducing sugars, might be covered by commercial price of the produced biomass [rich in protein (35.7% on dry weight) with a good amino acid profile], which could be used as a protein source in animal feed, because the microorganism used is not toxic. *R. pligosporus* is already established as suitable for human consumption in tempeh (Sorenson and Hesseltine 1966). 5. Prolific land, where beets are now cultivated, will be released, seeing that carob tree can be grown on barren, rocky and dry regions (e.g., Southern Greece and Mediterranean sea islands). 6. Energy (electricity, fuel), required for the beet irrigation, will be saved. Carob tree, as a drought resistant plant, could be a solution to the severe problem of water scarcity that

Mediterranean countries, especially Greece, face recently, mainly during summer.

On the basis of the above mentioned facts, sucrose extraction from carob pod could possibly stir up a revolution in the sugar industry.

Fructose production : Since fructose has become acceptable to dietary health schemes, the requirements for this sugar are more and more increased (Stavropoulos 1985). Therefore, several studies have been carried out to produce fructose at low cost (Suntinanalert et al. 1986; Smith 1988).

Deseeded carob pod should be regarded as relatively rich in fructose (about 28-30%) [combined fructose (as sucrose) and free] (Marakis and Marakis 1993, 1996 a, b). So, fructose extraction from carob husk will be of commercial importance in carob producing countries, for example Greece, which presently imports fructose (Stavropoulos 1985). Marakis and Marakis (1996 a, b) obtained a liquor containing fructose (10.49% w/v) and ethanol (4.75% v/v) by microselective fermentation of carob glucose, using a glucophile yeast strain of *Saccharomyces cerevisiae*. This liquor, after removal of ethanol, contained 11.3% w/v fructose. Taking into account the fact that fructose is 1.7 times sweeter than sucrose (Shallenberger 1963), the about fructose syrup is equivalent to 19% (w/v) sucrose. This fructose syrup should find many applications in confectionery, dietetic food and other industries. On the other hand, the fermented product could also be used as a light alcoholic beverage (low alcohol content liquor).

In aqueous carob extract, a strain of *Saccharomyces* sp. hydrolyzed sucrose within 24 h and totally consumed the glucose and the 80% of the tannin content within 36 h incubation, thereby giving a clear fructose syrup and yeast biomass, rich in protein with balanced amino acid profile (Marakis et al. 1996 a, b). Thus, the above mentioned procedures could be used to treat aqueous carob extract for fructose syrup production, as carob extract treatment cost might be covered by the commercial price of the ethanol or yeast biomass.

Microbial proteins : The need for alternative protein has been universally recognized. Many schemes have been proposed for supplementing the world's increasing demand for protein with the microbial protein production. Human beings depend upon ruminants and poultry convert low quality plant proteins into high quality animal proteins, which can then be used by man. The general scheme of green plant carbohydrate conversion into fungal protein, which in turn, can be converted to animal protein, has been reported by Gray et al (1964), Gray (1965), Gray and Abou-El-Seoud (1966), Sekeri-Pataryas et al (1973). Many microorganisms have been used for this purpose on a wide variety of inexpensive substrate, mainly of agricultural origin.

Carob pod with high sugar contents is a proper raw material for microbial protein production. Several workers (Sekeri-Pataryas et al. 1973; Imrie and Vlitos 1975; Drouliscos et al. 1976; Kokke 1977; Marakis 1980, 1985; Marakis and Karagouni 1985) have tried to produce microbial biomass, applying shaker/submerged culture of the aqueous carob extract. The carob tannins (toxic to microbial cell) are the main problem. Thus, extensive microbial screening to isolate microorganisms with high tanninolytic ability were carried out by Tate and Lyle Co. (Imrie and Vlitos 1975); Marakis (1980, 1985; Marakis and Karagouni (1985) and Marakis and Diamantoglou (1990b). Two fungal strains (*A. carbonarius* and *P. glabrum*), with high tanninolytic ability, were isolated and used either in individual or mixed cultures (Marakis 1980, 1985; Marakis and Diamantoglou 1990a). These fungi were cultivated in carob media, such as liquids (aqueous carob extract), slurries [carob powder slurries [carob powder or spent carob (extracted carob pod) powder suspended in water] or solids (carob powder or spent carob powder). The fermented products (mycelial biomass produced by liquid cultures, fermented residues produced by slurry or solid state cultures) were rich in fungal protein of good qualtily (balanced amino acid profile). Nucleic acid, ash, B-group vitamins and lipid contents were acceptable for animal feeding (Forage 1978). As Marakis (1985) reported, the nutritional quality of the *A. carbonarius* mycelium was comparable to those of soybean meal and other protein sources of microbial or agricultural origin. On the other hand, the nutritional indices of the slurry or solid state fermentation products were slightly lower than those of soybean meal, but higher than those reported by Drouliscos et al (1976). This could be due to a certain carob lignocellulose content of the slurry or solid state fermented products, because, as Melefaki-Perela (1981) has reported, there is a negative correlation between digestibility and lignocellulose.

Taking into account the process of the carob component conversion to single cell protein, a question may be asked i.e., out of one or two step

carob fermentation, which protein production system is advantageous ? In reply to the above question and in order to establish an econometric model for the upgrading of carob value, the growth of the microorganisms with good characteristics for protein production, should be separately studied in aqueous carob extract and spent carob (Marakis and Diamantoglou 1990a). It is supposed that microorganisms must use the carob components (carbohydrates, lignin, tannins, etc) differently, when they are all together [carob powder media (one-step)], but not, when they are grown separately [aqueous extract - spent carob (two-step system)]. This happens, because the presence of one component in the substrate influences the utilization of the other (e.g., glucose effect phenomenon). Marakis (1980) found higher total protein production (mg/flask) in two-step system, than that in one-step system fermentation, while the protein productivity (g/l medium/h) was 20% higher in one-step, compared to that in two-step system. Thus, the choice of the type of fermentation system will depend on the examined parameter.

In Cyprus, for the upgrading of the carob pod nutritional value, trials to develop a legume silage with carobs were undertaken (Esbenshade and Wilson 1986). Carob extract was added at a rate 1.5% by weight to *Trifolium alexandrium* (Egyptian clover) and *Vicia sativa* (vetch), in addition to various mixtures with barley. The resulting percentages of crude protein in dry matter were not particularly high (10.2-17%). Since, the cost of such ensilage would be relatively high, adoption of this carob upgrading technique would be limited.

Although fungal protein production from aqueous carob extract and enrichment of kibbled carob or spent carob have been studied, the protein production at industrial scale has not been succeeded yet, because of the lack of nutritional trials on poultry and ruminants. Thorough nutritional evaluation of fermented carob products is required, in order to determine any possible toxicity of these products.

Other uses of carob extract : Aqueous carob extract produced by autoclaving (Marakis and Karagouni 1985) has a deep brown colour, because of the high tannin contents. This carob liquor could be used for commercial production of high commercial value products like pullulan. As Catley (1971) reported, sucrose and glucose appeared to be among the best carbon sources for pullulan production. Thereafter, Marakis et al (1994) studied the pullulan production by cultivation of *Aureobasidium pullulans* in aqueous carob extract media. They found that the overall volumetric productivity, the specific pullulan synthesis rate and pullulan yield were higher in aqueous carob extract media, containing 5% (v/v) vinasse (56% (w/v) of organic substances), than media containing only carob extract as sole carbon source.

Locust bean gum : This is the common name applied to the gum found in the endosperm of carob seeds. From a botanical point of view, LBG is the reserve material, which is used up, when the seed starts to germinate. In the manufacture of LBG, it is obvious that the necessary steps are a) removal of the hard seed coat (hull), b) separation of the endosperm (gum) from embryo and c) grinding of the tough endosperm splits to a fine flour. The first step is the most difficult one and is achieved by various processes [chemical (acid treatment), physical (heat), mechanical means]. The endosperm halves separate readily to reveal embryo, which is cracked and separated by sifting. To produce 1 kg LBG, about 3 kg seeds are needed.

Endosperm is manufactured at various degrees of purity, depending on its application. Basically, there are three grades of gum products e.g., high grade, food-grade and technical or pet food-grade. The first two grade gums are used, where clarity of solution and a very high viscosity are required. Technical grade gum is used, where the presence of some germ and hull residues (speks) of the seed coat or embryo is acceptable. Some manufacturers can produce LBG of several levels of purity, depending upon market needs. More than half the gum in the Mediterranean region is technical or food-grade, while the bulk of food-grade gum is used for food processing in the United States (Esbenshade and Wilson 1986). For applications as a food additive, high-grade or food-grade gums are permitted for which the FAO/WHO has set specifications, to limit the amounts of impurities allowed (Noukon 1987).

The most valuable property, which makes LBG an interesting industrial gum is its behaviour towards water (Noukon 1987). As most carbohydrate polymers, it has a high water affinity, swells up and goes in solution upon heating, thereby forming very viscous solutions even in dilute solutions. Therefore, the viscosity of LBG aqueous solutions is one of the most important properties, because it is a measure of its effect as a thickening agent. As LBG is a neutral polysaccharide, its viscosity

is marginally affected by salts (e.g. NaCl) and slight pH changes.

Another very important property of LBG, which makes it superior to some other galactomannans, is its strong interaction with certain other polysaccharides, notably carrageenans, agar and xanthan gum. Detailed studies on interaction of LBG with carrageenan, in their mixtures, have been carried out by Fernandes et al (1991a, b; 1992), Lopes da Silva and Goncalves (1990) and Lopes da Silva et al (1992, 1993). The gel strength and elasticity of the above mentioned gums are greatly increased by the addition of LBG. The non-gelling xanthan gum can be induced to form thermoreversible gels in high dilutions, if mixed with LBG. This synergism is very important for many gelling systems to impart the desired texture to food and other products.

The excellent properties of LBG makes it a interesting gum for use in many industries ranging from textiles and papers to paints for incorporation in explosives, flotation, flocculation, oil well drilling additives, cosmetic and pharmaceutical preparations and human food products (syrups, gravies, marmalades, fruit jellies, puddings, sour cream, yoghurt, buttermilk, etc). A very important and probably the oldest use is as a stabilizer in ice creams to give a stable, smooth and creamy mouthfeel. Mixtures of LBG with carrageenans are used extensively in canned pet foods to give a desired body and texture to the meat gravy. LBG is a good sizing agent for cotton and staple fibre yarns, while its use in the desizing operation needs only hot water, without any treatment with enzymes. It is an excellent print paste thickener for roller and screen printing, being superior to arabic, starch and tragacanth gums. This gum can also be used for leather tanning (Winer 1980).

Due to relatively high price of LBG, applications of the special properties of this gum are confined to essential or to high priced products. So, the most important LBG applications are as a thickening, binding, gelling and stabilizing reagent in a great variety of food products and canned pet foods. Another main application of LBG is as a wet-end additive for wood pulp treatment.

Environment potentiality of carob tree (environmental uses) : Carob tree grows mostly on marginal land in Mediterranean area and other parts with similar climatic conditions. This tree, being a sclerophyllous plant, can survive drought. In the host and dry parts of the Mediterranean, the carob tree is frequently the dominant species of a climax system on thin and rocky soils, which are sparsely covered by perennial shrubs (Winer 1980). Whenever such land is used as pastoral range land or rainfed farmland, it becomes vulnerable to degradation and loss of productivity. Mediterranean has become a fragile ecosystem and the seasonality of rain greatly contributes to this. It has been estimated that there is 1.32 million km^2 area, which is undergoing desertification in this region (Winer 1980). Groundwater reserves are deteriorating, water tables falling and water quality declining. The overriding cause of this fragility has been said to be the man. This unacceptable environment degradation should be confronted by carob tree orchards, because this plant can increase soil moisture levels, help prevent run-off and erosion and at the same time, it produces fruit (rich in water-soluble sugars), timber, fodder and shade. In areas with high frequency of drought, the long-term wisdom of establishing fodder reserves, which are not dependent on seasonal rainfall for their productivity, the carob tree, which needs light, but no irrigation, is the best plant. In Mediterranean, carob fodder reserves have been traditionally planted as orchards on steep or otherwise unproductive soils. Esbenshade and Wilson (1986) stressed that similar plantings in Australia could well be established on public lands, e.g., shire roadside verges, which are too degraded to be otherwise useful, or to serve as protective greenbelts on the margins of cultivated and pastoral properties, where yields of good products are too frequently jeopardized by wind erosion. Furthermore, carobs in urban and rural parts provide deep shade and handsome evergreen definition to grassy areas, lakes and water sources.

Reports on carob tree suggest that the carob leathery green leaves could assist well by slowing grass fires, so that the fire could be fought more effectively. In Valencia province (Spain), carob tree zones surround rural villages, which are susceptible to fire. Associated with these, carob trees are dense stands of *Cistus* spp. (commonly known as rock-rose). This plant retards fire and it is also an excellent source of nectar for honeybees.

Aqueous carob extract has been proved to be an excellent over-wintering supply for colonies of bees, where nectar supplies are reduced by cool winter temperatures and rainfall (Esbenshade and Wilson 1986). Therefore, apiarists should be of help to the bees during difficult periods, feeding them

with carob honey.

In conclusion, farmers and grazers have a fine opportunity to benefit from soil conservation, drought fodder production and possible off-farm sales by planting carob trees, either as field windbreaks, as greenbelts (protective orchards) on the margins of cultivated and grazing properties, or as scattered shade trees within paddocks, whereby the nature pods fall to the ground and are directly consumed by livestock.

Future potentials of the carob

Although several studies have been carried out on the improvement of the nutritional value of carob pods and the expansion of its uses, the commercial prices of this agricultural product remain very low. Subsequently, world carob production declined from 600,000 tonnes in the early 1950s to 315,000 in the present (Orphanos and Papaconstantinou 1969; Marti 1984; Tous et al. 1996). The basic reasons of this unhappy situation could be the following :

1. The traditional uses of the carob husk (human food, animal feed) and carob seed (LBG extraction) are continued until now.

2. No study on new carob products (e.g., fungal protein) has been initiated fully on commercial scale, so far. So, the industry has not been convinced to invest in the production of a new carob product yet.

3. LBG has been the most valuable carob product. However, the use of alternative plant gums (guar, tragacanth, etc) or synthetially produced substitutes has reduced interest in the carob fruit. This, in combination with the development of other sectors of the economy, notably industry and tourism, in the Mediterranean countries, has geopardized the carob industry. This situation led carob growers to neglect or even abandon carob trees (no harvest of carob beans, inadequate carob tree cultivation, etc).

4. In the last 20 years, carob been prices increased gradually for the husk material, but erratically and aberrantly for the seed, mainly in response to short supply. For example, in 1985, the seed sold was two-and-half-times more than in the previous year and four-times more than in the following year ; then, remained steady over the period 1990-93, but only to be tripled in price in 1994-1995 (Orphanos 1996). However, if inflation is taken into account, prices for carob husk remained virtually constant over the last 20 years, whereas prices for the seed increased overall, but with significant fluctuation and aberrant peaks in 1985, 1994-1995 (Orphanos 1996). This behaviour of the market is not conducive to maintain a healthy carob industry. One of the reasons is that the LBG users replaced this excellent quality gum by other gums.

In spite of the above mentioned unacceptable carob situations, there is no doubt that the carob should continue to be in place as an integral component of the Mediterranean environment. Indeed, the carob tree has a great potential for restoring the vegetation of degraded dry areas and for improving of the productivity of lands, which would be marginal for other crops. Carob crop, which has received little attention during the last many years, is currently being emphasized as an alternative in dry land areas with Mediterranean climates for diversification and revitalization of coastal agriculture. Of course, in order to continue carob bean to be harvested as a crop, certain things on present carob practice should be improved or even to be changed. In this context, the following suggestions may be considered :

1. Any effort at the steady carob production year to year will have to be considered on competitive basis relative to other crops. For example, if the carob trees are going to be irrigated, the carob bean production will have to be as profitable as, for example, citrus. As it has been previously mentioned, carob production is higher, when the trees are irrigated, than trees which are not irrigated. In view of the fact that rainfall in previous years appears to determine to a considerable extent the following years yield, the timing of this effect needs to be established so that irrigation may be timed accordingly.

2. Financing of the agronomic studies will help improve carob cultivation practices.

3. Increasing the basic knowledge about the carob tree will have a beneficial effect.

4. Encouraging research on carob propagation will help to diminish the juvenile period of the carob tree by proper grafting techniques, such as shield-budding or patch-budding.

5. Characterisation of carob varieties in all carob producing countries, will facilitate the selection of future plants according to market needs.

6. In establishing carob orchards, the main agronomic factors, which should be considered in choosing a carob variety, are a) the size of tree,

as medium or small sized trees with erect habit growth are desirable in order to maximize production and facilitate harvesting, b) the form and size of pods as the large and straight fruits are collected more easily than curved or twisted ones, c) the uniform ripening and low resistance to fruit abcission, as the fruits fall themselves after their ripening, d) the resistance to diseases (*Oidium*, etc), e) the high and regular carob yield and f) the seed participation in the bean weight.

If the target is the extraction of water-soluble sugars of LBG production, the proper variety should be chosen in each case. The Greek carob varieties 'g-3' and 'H-4', with a high (up to 60%) water-soluble sugar content and low (>10%) seed participation (Marakis et al. 1987; Marakis 1992; Marakis et al. 1996 a, b) are considered as proper varieties for sugar extraction. On the other hand, the Greek varieties 'u-1' and 'A-1', with a high (30-37%) seed participation (Marakis et al. 1987; Gaities et al. 1994) should be used for LBG extraction. The current trend is to grow good dual purpose cultivars (pulp and kernel). A high and constant carob seed production may contribute to a stabilization of the LBG price.

At present, commercial interests in the carob beans, include medium husk content, medium-high seed participation, good content and quality of LBG. Orphanos and Papaconstantinou (1969) have reported a Cyprus carob variety 'Koundourka', which combined medium tree size, high seed content (15%) and shelf-shedding of the ripe pods. Tous et al (1996) suggested several Spanish varieties ('Mulata', 'Tylliria', 'Matalafera', etc) of commercial interest.

7. Hand harvesting is the most costly, labour-intensive and time consuming practice of traditional carob cultivation. Estimates of harvesting cost have varied from 17% of total production expenses to a level almost as high as the market price for the fruit, where labour has been employed (Esbenshade and Wilson 1986). In the years of low carob production, the cost of carob collection is high and carob been havesting is not profitable. Therefore, more modern harvesting systems could be adapted, using specially modified mechanical sweepers and pick-up machines similar to those now used to harvest almonds and walnuts. Self-propelled shaking and catching frames, as used to collect some deciduous fruits, would be feasible for ripe carob beans. In that way, a reduction of the carob production cost should be expected.

8. For carob beans to continue to be harvested as a crop, higher price needs to be offered for this fruit. This can be achieved through identification of alternative and valuable uses not only of the gum, but also of the husk material. For example, sugar utilization for pullulan and fructose production or other product with high commercial price will be necessary, For this purpose, an international coordination of research efforts is needed a) to encourage, by funding research on carob uses. This should be directed to basic and applied research projects, b) funding of work on carob products with innovative or integral ways of carob utiliation and c) a strategic and tactical planning the LBG market demand and the equilibrium pod price should investigated.

In conclusion, an econometric, computerised model, which would define the cost of carob component valorisation could be designed. The model should be constructed on the basis of all the possible alternatives for the complete utilisation of the carob beans with procedures friendly to environment.

To this end, the appropriate incentives should be given by Governments, mainly of the carob producing countries.

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Moisture Diffusion During Hydration of Maize

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Moisture diffusion during water soaking of 'Hi-Starch' maize kernels, at three initial moisture contents and the temperatures ranging from 25-70°C, was studied. The soaking data were fitted in Becker's model to determine the moisture diffusivity. Moisture gain was found to follow Becker's model at low values of soaking period in the temperature range studied. The moisture diffusivity was found to be independent of initial moisture content at 25°C. It varied from 0.1585 x 10^{-6} to 1.7455 x 10^{-6} m^2/h in the entire range of soaking temperatures. The relationship between moisture diffusivity and reciprocal of absolute temperature followed the Arrhenius equation as $D=15.2745\ e^{-(5505.41/T)}$.

Keywords : Moisture diffusion, Maize soaking, Moisture gain, Energy of activation, Arrhenius equation, Soaking temperature.

Maize, one of the important cereal crops in the world agricultural economy, is consumed directly as sweet corn, pop corn, alkali-cooked maize and other food items, made after traditional stone grinding of the maize as well as for live-stock feeding. The value-added processing of maize by wet and dry milling includes fractionation process by separating its products. Conditioning of maize by addition of moisture and tempering is an important unit operation, prior to milling. Moisture diffuses into the grain during moisture addition, because of concentration gradient. Apart from this, diffusion can also caused by activity gradient, as in reverse osmosis, pressure gradient or temperature gradient.

Extensive research work has been done on drying of different grains, with the primary focus on modelling diffusion of moisture. Syarief et al (1987) reported different diffusivity coefficient data for corn kernel components, during drying. They reported the largest diffusion coefficient of germ, followed by floury, horny endosperm and pericarp. Diffusion of moisture is generally enhanced by the temperature of the fluid medium and it has an exponential relationship with the inverse of the fluid temperature (Steffe and Singh 1980; Muthukumarappan and Gunasekaran 1990; Walton et al. 1988). Muthukumarappan and Gunasekaran (1990) reported decrease in vapour diffusivity with relative humidity. Lu et al (1984) conducted soaking tests on 'Newbonnet long-grain' rough rice and found that Becker's model fits best for the experimental data, among the four rewetting models tested. Ali (1974) also reported soaking behaviour of three varieties ('IR-8', 'Patni-23' and 'Sitsal') of paddy and found that the Becker's model fits best. Fan et al (1963) reported the diffusion rates of water in three varieties of corn and two varieties of sorghum in the temperature range of 0 to 100°C. Hsu (1983) reported the influence of temperature on the concentration-dependence diffusivity of water into soybean and found applicability of Arrhenius relation between water diffusivity and temperature. However, only limited information is available for maize on diffusion of moisture during direct imbibition.

In the present paper, attempts have made to generate hydration data for maize at different temperatures and determine the energy of activation as well as the diffusivity of moisture in the maize, using the model developed by Becker (1960).

Materials and Methods

Maize of 'Hi-Starch' variety was obtained from the Experimental farm of the department of Agricultural and Food Engineering. Indian Institute of Technology, Kharagpur, with 32% db moisture content. The 10 kg maize sample was sealed in ziploc (self sealing) type polyethylene bags and stored in a chamber maintained at 3°C. Prior to experimentation, the samples were taken out from the storage chamber and the sealed bags were equilibrated to room temperature for 24 h. On opening the bags, maize grain moisture was found to be 31.3% db. Soaking tests were conducted at four levels of initial moisture contents, viz., 10.3. 20.3 and 31.3% db at 25°C, in addition to 11% db at 30, 40, 50, 60 and 70°C. The samples with lower than 31.3% db were obtained by shade-drying at room temperature (approximately 30°C). Only sound kernels were used for the experiments. Soaking was done for 14 levels of soaking periods, viz. 0.33, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 10, 14, 18

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and 20 h by keeping 15 g sample in 50 ml test tubes, with grain to distilled water ratio of 1:2. Initial moisture content of maize was determined by oven drying of the whole kernels in duplicate at 103°C for 72 h (AACC 1969) and expressed as percentage on dry basis. The moisture gain was calculated from the gain in weight of the sample (Becker 1960). Each sample was weighed to an accuracy of 0.001 g, using electronic digital balance. The test tubes containing distilled water at desired temperature, t_w, was taken, maize sample added to it and then the test tubes were submerged in the constant temperature water bath at $t_s \pm 0.5$°C for soaking experiments. The value of t_w was calculated by the heat balance, as follows:

$$t_w = t_s + \frac{M_m\ S_m\ (t_s - t_m)}{M_w\ S_w} \quad \text{..... (1)}$$

Where,

t_m = initial temperature of maize, °C
M_m = mass of maize, g
M_w = mass of water, g
S_m = specific heat of maize, 0.42 cal/g°C
S_m = specific heat of water, cal/g°C

During soaking experiments, the samples were removed at specific intervals (ranging from 0.33 to 24 h) and the soaked grains were quickly blotted with the paper towels (4–5 times) to remove surface moisture (Becker 1960; Fan et al. 1963; Lu et al. 1994) and weighed.

In order to determine s/v ratio, surface area (s) was calculated, using the geometric mean diam (D_p) and sphericity (ø) of the kernel (McCabe et al. 1993) as

$$s = \pi\ D_p^2 \phi \quad \text{..... (2)}$$

The D_p and ø of the maize kernels were determined (Mohsenin 1970) as :

$$D_p = (\text{length x width x thickness})^{1/3} \quad \text{.....(3)}$$

$$\phi = D_p / \text{length} \quad \text{.....(4)}$$

The three linear dimensions were measured with a vernier caliper (least count 0.02 mm). D_p and ø were averaged from 50 maize kernels. The volume (v) of each kernel was calculated from the measurement of the volume of the 50 kernels measured, with an air comparison pycnometer (Beckman, model 930) and replicated thrice.

Mathematical model : Moisture diffusion into the grains is primarily caused by concentration gradient. This gradient tends to move the water molecules to equalize concentration. The moisture diffusion is defined by Fick's law as :

$$\frac{\delta c}{\delta t} = D\left[\frac{\delta^2 c}{\delta x^2} + \frac{\delta^2 c}{\delta y^2} + \frac{\delta^2 c}{\delta z^2}\right] \quad \text{.....(5)}$$

where D is the moisture diffusivity, c is the concentration of diffusion substance at a point in solid, x, y and z are Cartesian coordinates of the point under consideration and t is the diffusion time. Equation (5) can be integrated approximately for a particle of arbitrary shape (Becker 1959) for small values of X as:

$$\frac{c_s - c}{c_s - c_o} = 1 - \frac{2}{\sqrt{\pi}} X - \quad \text{....(6)}$$

Where c is the average concentration, c_s is the concentration at the bounding surface, c_o is the initial concentration, and $X = s/v\sqrt{(Dt)}$, in which s is surface area and v is volume.

If the concentration term is represented by the moisture content, then :

$$MR = (m_s - m)/(m_s - m_o) \quad \text{....(7)}$$

where MR is moisture ratio. m, m_o, and m_s are average moisture content at any given soaking duration, initial moisture content and moisture content at the bounding surface, respectively.

Equation (6) can be rewritten as follows :

$$1 - MR = (2/\sqrt{\pi})\ X \quad \text{....(8)}$$

Combining equation (7) and equation (8), we get in terms of experimental variables :

$$m = m_o + \alpha\sqrt{t} \quad \text{.....(9)}$$

where

$$\alpha = (2/\sqrt{\pi})\ (m_s - m_o)\ (s/v)\ \sqrt{D} \quad \text{.....(10)}$$

$$\text{or } D = (\alpha\sqrt{\pi}/\ (2\ (m_s - m_o)\ (s/v)^2 \quad \text{.....(11)}$$

Becker (1960) and Fan et al (1963) provided a method for calculating the m_s value from absorption data and the same procedure is used for analysis. As the quantities s/v, $\sqrt{D}t$, m_s and m_o are all constant in Equation (10), Equation (9), therefore, can be written as :

$$m - m_o = \alpha'\ (m_s - m_o) \quad \text{....(12)}$$

where

$$\alpha' = 2/\sqrt{\pi}\ (s/v)\ \sqrt{(Dt)}$$

Equation (12) shows that, in case the diffusion time, t, is kept constant, the quantity $(m-m_o)$ should be a linear function of m_o with a slope of α'. On extending the line to x-axis, i.e., when $m-m_o$ equals zero, the intercept can be termed as m_s (Becker 1960; Fan et al. 1963).

Results and Discussion

The experimental data on the soaking of water

are plotted at different soaking temperatures (Fig.1). The increase in moisture content is found to be linear with square root of soaking period upto 4.5 h, when the soaking temperature is 25°C. Thereafter, the hydration curve deviated from the linearity. However, the linear relationship did exist at higher temperatures as well, but for a shorter period. As the linear relationship existed for lower soaking periods, equation (9) is valid and the data, therefore, have been analyzed for linear portion only. The deviation from the linearity may be attributed to the slow absorption of water by maize grains at higher soaking periods and approaching of the system towards gelatinization at higher temperatures (Ali 1974).

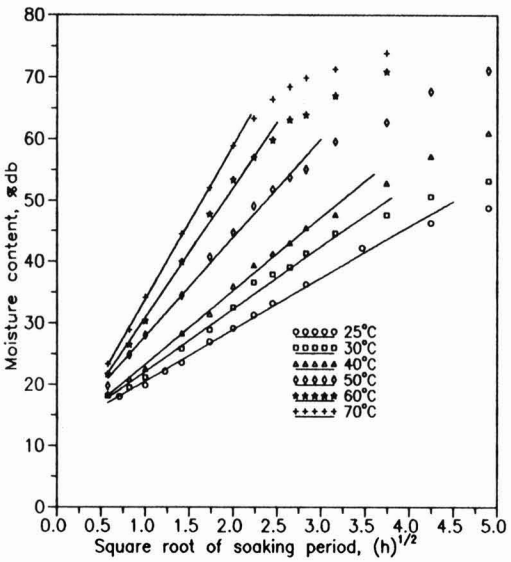

Fig. 1. Change in moisture content of 'Ili-starch' maize with absorption time of 11% db initial moisture

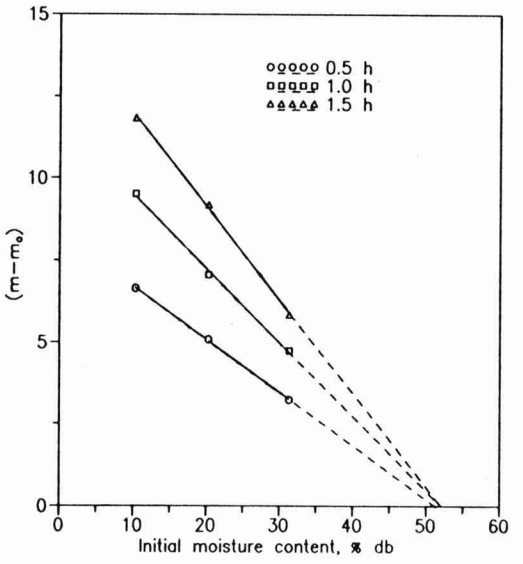

Fig. 2. The moisture gain in an absorption time of 0.5, 1.0, 1.5 h as a function of initial moisture content at 25 °C, showing regression on an effective surface moisture content of 52% db

The value of m_s is evaluated by the experimental data for soaking period of 0.5 h, which on extending to x-axis meets at 52% (Fig. 2). Two other curves for soaking periods of 1.0 and 1.5 h are also plotted, which, on extending, meet at the same point, i.e., 52%. Fan et al (1963) also reported the value of m_s for corn to be between 51.5% and 54.5% at temperatures 38 and 71°C, respectively, averaging to 53%.

The diffusion model described here was used for determining the moisture diffusivity, by plotting the moisture gain (1-MR) with square root of soaking period at three levels of initial moisture contents, viz, 10.3, 20.3 and 31.3% db at 25°C (Fig. 3). Since s, v and D in equation (11) are constant, (1-MR) has a direct relationship with $\sqrt{t}$. It is also inferred that slope of equation (13) is independent of initial moisture content at 25°C, as the moisture gain by the samples of the three levels of moisture content cluster around the same straight line for 6 h soaking duration with the following expression:

$$1 - MR = 0.01304 + 0.217255\sqrt{t} \quad ....(13)$$

$$(r^2 = 0.99)$$

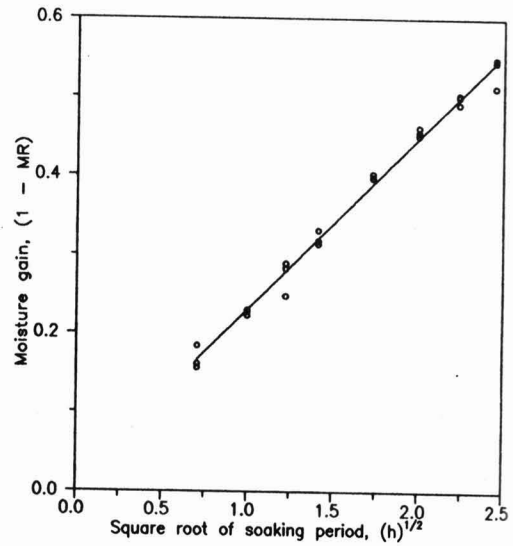

Fig. 3. Relation between mosture gain and soaking period, upto 6 h at initial moisture contents of 10.3, 20.3 and 31.3% db at 25°C

TABLE 1. MOISTURE DIFFUSIVITY OF MAIZE AT DIFFERENT SOAKING TEMPERATURES FOR M_o=11% db

Soaking temperature, °C	α	Moisture diffusivity, D x 10^6, m^2/h	Coefficient of determination, r^2	Valid for soaking period, h
25*	0.217255	0.159	0.99	20
30	0.24882	0.208	0.99	14
40	0.28884	0.280	0.99	13
50	0.42331	0.602	1.00	9
60	0.5518	1.023	1.00	6
70	0.7208	1.746	1.00	4

* Intial moisture content : 10.3% db

The moisture diffusivity is calculated using the slope of the line from the equation (13) in equation (11) at 25°C as:

$\sqrt{D}$ = 0.217255 $\sqrt{\pi}$/)2 ·4.835) 10^{-2}

or D = 1.5857 x 10^{-7} m^2/h

The effect of temperature on the moisture diffusivity is determined by plotting the moisture gain (1-MR) for maize (M_o=11% db) with square root of soaking period at 25, 30, 40, 50, 60 and 70°C (Fig. 4). It is observed that, in the soaking temperature range studied also, the moisture gain follows a linear relation for low values of soaking period. The α values are found to be increased with soaking temperatures. Table 1 summarizes the values of α, moisture diffusivity, coefficient of determination and valid soaking period for the model at the corresponding soaking temperatures.

The values of D, the moisture diffusivity, were plotted against the reciprocal of absolute temperature in Fig. 5 and the linear regression with least square method was found to be Arrhenius-type

$$D = 15.2745\ e^{-5505.41/T} \quad ....(14)$$

(r^2 = 0.99)

The energy of activation, thus evaluated from the Arrhenius relation, is 10.94 kcal/mole.

The moisture diffusivity in the 'Hi-Starch' maize varied from 0.159 x 10^{-6} to 1.746 x 10^{-6} m^2/h in the temperature range of 25 to 70°C. The moisture diffusivity of maize during water soaking is not well documented in the literature, though the vapour diffusivity in 'K6400' and 'Dekalb 547' varieties of corn was reported (Muthukumarappan and Gunasekaran 1990) to be 0.803 x 10^{-7} to 4.318 x 10^{-7} m^2/h and 0.819 x 10^{-7} to 4.087 x 10^{-7} in the temperature range of 25 to 40°C and relative humidity range of 75 to 95% during adsorption, respectively. Considering the different kernel geometry, viz., infinite slab, infinite cylinder and sphere, the energy of activation, evaluated from the relation reported, vary from 8.01 to 9.937 and 7.57 to 10.86 kcal/mole for 'K6400' and 'Dekalb' variety of maize, respectively in the relative humidity range of 75 to 95%. Fan et al (1963) also reported that the energy values of activation were 6.853, 7.578 and 8.167 kcal/more for 'K-4 hybrid popcorn', 'K-1859 hybrid corn' and 'Gold Rash sweet corn' during water soaking, respectively. There is a

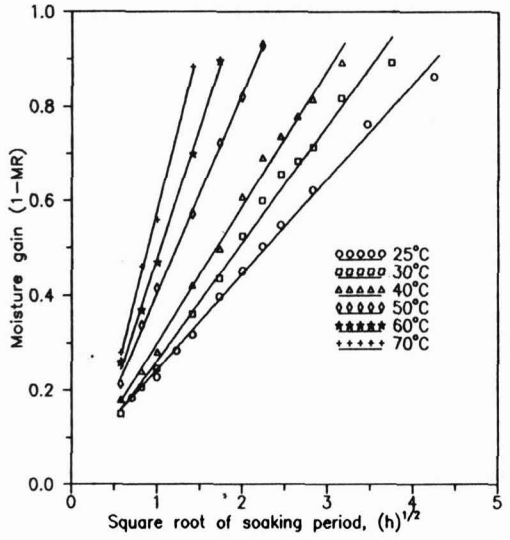

Fig. 4. Relation between moisture gain and absorption time of 'Hi-starch' maize at six levels of soaking temperatures for M_o=11% db

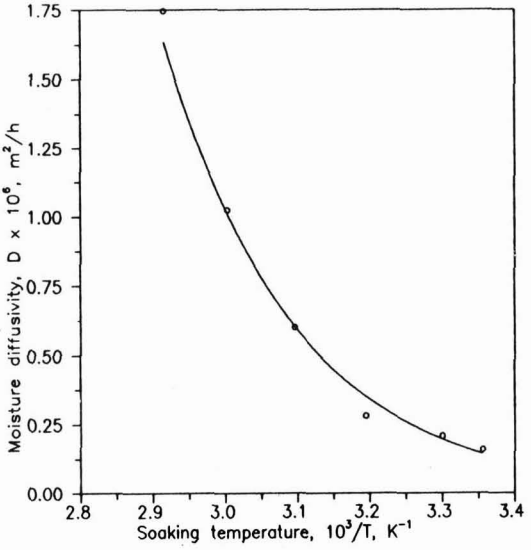

Fig. 5. The moisture diffusivity as a function of the reciprocal of the absolute temperatures for M_o=11% db

marginal difference in the moisture diffusivity in maize as well as the energy of activation and this may be attributed to the varietal differences. The moisture diffusivity, D, in the maize during soaking, when plotted with reciprocal of absolute temperature, was found to follow Arrhenius equation.

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Hypocholesterolemic Activity of Saponin on Cholesterol Added *Bengal*gram *(Cicer arietinum)* Diet in Rats

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Inclusion of purified alfalfa saponin in *Bengal*gram diet showed no interference with food intake and food efficiency ratio during 47 days of feeding experiment. Saponin supplemented diet lowered total plasma cholesterol, the effect being prominent, when cholesterol was absent in the diet. In addition, saponin appeared to be a potent antiatherogenic agent, when supplemented to cholesterol-free and cholesterol containing *Bengalgram* diets, but saponin supplementation did not exert any significant effect on total liver lipids. The hypocholesterolemic and antiatherogenic effect of saponin could be directly correlated with their ability to decrease intestinal cholesterol absorption and the increase the faecal excretion of bile acids.

Keywords : *Bengal*gram, Saponin, Hypercholesterolemia, Atherogenisity, Cholesterol absorption, Cholic acid excretion

High level of plasma cholesterol is a causative factor of atherosclerosis (Mathur et al. 1961). Recent studies have shown that atherosclerosis risk is not only attributed to the total serum cholesterol, but also to its distribution among lipoproteins (Bergeron and Jacques 1989). The low density lipoproteins (LDL) are the major carriers of cholesterol towards tissues having atherogenic potential, while the high density lipoproteins (HDL) carry cholesterol from peripheral tissues to the liver (Bergeron and Jacques 1989; Mokady and Liener 1982). HDLs, thus, give protection against atherosclerosis (Bergeron and Jacques 1989; Brinton et al. 1990).

Among the various methods available to reduce the plasma cholesterol, the most suitable would be the one involving a change in dietary regimens. *Bengal*gram (*Cicer arietinum*), which forms an important part of Indian diets, has been reported to be more hypocholesterolemic than other pulses (Mathur et al. 1968; Sharma 1987). However, Saraswathi Devi and Kurup (1972) did not observe such effects in rats. Similarly, divergent reports are available on the hypocholesterolemic action of *Bengal*gram. Mathur et al (1968) and Leelamma et al (1978) have shown that this effect is due to its protein, while Soni et al (1982) reported it to be due to its carbohydrates.

Another dietary factor, which has been reported to have antiatherogenic influence on animals as well as on humans, is saponin (Shutler et al. 1987; Southon et al. 1988). It has been strongly suggested that consumption of foods, rich in saponin or with supplement of purified saponin component, could be beneficial in terms of reducing hypercholesterolemia. In the present study, the hypocholesterolemic action of purified alfalfa saponin has been studied, by taking whole *Bengal*gram as a protein source.

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Materials and Methods

Alfalfa saponin from LOBA Chemicals, cholesterol from SRL Bombay, 4-^{14}C cholesterol (specific activity: 50.6 mci/mmole) from Amersham International, England) and commercial kit for cholesterol estimation from CSIR Center For Biochemicals. New Delhi, were obtained.

Experimental design and diets : Growing albino rats, 'Wistar' strain (purchased from All India Institute of Medical Sciences, New Delhi), initially weighing 50-60 g, were used in the feeding studies. A total of 24 rats were distributed randomly into 4 groups, each containing 6 rats. The mean weight of the rats in each group was 57±0.5 g. They were housed individually in cages in an air conditioned room (22-24°C, with 12 h light cycle). Initially, rats were fed a ground *Bengal*gram diet to adopt them for the test diets. After 2 days, rats were fed *ad libitum* water and any one of the experimental diets (Table 1).

Test diets were prepared according to the formula of Eggum (1973), in such a way that each rat got 10 g dry matter, 150 mg N, 4% mineral mixture, and 1.6% vitamin mixture per day. The total feeding period lasted for 47 days. Faeces were collected on the last 3 days for cholic acid estimation.

For the study of intestinal cholesterol absorption. 4-^{14}C cholesterol-labelled diets were prepared and fed to the rats, as described by Bhattacharya and Eggen (1980). During the radio labelled study

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS

Ingredients, g/kg diet	Diet groups			
	Bengal-gram	*Bengal*-gram + cholesterol	*Bengal*-gram + saponin	*Bengal*-gram + cholesterol + saponin
	(1)	(2)	(3)	(4)
*Bengal*gram	356.69	356.69	356.69	356.69
Mineral mixture, 4%	37.95	37.95	37.95	37.95
Vitamin mixture, 1.6%	15.18	15.18	15.18	15.18
Cholesterol, 0.3%	-	3.00	-	3.00
Saponin, 0.6%	-	-	6.00	6.00
N-free diet	590.18	587.18	584.18	581.18

Protein content in the diets was maintained at 10% on dry weight basis, by using the N-free diet. Groundnut oil was added to keep the fat content of the diet at 10%. Fatty acid distribution of groundnut oil was C 16:0: 11%, C 18:0 : 3%, C 18:1: 40%, C 18:2 : 40%, C 20:0 : 1% and C 22:0: 4%.

period, rats were housed individually in metabolic cages. Urine and faeces were collected separately during the entire study period. For further analysis, faeces were stored in a cool, dry place, after oven drying at 60°C. Food intake was recorded daily and body weight gain weekly. At the end of the experiment, rats were starved for 24 h and sacrificed on the next day. Organs such as liver, heart, kidney and spleen were collected, weighed and stored at -70°C. Blood (4-6 ml) was collected by cardiac puncture. Total serum cholesterol, HDL cholesterol and (LDL+VLDL) cholesterol were analyzed by precipitation method (Lopes et al. 1977; Jung et al. 1978). The total lipids from liver were isolated, as described by Folch et al (1957) and the total cholesterol in liver lipid was estimated by the method of Kabara (1962). Cholic acid in the faeces was estimated by the colorimetric method of Boyd et al (1966). Intestinal cholesterol absorption was determined, as described by Borgstorm (1969).

Statistical analysis : Values are reported as means ± SEM. Data were analyzed by one way analysis of variance (ANOVA). When ANOVA indicated significant difference ($p<0.05$), the mean values of the treatment were compared by Fisher's least significant difference method at $p<0.05$.

Results and Discussion

Food intake, body weight gain and FER were not influenced by any of the test diets (Table 2). As reported earlier by Cheeke (1971), the growth depressing activity of saponin was not detected in the present study. This might be due to 5 times lower level of saponin used in the present study

TABLE 2. EFFECTS OF SAPONIN SUPPLEMENTED *BENGAL*-GRAM DIET ON FOOD INTAKE, WEIGHT GAIN AND FOOD EFFICIENCY RATIO

Dietary treatment	Food intake in 40 days, g	Weight gain in 40 days, g	FER
*Bengal*gram (n=5)	326.0±15.4	29.5±3.1	0.09±0.01
*Bengal*gram + cholesterol (n=6)	385.7±16.9	49.7±2.6	0.13±0.01
*Bengal*gram + saponin (n=5)	366.6±25.6	40.1±7.8	0.11±0.06
*Bengal*gram + cholesterol + saponin (n=6)	356.7±18.9	36.6±5.3	0.10±0.01
	NS	NS	NS

Values are means ± SEM. Rats, initially weighing 57.5±0.5 g, were fed experimental diets for 47 days. Food intake was recorded daily and weight gain weekly. NS= Non-significant

(0.6%), which may not be enough to cause the growth depression during the study period. The data in the present study support the fact that supplementation of cholesterol and saponin to the basal *Bengal*gram diet is having growth stimulatory effect on rats. As a result of increase in body weight by hypercholesterolemia inducing diet (group 2 diet), the weights of liver, heart, and kidney have also been found to be increased (Table 3). Supplementation of saponin in group 2 diet reduced the heart weight. When group 1 diet was supplemented with saponin, it led to liver enlargement. But, there was no significant effect on lipid content, although there was a significant increase in cholesterol (Table 3).

TABLE 3. EFFECTS OF SAPONIN SUPPLEMENTED *BENGAL*-GRAM DIETS ON DIFFERENT ORGAN WEIGHTS (g/RAT) AND LIVER LIPIDS OF RATS.

Dietary treatment	Weight of organ, g					
	Heart	Kidney	Spleen	Liver	Liver lipid, mg/g	Liver cholesterol, mg/g
*Bengal*gram (n=5)	0.36^{a} ± 0.02	0.68^{a} ± 0.05	0.18 ± 0.03	2.85^{a} ± 0.01	41.14 ± 4.9	4.73 ± 0.3
*Bengal*gram + cholesterol (n=6)	0.41^{b} ± 0.02	0.83^{b} ± 0.30	0.24 ± 0.05	3.95^{b} ± 0.20	46.07 ± 1.9	5.79 ± 0.6
*Bengal*gram + saponin (n=5)	0.39^{ab} ± 0.02	0.72^{a} ± 0.30	0.19 ± 0.01	4.07^{b} ± 0.30	46.33 ± 4.9	5.60 ± 0.2
*Bengal*gram + cholesterol + saponin (n=6)	0.36^{ac} ± 0.02	0.81^{bc} ± 0.30	0.24 ± 0.04	3.54^{ab} ± 0.30	43.93 ± 4.2	7.05 ± 0.7
			NS		NS	NS

Values are means ± SEM. Values with different superscript letters (a, b, ab, bc) differ significantly from each other ($p \leq 0.05$). n=number of experimental animals in each group. NS= Non-significant.

TABLE 4. EFFECTS OF SAPONIN SUPPLEMENTATION IN *BENGALGRAM* ON TOTAL PLASMA AND LIPOPROTEIN CHOLESTEROL IN RATS

Dietary groups	Total plasma cholesterol, mg/dl	HDL cholesterol, mg/dl	LDL+VLDL cholesterol mg/dl	HDL/Total cholesterol, mg/dl
*Bengal*gram (n=5)	92.2±15.2[a]	26.09±1.58	65.00±11.0[a]	0.283±0.02[a]
*Bengal*gram + cholesterol (n=6)	129.5±6.1[b]	33.20±1.44	94.24±5.79[b]	0.256±0.01[a]
*Bengal*gram + saponin (n=5)	86.4±9.2[a]	31.89±3.43	53.27±6.18[a]	0.369±0.02[b]
*Bengal*gram + cholesterol + saponin (n=6)	89.2±9.0[ac]	26.82±1.35 NS	61.82±9.12[ac]	0.301±0.06[ab]

Values are means ± SEM. Values with different superscript letters (a, b, ab, ac) differ significantly from each other ($p \leq 0.05$), n= number of experimental animals in each group. NS= Non-significant

As given in Table 4, the addition of cholesterol to *Bengal*gram diet made it hypercholesterolemic by raising the total plasma cholesterol to a significant level. This diet also resulted in an increase in the cholesterol distribution in various lipoprotein fractions (HDL and LDL+VLDL) to the same extent. As a result of this, HDL/total cholesterol ratio, which is inversely related to the development of atherosclerosis (Miller and Asheratt 1976), did not alter much. Supplementation of saponin with group 2 diet made it hypocholesterolemic, thereby leading to the neutralization of the hypercholesterolemic effect produced by feeding cholesterol, But, the presence of saponin in group 2 diet appeared to make this diet antiatherogenic, because the lipoprotein cholesterol level of rats fed with the above diet resulted in a significant increase in HDL/cholesterol ratio.

TABLE 5. EFFECTS OF SAPONIN SUPPLEMENTED *BENGALGRAM* DIET ON [4-^{14}C] LABELLED CHOLESTEROL ABSORPTION IN RATS

Dietary groups	Total radio activity intake, cpm/rat (A)	Total radio activity in faeces, cpm/rat (B)	% of labelled cholesterol absorption cpm/rat $\frac{A-B}{A} \times 100$
*Bengal*gram (n=5)	520599 ± 21004	101143 ± 4483	80.5±0.08[a]
*Bengal*gram + cholesterol (n=6)	585587 ± 112143	90797 ± 24618	84.4±1.20[a]
*Bengal*gram + saponin (n=5)	543673 ± 52057	160927 ± 38584	70.4±4.84[b]
*Bengal*gram + cholesterol + saponin (n=6)	512434 ± 134313 NS	61692 ± 16234	88.0±1.77[ac]

Values are means ± SEM. Each group of rats was fed with [4-^{14}C] cholesterol labelled diet for 6 days. Faecal lipids were extracted from the faeces collected during the entire period of study and analyzed for the radio active cholesterol. Values with different superscript letters are (a, b, ac) differ significantly from each other ($p \leq 0.05$). n = number of experimental animals in each group. NS= Non-significant

The hypocholesterolemic and antiatherogenic effect of saponin is assumed to result from a combined effect of either a decrease in the intestinal cholesterol absorption or an increase in the faecal excretion of cholic acid (Oakenfull and Sidhu 1983). In the present investigation, the value of intestinal cholesterol absorption varied from 70–80% (Table 5). The total radioactivity intake by rats, among various dietary groups, did not alter significantly. However, it was found that saponin supplemented basal diet could decrease the cholesterol absorption to a significant level. But, when fed along with hypercholesterolemic diet, the effect of saponin got nullified and the absorption of cholesterol increased.

The mechanism by which saponin prevents the absorption of cholesterol is not clear. However, one simple physico-chemical explanation given by Sidhu and Oakenfull (1986) for this could be valid. It states that a part of the ingested saponin, which had remained within the gastro intestinal tract, might have interacted directly with cholesterol, thereby resulting in an insoluble complex, which prevents its absorption. When excess cholesterol is already present in diet, as in the case of diet 4, a considerable part of the complex forming sites of saponin might have got saturated with unlabelled cholesterol, thereby increasing the absorption of labelled cholesterol.

As with cholesterol, saponin might have formed an insoluble complex with bile acids, which can lead to an increased excretion of bile salts, through faeces. This is an indirect route for the elimination of cholesterol (Oakenfull and Sidhu 1983). When rats were fed with diets containing cholesterol, bile acid excretion was found to decrease (Table 6). This might be due to the fact that, since both cholesterol and bile acids are similar in structure, cholesterol in the diet might be competing with cholic acid for complex formation with saponin and occupy a considerable part of the binding sites of saponin.

TABLE 6. EFFECTS OF SAPONIN SUPPLEMENTED *BENGALGRAM* DIET ON FAECAL CHOLIC ACID EXCRETION IN RATS

Dietary groups	Cholic acid, mg/g dry faeces	Excretion of faeces, g/day
*Bengal*gram (n=5)	2.56±0.16[a]	1.63±0.2
*Bengal*gram + cholesterol (n=6)	1.59±0.23[b]	2.14±0.3
*Bengal*gram + saponin (n=5)	4.93±0.15[c]	1.79±0.5
*Bengal*gram + cholesterol + saponin (n=6)	3.20±0.37[ad]	1.71±0.3 NS

Values are means ± SEM. The faeces were collected during the entire 47 days of study and faecal cholic acid estimated. Values with different superscript letters are significantly different from each other ($p \leq 0.05$). n = number of experimental animals in each group. NS= Non-significant

Conclusion

Along with whole *Bengal*gram as a protein source, saponin (0.6%) is effective as an hypocholesterolemic agent, only when the diet contains cholesterol. But it shows its antiatherogenisity, both with basal diet and hypercholesterolemia inducing diet. The hypocholesterolemic and antiatherogenic effects of saponin supplemented *Bengal*gram diet appears to be due to a) lowering of intestinal absorption of cholesterol, b) shifting the dynamic equilibrium towards the catabolism of cholesterol to cholic acid and c) altering the distribution of cholesterol among lipoproteins.

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Effect of Graded Levels of Insect Infestation on the Chemical Composition of *Bengal*gram

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Effect of graded levels of *Callosobruchus chinensis* L., infestation on physio-chemical parameters, protein efficiency ratio, feed efficiency ratio, net protein ratio and protein retention efficiency of *Bengal*gram was studied. With increase in the level of infestation, significant increases ($P<0.05$) in all the parameters were observed, except for decreases in values for true protein, calories, methionine, protein efficiency ratio, feed efficiency ratio, net protein ratio and protein retention efficiency. Increase in uric acid was manifold. The insect infested *Bengal*gram was damaged qualitatively as well as quantitatively. Such grains should not be consumed by human beings.

Keywords : Insect infestation, *Bengal*gram, True protein, Methionine, Protein efficiency ratio, Feed efficiency ratio, Net protein retention efficiency.

Legume is a major constituent of diets of masses in developing countries like India, mainly because the consumption of animal protein (except milk) is still considered a religious and social taboo (Anon 1978). One such legume, *Bengal*gram (*Cicer arietinum*), a rich source of proteins, is widely grown and consumed in India. Legume is generally stored in jute bags, mud containers and in rooms for a year or till the harvest of next crop. Both qualitative and quantitative losses are inflicted by insect, *Callosobruchus chinensis* L. during storage (Gupta et al. 1984; Khurb 1981; Shehnaz and Theophillus 1975; Modgil and Mehta 1984). No detailed information is available on the effect of graded levels of infestation on proximate principles, methionine, uric acid, protein efficiency ratio, feed efficiency ratio, net protein ratio, and protein retention efficiency of *Bengal*gram. In the present study, an attempt has been made to study the impact of graded levels of infestation on these parameters.

Materials and Methods

*Bengal*gram "G-24" was procured from the Directorate of Farms of the University. Pulse beetles, *Callosobrouchus chinensis* L., obtained from the Department of Entomology of the University, were released in 500 g *Bengal*gram in a container covered with muslin cloth and held at 28±2°C and 75±2% relative humidity for maintaining insect culture. Legumes were cleaned manually to get rid of dust/other foreign materials and 750 g sample was placed in triplicate in 18 plastic air tight containers of 2 kg capacity. In each container, 80 pulse beetles irrespective of sex were released, covered with lids and kept for 28 days at room temperature (33° to 42°C). Depending upon climatic conditions, pulse beetle completes its life cycle in 23 to 28 days (Arora 1977). The grains were first observed after 28 days, followed by 15 days interval, for obtaining desired levels of infestation (10, 20, 30, 40, 50 and 60%). The infestation levels were determined on the basis of examination of holes seen in legumes. On obtaining desired levels of infestation, the legumes, along with containers, were deep-frozen for 72 h to kill the adults as well as the developing insects. The insect debris and fross were removed manually and samples were stored in refrigerator till further analysis. For determining embedded larvae, 1000 grains (in triplicate) from each container were soaked overnight. Next morning, grains were dissected with a sharp blade. Density was determined by noting the change in water level, after adding one hundred grains (weighed) :

$$\text{Density} = \frac{\text{Weight of pulse grain}}{\text{Rise in water level}}$$

Two hundred g sample was ground in udicyclone and kept in air-tight plastic bottles, till further chemical analysis. Proximate principles were analyzed, according to standard methods (AOAC 1980). Calorific value was estimated by chromic oxide method (O'Sheer and Mayure 1962). The nitrogen content was estimated by microKjeldhal method (AOAC 1980) and it was multiplied by a factor of 6.25 to obtain crude protein values. The non-protein nitrogen was estimated, according to the method of Kapoor et al (1975). The extraction of uric acid was done by AOAC (1980) method for estimation by O'Sheer (1971) method. The fat-free samples were estimated for methionine by the

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method of Gupta and Dass (1954) and McCarthy and Pilli (1959). Thiamine was estimated by the method of Schenderl (1970). The data were subjected to analysis of variance and correlation matrix (Snedecor and Cochran 1968).

Eighty male albino "Wistar strain" weanling rats, aged 21 days and weighing 31±5 g, were obtained from the germ-free animal house of the University. They were divided into 8 groups randomly. One control group was fed casein and second group was given uninfested *Bengal*gram. Remaining groups were given infested legume at 10, 20, 30, 40, 50 and 60% levels of infestation for 37 days. All the diets contained (g/100g diet) sucrose 10, mineral mixture 4, vitamin mixture 1, cellulose 5, choline chloride 0.02, in addition to 55.50, 53.76, 52.60, 51.28, 49.16, 45.66 and 42.50 legumes at control, 10, 20, 30, 40, 50 and 60% infestation levels. Starch was added to make up for 100g of each diet. The composition of mineral and vitamin mixtures was, as recommended by NAS (1972) committee. The ingredients were mixed thoroughly to ensure uniform distribution of vitamin and mineral mixture and passed through 70 mesh sieve. Feed efficiency ratio and protein efficiency ratio were determined by the method of Chapman et al (1959). Net protein ratio was determined by the method of Binder and Doell (1957). Protein retention efficiency was determined by multiplying net protein ratio by 16.

Results and Discussion

Weight of infested *Bengal*gram increased upto 10% level of infestation (Table 1) and afterwards decreased significantly with a maximum loss of upto 33% in 60% infested grains. Due to multiplication, the percentage of embedded larvae increased significantly upto 30% infestation level. Afterwards, it decreased significantly ($P<0.05$), because of the emergence of the adults out of the pulse. Similar trend was observed for density. The initial increase in these parameters might be due to the presence of insect larvae and pupal stages within the grains. With increase in level of infestation, the number of holes increased in the legume, because adult insects emerged out after consumption of endosperm portion of grain. Similar results have been reported by other workers in stored grains (Srivastava et al. 1988, Vimal and Pushpamma 1983; Modgil and Mehta 1994).

Significant increase in proximate composition of insect infested grains was observed (Table 1). Changes were minimum at 10% infestation level and maximum at 60% infestation level. Increase in moisture might be due to increased insect population, insect metabolic activity and also the seed activity as well as seed respiration (Vimala and Pushpamma 1981). Increases in all other parameters might be due to consumption of endosperm portion of grain by insects, thereby leaving behind the bran-rich legumes (Gupta et al. 1984; Khurb 1981). Increased insect infestion resulted in increases in crude proteins, non-protein nitrogen and uric acid, which might be due to increased insect population, insect excreta and insect body fragments present within the grain. Significant decreases in true protein, energy, methionine and thiamine were observed at higher levels of infestation. Decrease in the energy value might be due to consumption of endosperm by insects, which

TABLE 1. PHYSICO-CHEMICAL CHANGES IN INSECT INFESTED *BENGAL*GRAM

	Infestation level, %								
Attributes	0	10	20	30	40	50	60	S.E.	CD P<0.05
Weight, g	750.0	766.8	759.5	645.3	603.3	578.8	503.2	2.78	5.68
	(0.00)	(+2.20)	(+1.30)	(-14.0)	(-19.6)	(-23.0)	(-32.9)		
Embedded larvae, %	0.8	26.4	46.9	58.1	45.8	43.4	39.9	1.34	2.75
Density, wt/vol, ml	1.2	1.3	1.4	1.3	1.2	1.1	1.0	0.01	0.02
Moisture, %	8.5	9.1	10.5	11.5	12.3	13.7	14.5	0.16	0.36
Ash, %	3.1	3.3	3.8	4.0	4.4	4.8	5.1	0.02	0.04
Crude protein, %	17.9	18.6	19.0	19.5	20.3	21.9	23.6	0.08	0.16
Crude fibre, %	3.9	4.2	5.0	5.4	6.0	6.7	7.7	0.03	0.06
Crude fat, %	4.4	3.9	4.7	4.9	5.1	5.3	5.5	0.07	0.15
Energy Kcal/100 g	338.0	331.0	324.0	318.0	308.0	295.0	271.0	1.74	3.63
Methionine, mg/100g	305.4	289.8	269.7	249.6	232.9	217.6	196.8	4.16	9.06
NPN, g/100 g	0.0001	0.2	0.5	0.8	1.0	1.4	2.0	0.0005	0.001
True protein, %	17.94	17.10	15.8	14.3	13.9	12.9	11.2	0.51	1.11
Uric acid, mg/100 g	0.10	474.4	782.0	1195.1	1607.7	2276.9	3551.3	102.78	223.13
Thiamine, mg/100 g	0.32	0.30	0.28	0.25	0.21	0.18	0.15	0.0006	0.014

TABLE 2. FEED EFFICIENCY RATIO, PROTEIN EFFICIENCY RATIO, NET PROTEIN RATIO AND PROTEIN RETENTION EFFICIENCY OF INSECT INFESTED *BENGAL*GRAM DIET

Attributes	Diets: Casein	Uninfested pulse	Infestation, % 10	20	30	40	50	60	CD P<0.05
Feed consumed, g	148.4±3.5	161.3±4.2	153.8±3.2	146.3±3.1	152.1±3.1	157.7±3.9	152.9±3.5	148.1±2.9	31.35
Protein consumed, g	14.8±0.35	16.1±0.42	15.4±0.32	14.6±0.31	15.2±0.31	15.8±0.39	15.3±0.35	14.8±2.8	3.14
Weight gain, g	52.10±6.0	34.08±4.2	32.47±3.8	30.86±3.4	28.30±3.0	25.74±2.9	20.66±2.8	15.56±4.5	2.14
Feed effi, ratio	3.52±0.51	2.81±0.63	2.10±0.42	1.95±0.28	1.69±0.25	1.44±0.34	1.25±0.34	1.06±0.12	0.18
Protein effi, ratio	0.35±0.05	0.28±0.06	0.21±0.04	0.19±0.03	0.17±0.02	0.14±0.03	0.12±0.03	0.10±0.02	0.02
Net protein ratio	3.91±0.56	2.95±0.26	2.65±0.25	0.36±0.22	2.16±0.24	1.96±0.39	1.82±0.30	1.75±0.46	0.20
Protein retention efficiency	62.56±9.5	47.28±4.41	42.56±3.3	37.84±3.5	34.63±3.21	31.41±6.2	29.70±5.2	27.97±4.5	3.30

Values are the mean of 10 rats.

otherwise contributes a major source of carbohydrates in *Bengal*gram (Singh et al. 1968). Due to the presence of insect body fragments, the non-protein nitrogen and uric acid increased, thereby resulting in an increase in crude proteins, but decrease in true protein. Uric acid is the end product of protein metabolism in insects. Manifold increases in uric acid at higher levels of infestation are of significant importance from the hygienic, nutritional and acceptability points of view and also gout causing potential of infested legumes (Swaminathan 1977; Passmore and Eastwood 1987). Decreases in methionine and thiamine contents at all levels of infestation were due to consumption of amino acids and vitamins by insects. Methionine and thiamine are the ones among amino acids and vitamins required by insects for their growth (Gilmour 1961). Due to poor protein quality of insect-infested *Bengal*gram, feed efficiency ratio, protein efficiency ratio, net protein ratio and protein retention efficiency decreased significantly (Table 2). Decrease was minimum at 10% and maximum at 60% levels of infestation. There was poor weight gain in insects fed on infested legume. Similar results have been reported by Shehnaz and Theophillus (1975), Khurb (1981) and Modgil and Mehta (1994). *In vitro* studies of infested legume showed an increase in crude protein content, while *in vivo* studies showed the adverse effect of infestation on the protein value of legume.

TABLE 3. CORRELATION BETWEEN LEVELS OF INFESTATION AND DIFFERENT PARAMETERS

Attributes	Correlation*
Weight	-0.998
Density	-0.998
Energy	-0.994
True protein	-0.992
Moisture	0.924
Ash	0.996
Crude protein	0.998
Crude fat	0.998
Crude fibre	0.994
Thiamine	-0.996
Methionine	-0.994
Uric acid	0.948
N P N	0.942

* Significant at (P<0.05)

Significant negative correlation was observed between infestation level and weight density, true protein calories, methionine and thiamine (Table 3). All other parameters showed highly significant correlation. Insect infestation resulted in qualitative and quantitative losses in *Bengal*gram. Nutritive value of legume is reduced due to infestation and consumption of infested legumes with higher amounts of uric acid might cause gout in humans.

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Association and Variation Among Cooking Quality Traits in *Kabuli* Chickpea (*Cicer arietinum* L.)

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One hundred and ten *Kabuli* chickpea genotypes were studied for physical and gravimetric properties to judge their role in cooking quality. Seed index, seed volume, seed density, swelling capacity and seed coat content were found to be important attributes, affecting cooking quality to a greater extent. The genotypes 'FLIP 88-36C', 'FLIP 88-39C', 'FLIP 90-127C', 'HK 91-23', 'HK 92-98', 'KH 92-96' and 'HK 92-100' were found to be better and could be used in breeding programme to select desirable segregants for cooking quality.

Keywords : Chickpea, Cooking quality, *Kabuli*, Genotypes, Physical properties.

Among the grain legumes, chickpea (*Cicer arietinum* L.) is an important source for protein in several developing countries, including India. Chickpea can be classified into two basic types, *desi* and *kabuli*. *Desi* chickpea contributes to about 85% of the total chickpea production and *kabuli*, the rest. *Kabuli* type chickpeas are characterised by large size, ram-head shape and beige coloured seeds with a low percentage of fibre, whereas *desi* type chickpeas are small sized, angular shaped, and coloured, with a high percentage of fibre (Singh 1987). *Kabuli* chickpea, possessing high biological value and utilisable proteins, is nutritionally better than *desi* chickpea (Singh et al. 1991). Literature reveals scattered and meagre information on cooking quality of *kabuli* chickpea. The present study pertains to cooking quality of 110 *kabuli* genotypes, derived from different sources.

Materials and Methods

For the study, 110 *kabuli* genotypes were obtained from ICARDA (International Centre for Agricultural Research in Dry Areas, Syria), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India), Chickpea Centres of India and Chaudhary Charan Singh Haryana Agricultural University, Hisar, India. All the genotypes were grown during winter season of 1993-94 at the farms of Pulses Research Area, Department of Plant Breeding, CCS HAU, Hisar, under normal chickpea growing conditions. The row to row spacing of each genotype was kept at 30cm in 4 meter row length. The seeds of each genotype were harvested for laboratory tests. All the laboratory tests for each character were carried out in triplicates and the mean values were used for statistical analysis.

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The physical characteristics, namely, seed index (100 seed weight), seed density and seed volume, were determined by the method employed by Williams et al (1983). Bulk density was measured as a ratio of mass and volume, using a measuring cylinder of 50 ml capacity. Hull thickness was recorded by screw gauge, having least count precision of 0.01 mm. To determine hydration capacity, hydration index and swelling capacity, 50 seeds of known weight were incubated in 100 ml distilled water overnight at room temperature (22°C) by employing the method of William et al (1983). Excess water was drained off and surface water was removed with absorbant paper, before recording the volume and weight of swollen seeds.

The seed coat (%) was determined by the method of Singh and Jambunathan (1981). Samples were steeped (grain to water ratio 1:4) at 5°C overnight, the seed coats were removed manually and dried at 70°C to a constant weight in hot air circulating oven. The water uptake by the seeds was studied by incubating a fixed volume of known weight of chickpeas in distilled water at room temperature at 1:4 ratio in measuring cylinders for 4 h. The decrease in volume of water at the end of 1, 2, 3 and 4 h was recorded.

To determine the cooking time, a small container of 25 ml capacity was filled with seeds of a known weight and placed in a 250 ml conical flask. Distilled water (200 ml) was added and chickpea samples were boiled. The samples were stirred at 2 min interval, to facilitate uniform heating at all the times. The degree of cooking was judged visually by the seed pressing between fingers till, softness. The excess cooking water was decanted, filtered and made to 100 ml to determine the dissolved solids and electrical conductivity, as

mentioned by Sood et al (1991). The weight and volume of cooked sample were recorded to calculate water absorption after cooking.

Results and Discussion

Variation in cooking quality attributes : The results are presented in Table 1. All the characters indicated considerable variations. The seed index (100 seed weight) varied from 16.40 ('BG267') to 42.22 ('FLIP 88-39C'). The range for seed coat (%) was recorded to be from 2.39 ('HK 91-23') to 7.80 ('FLIP 88-36C'). Swelling capacity among the genotypes also showed wide variations between 0.14 ('BG 267') to 0.70 ('GNG 827'). Except for bulk density, the variations in different physico-chemical attributes were wide. Water uptake increased till 2 h, but it was less pronounced at 3 and 4 h. It showed that genotypes imbibed more water during initial cooking time (Table 1).

Variation in water absorption (162.44-236.29 ml) and cooking time (40-113 min) were prominent in 'HK 92-89', 'HK 92-98', 'ICCV 91304' and 'FLIP 88-34C' genotypes. Such variations have also been reported earlier (Willams et al. 1983). The variations in cooking time may be due to different nutrient levels, like water, nitrogen, phosphorus and the type of water used in cooking as well as the altitude (Williams and Singh 1987). Weight of cooked pulse (191.52-276.01 g) and % solid dispersion (1.18-15.15) also showed wide variations, the maximum values being for 'HK 89-129', 'HK 92-96', while the minimum values being for 'FLIP 88-66C' and 'HK 92-119' genotypes. These genotypes, showing wide variations, could be selected and used in the breeding programme.

Important genotypes for various desirable attributes: Table 2 depicts the promising genotypes for all traits. For seed weight, seed volume, seed density, swelling capacity, hydration capacity and hull thickness, the important genotypes are from ICARDA and ICRISAT. The genotypes, viz., 'FLIP 88-36C', 'FLIP 88-39C' and 'FLIP 90-127C' have more than 40 g/100 seed weight, in addition to be promising for many of these attributes. Therefore, such genotypes could be used in breeding programmes to select desirable and superior traits for seed weight, seed volume, seed density, swelling capacity and hydration capacity.

Low seed coat content and hull thickness are the two well accepted attributes, which affect grain quality (Singh et al. 1980; Williams and Singh 1987). Genotypes possessing both these attributes, in the present study, were from Hisar (India) and ICRISAT (Table 2). 'HK 91-23' had good 100 seed weight of 26g and seed coat content of 2.39%. Such genotypes could be used for selecting desirable

TABLE 1. MEAN AND RANGE FOR QUALITY TRAITS OF 110 GENOTYPES OF *KABULI* CHICKPEA

Characters	Range	Mean	SD	CV, %
100 seed weight, g	16.40–42.22	29.081±0.530	5.562	19.124
Seed coat, %	2.39–7.80	4.589±0.085	0.889	19.372
Seed volume, ml/100 seed	7.00–16.00	11.327±0.187	1.959	17.295
Seed density, g/ml	1.37–3.43	2.572±0.030	0.318	12.364
Swelling capacity, ml/seed	0.14–0.70	0.31±0.070	0.090	29.032
Hydration capacity, g/seed	0.08–0.49	0.315±0.006	0.061	19.365
Hull thickness, mm	0.15–0.37	0.24±0.004	0.043	17.917
Bulk density, g/ml	0.74–0.84	0.803±0.002	0.021	2.615
Hydration index, g/seed	0.47–1.66	1.085±0.009	0.089	8.202
Water uptake, g/100 seeds				
After 1 h	32.40–118.48	71.673±1.493	15.655	21.842
After 2 h	35.34–175.00	88.048±1.759	18.452	20.957
After 3 h	54.00–174.62	101.685±1.831	19.206	18.888
After 4 h	64.80–174.62	112.270±1.862	19.526	17.392
Water absorption after cooking, ml/100 g	162.44–236.29	190.840±1.090	11.434	5.991
Weight of cooked pulse, g	191.52–276.01	216.052±2.855	29.943	13.859
Solid dispersion, %	1.18–15.15	5.678±0.232	2.437	42.920
Cooking time, min	40–113	57.191±1.148	12.045	21.061
Electrical conductivity of cooked pulse, µm	0.65–3.25	2.081±0.073	0.767	36.857

Mean ± Standard error; SD = Standard deviation, CV = Coefficient of variation

TABLE 2. GENOTYPES OF IMPORTANT QUALITY TRAITS IN *KABULI* CHICKPEA

Character	Genotypes		Origin	100 seed weight
100 seed weight, g	'FLIP 88-39C'	(42.22)	ICARDA/ICRISAT	42.22
	"FLIP 88-36C'	(41.97)	-do-	41.97
	'FLIP 90-127C'	(41.11)	-do-	41.11
Seed coat, %	'HK 91-23'	(2.39)	CCS HAU, Hisar	25.94
	'HK 92-97'	(2.92)	-do-	37.58
	'ICCV 89514'	(3.32)	ICRISAT	24.25
Seed volume, ml/100 seeds	'FLIP 88-36C'	(16.0)	ICARDA/ICRISAT	41.97
	"HK 91-158'	(15.0)	CCS HAU, Hisar	38.43
	'FLIP 88-39C'	(15.0)	ICARDA/ICRISAT	42.22
	'FLIP 88-47C'	(15.0)	-do-	37.72
Seed density, g/ml	'FLIP 90-127C'	(3.43)	ICARDA/ICRISAT	41.11
	'HK 92-95'	(3.25)	CCS HAU, Hisar	37.37
	'FLIP 90-127C'	(3.16)	Icarda/Icrisat	34.76
Swelling capacity, ml/seed	'GNG 827'	(0.70)	Shri Ganganagar	35.42
	"FLIP 90-127C'	(0.50)	ICARDA/ICRISAT	34.76
	'HK 92-100'	(0.40)	CCS HAU, Hisar	35.23
	'FLIP 88-36C'	(0.40)	ICARDA/ICRISAT	41.97
	'FLIP 88-47C'	(0.40)	-do-	36.83
	'FLIP 81-89C'	(0.40)	-do-	36.62
Hydration capacity, g/seed	'FLIP 88-36C'	(0.49)	ICARDA/ICRISAT	41.97
	'FLIP 88-47C'	(0.43)	-do-	36.83
	'HK 91-158'	(0.42)	CCS HAU, Hisar	38.43
	'FLIP 89-82C'	(0.42)	ICARDA/ICRISAT	33.77
	'FLIP 88-66C'	(0.42)	-do-	36.62
Hull thickness, mm	'ICCV 91305'	(0.15)	ICRISAT	23.82
	'FLIP 89-82C'	(0.15)	ICARDA/ICRISAT	33.77
	'ICCV 89514'	(0.16)	ICRISAT	33.55
Bulk density, g/ml	'Cora Hisari'	(0.84)	CCS HAU, Hisar	24.30
	'HK 90-230'	(0.84)	-do-	32.32
	'DGK 90-25'	(0.84)	Dholi, IARI, New Delhi	21.07
	'ICCV 89512'	(0.84)	ICRISAT	22.87
	'ICCV 6'	(0.84)	-do-	17.80
	'ICCV 89514'	(0.84)	-do-	21.80
Hydration index, g/seed	'ICCV 91302'	(1.66)	ICRISAT	36.62
	'HK 92-102'	(1.21)	CCS HAU, Hisar	31.03
	'ICCV 91306'	(1.20)	ICRISAT	17.36
Water uptake, g/100 seeds				
After 1 h	'NDGK 90-29'	(118.48)	Narender Dev. University	24.82
	'HK 92-102'	(105.12)	CCS HAU, Hisar	27.61
	'BGM 449'	(105.04)	IARI, New Delhi	20.63
After 2 h	'HK 92-105'	(174.62)	CCS HAU, Hisar	29.72
	'NDGK 90-29'	(127.60)	Narender Dev. University	24.82
	'BGM 449'	(124.14)	IARI, New Delhi	20.63
After 3 h	'HK 92-102'	(174.62)	CCS HAU, Hisar	29.72
	'HK 92-102'	(142.66)	-do-	27.61
	'NDGK 90-29'	(136.71)	Narender Dev. University	24.82
After 4 h	'HK 92-102'	(174.62)	CCS HAU, Hisar	29.72
	'BGM 449'	(152.79)	-do-	22.56
	'ICCV 5'	(146.74)	ICRISAT	22.56

(Contd...)

TABLE 2. CONTD...

Character	Genotypes		Origin	100 seed weight
Water absorption after cooking, ml/100 g	'HK 92-98'	(236.29)	CCS HAU, Hisar	30.61
	'HK 90-201'	(225.21)	-do-	30.00
	'ICCV 5'	(219.38)	ICRISAT	29.30
Weight of cooked pulse, g	'HK 92-100'	(231.25)	CCS HAU, Hisar	35.23
	'FLIP 89-84C'	(226.99)	ICARDA/ICRISAT	32.00
	'HK 92-98'	(226.90)	CCS HAU, Hisar	30.61
Solid dispersion, %	'HK 92-96'	(15.15)	CCS HAU, Hisar	30.45
	'HK 92-104'	(14.92)	-do-	38.00
	'ICCV 91304'	(13.94)	ICRISAT	23.32
Cooking time, min	'ICCV 91304'	(40)	ICRISAT	22.16
	'HK 92-93'	(45)	CCS HAU, Hisar	30.71
	'HK 92-111'	(45)	-do-	25.64
	'Flip 90-127C'	(45)	ICARDA/ICRISAT	41.11
	'HK 90-203'	(45)	CCS HAU, Hisar	32.82
	'HK 91-11'	(45)	-do-	19.33
Electrial conductivity of cooked pulse, μm	'HK 92-99'	(3.25)	CCS HAU, Hisar	27.38
	'HK 92-88'	(3.00)	-do-	27.56
	'HK 92-109'	(3.25)	-do-	28.76

genotypes in a breeding programme designed for quality improvement. Seed coat ranged from 5.7 to 8.8% (Singh and Jambunathan 1981) and 3.7 to 7.0% (Singh et al. 1980) in *kabuli* chickpea. The nature and amount of seed coat in pulses play an important role in governing qualitative changes during cooking, milling, processing and stock-feed purposes, as 80% of total seed fibre is accounted by seed coat. A low seed coat raises the theoretical maximum extraction of endosperm and increases the energy available to monogastric animals (Knights 1989). For water uptake, 'HK 92-105' is the desirable genotype, because it showed a value of 174.62 g/100 seed after 2 h.

Genotypes 'HK 92-98' for water absorption after cooking, 'HK 92-100' for weight of cooked pulse and 'HK 92-96' for solid dispersion (%) were all from Hisar (India) Centre. Cooking time is an important criterion for cooking quality evaluation. The genotypes showing lesser cooking time in the present study were mainly from Hisar. 'FLIP 90-127C', which got cooked in 45 min, had 100 seed weight of 41.11 g. Though larger seeds have been reported to generally take longer time for cooking, contradictory reports have also been observed by Singh et al (1991). This may be due to affinity and permeability of the seed coat as well as the cotyledons to hot water. Other causes include physical hardness of the seed itself, the chemical composition of the cell walls, internal structure and compactness of seed coat and endosperm material. All these could ultimately affect seed steeping in water and its imbibition (Muller 1967).

Association among various characters : The correlation coefficients among various cooking quality attributes have been presented in Table 3. Hundred seed weight had positive and significant association with seed volume (0.787), seed density (0.360), swelling capacity (0.362), hydration capacity (0.885) and hydration index (0.201). Except for hydration index, similar results were also reported by Williams et al (1983). The negative significant association of seed weight was observed with seed coat (-0.216), bulk density (-0.298) and water uptake at different intervals (-0.206,-0.222, -0.216, -0.214). Hull thickness showed correlation with seed index, but the magnitude was non-significant (-0.137). Similar observations were also made earlier (Singh et al. 1980). Hull thickness also showed negative but significant correlation with seed volume (-0.244) and swelling capacity (-0.188).

The seed weight (0.148) and its related attributes, viz., seed volume (0.081), seed density (0.145) and hydration capacity (0.149) exhibited tendency to positively correlate with cooking time, though non-significantly, while Williams et al (1983) and Badsha et al (1987) had reported strong and positive association of these characters with cooking time. The possible reasons for such contrasting

trend may be the variability of seed coat content and hull thickness, as seed coat is rich in polyphenols and other anti-nutrients that might have reduced the cooking quality and hence affected association with other attributes. Williams and Singh (1987) have explored such possible effects of seed coat and hull thickness as well as some other attributes affecting cooking time.

Water uptake at different periods is found to be positively and significantly correlated among themselves and also with solid dispersion (%), thereby indicating that higher water absorption results in greater solid dispersion in leachates, which is a good indicator of cooking quality. Solid dispersion had positive and significant association with sweeling capacity and water uptake at all intervals.

The seed weight, seed volume, seed density, swelling capacity and seed coat (%) are important attributes, which affect cooking quality. Solid dispersion (%) in food too has its significant role. Therefore, the seed coat content should be reduced, keeping in view the seed weight, though higher 100 seed weight may not result in lower seed coat content, but can definitely enhance the cooking time. Therefore, in breeding programmes, medium

TABLE 3. CORRELATION COEFFICIENTS AMONG VARIOUS COOKING QUALITY ATTRIBUTES IN *KABULI* CHICKPEA

	Character	1	2	3	4	5	6	7	8	9
1.	Seed size	1.00	-0.216*	0.787**	0.360**	0.362**	0.885**	-0.137	-0.298**	0.201*
2.	Seed coat		1.00	-0.136	-0.137	-0.218*	-0.127	0.047	-0.228*	-0.117
3.	Seed volume			1.00	-0.234*	0.243*	0.796**	-0.244**	-0.258*	-0.003
4.	Seed density				1.00	0.213*	0.199*	0.162	-0.094	0.306**
5.	Swelling capacity					1.00	0.340**	-0.188*	-0.282*	0.072
6.	Hydration capacity						1.00	-0.137	-0.305**	0.380**
7.	Hull thickness							1.00	0.003	0.009
8.	Bulk density								1.00	-0.054
9.	Hydration index									1.00

	Character	10 (W_1)	10 (W_2)	10 (W_3)	10 (W_4)	11	12	13	14	15
1.	Seed size	-0.206*	-0.222*	-0.216*	-0.214*	0.145	-0.062	0.034	0.148	0.040
2.	Seed coat	0.056	0.032	0.001	0.082	0.098	-0.216*	-0.068	0.060	-0.076
3.	Seed volume	-0.429**	-0.422**	-0.396**	-0.403**	0.108	0.016	-0.025	0.081	0.044
4.	Seed density	0.304**	0.266**	0.252**	0.263**	0.044	-0.105	0.070	0.145	0.023
5.	Swelling capacity	0.370**	0.229*	0.333**	0.209*	0.047	-0.028	0.243*	0.106	0.238*
6.	Hydration capacity	-0.168	-0.198*	-0.191*	-0.184	0.197*	-0.059	0.042	0.149	0.009
7.	Hull thickness	0.053	0.108	0.103	0.074	-0.029	0.002	-0.177	0.047	0.058
8.	Bulk density	-0.002	0.013	-0.027	-0.057	-0.168	0.105	-0.037	-0.072	-0.009
9.	Hydration index	0.296**	0.216*	0.303**	0.280*	0.169	0.060	0.028	0.031	-0.020
10.	Water uptake									
	After 1 h (W_1)	1.00	0.809**	0.816**	0.749**	0.141	0.067	0.279**	0.051	0.134
	After 2 h (W_2)		1.00	0.887**	0.785**	0.091	-0.005	0.186*	0.011	0.091
	After 3 h (W_3)			1.00	0.889**	0.156	0.107	0.235*	0.002	0.072
	After 4 h (W_4)				1.00	0.158	0.059	0.248**	0.007	0.078
11.	Water absorption after cooking					1.00	0.262**	-0.003	-0.109	0.063
12.	Weight of cooked pulse						1.00	0.068	0.008	0.146
13.	Solid dispersion							1.00	-0.116	0.097
14.	Cooking time								1.00	-0.044
15.	Electrical conductivity of cooked pulse, µm									1.00

* Significant at 5% level, ** Significant at 1% level

to bold seeds are the best starting points to minimise antinutritional factors, which are mainly located in seed coat. 'HK 91-23' and 'HK 92-97' genotypes, having lower seed coat and better 100 seed weight, should be utilized in breeding programme to obtain desirable segregants for seed coat and seed weight. Kumar and Singh (1989) also held similar views.

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Water Vapour Sorption Properties of Buffalo Milk Whey Protein Concentrates

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Whey protein concentrates, prepared by precipitation with carboxymethyl cellulose, adsorbed almost double the amount of water vapour, as compared the other whey protein concentrates, prepared by precipitation with sodium hexametaphosphate. Ion exchange chromatography-whey protein concentrates (IE-WPC) absorbed higher amount of water (about a_w 0.7), than other whey protein concentrates. Sodium hexametaphosphate-whey protein concentrates (SHMP-WPC) and carboxymethyl cellulose-whey protein concentrates (CMC-WPC) showed a dip in the isotherms around 0.28 water activity, while gel filtration-whey protein concentrates (GF-WPC) and IE-WPC and ultrafiltration-whey protein concentrates (UF-WPC) gave a smooth sigmoid isotherm with no discontinuity. The estimated surface area, amount of water for monolayer formation and energy constant related to heat adsorption ranged from 1008 to 1672 m^2/g, 0.287 to 0.476 g/g solids and 1.4 to 6.18, respectively.

Keywords : Whey protein concentrates, Buffalo milk, Cheese whey, Sorption isotherms, Water activity, BET equation

Water sorption affects drying, storage stability and behaviour of whey protein concentrates (WPCs) in many food systems (Greig 1979). Understanding sorption behaviour of whey protein concentrates is important (a) in the evaluation of water uptake, porosity, sorption/desorption enthalpies (b) for the estimation of specific surface area, crystalline state of components (lactose), optimization of processing (e.g., drying (c) in the assessment of packaging needs and (d) for the prediction and control of microbiological, chemical and physical stability.

The present study relates to the sorption isotherms (25°C) of water vapour obtained for whey protein concentrates, prepared from buffalo milk cheddar cheese whey by different methods. The sorption data are further used in calculating the surface area of these whey protein concentrates.

The buffalo milk-cheddar cheese, having 0.83% average protein, 4.88% carbohydrates, 0.4% fat and 0.59% ash was used in preparation of whey protein concentrates (WPCs) by the following methods (Bimlesh Kumar 1990) :

(i) Precipitation with sodium hexamataphosphates (0.07 M), (ii) Precipitation with sodium salt of carboxymethyl cellulose (0.38%), (iii) Gel filtration chromatography using Sephadex 'G-25', (iv) Ion-exchange chromatography, using 'CM Sephadex C-50' as an cation exchanger and (v) Ultrafiltration.

The WPCs obtained were freeze-dried and proteins, fat, moisture, ash and carbohydrates were estimated by standard procedures.

The water sorption isotherms of whey protein concentrate samples were determined at 25°C. The aqueous solution of sulphuric acid, having different normalities (4.5-19.0 N), which give different water activities (a_w) in the range of 0.9-0.1, were prepared (ASTM 1971). The samples were dried completely, keeping them in a desiccator having concentrated sulphuric acid for one week. Lots of each sample (0.2g) were weighed in watch glass and kept in each desiccator, having different water activities. The increase in weight was recorded, after interval of 1 to 2 days, till no further increase in weight was observed. Percentage of water sorbed was calculated and sorption isotherms (SIs) were plotted by taking 0.1 to 0.9 a_w on x-axis and percentage of water sorbed by dry WPC on y-axis.

The composition of whey protein concentrates depended on the method of their preparation (Table 1), which in turn, changes their water sorption behaviour. Equilibration of the WPC samples required a period of 14 days. The sorption values, calculated in terms of g/100 g were fairly reproducible within ± 0.1 of one another.

Sorption isotherms of WPCs, prepared using different methods, are given in Fig.1. It is observed that the WPCs prepared by the use of sodium hexametaphosphate and carboxymethyl cellulose show a dip in the isotherm around relative humidity of 0.28. This is in conformity with the data reported by earlier workers (Berlin 1981; Saltmarch and Labuza 1980). The discontinuity in the isotherm is associated with some phase change occurring in the concentrate. Earlier worker attributed this to the change taking place in the protein fraction

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TABLE 1. YIELD, COMPOSITION, PH AND MOISTURE SORPTION CHARACTERISTICS OF WHEY PROTEIN CONCENTRATES PREPARED BY DIFFERENT METHODS

Distribution of WPC	Yield, g/l	Average composition, g/100 g					pH at 0.5% aqueous solution	Moisture sorption characteristics		
		Proteins	Carbo-hydrates	Fat	Ash	Moisture		M	C	SA, m^2/g
SHMP-WPC	6.6	67.03*	9.65	6.83	17.81	3.05	4.50	-	-	-
CMC-WPC	6.2	60.99	17.98	15.63	1.86	2.20	4.85	-	-	-
GF-WPC	8.1	83.07	1.35	2.43	0.04	8.15	6.70	0.360	6.18	1263
IE-WPC	7.9	77.36	0.36	0.29	13.24	7.45	8.55	0.476	1.40	1672
UF-WPC	7.8	63.52	5.26	14.07	4.97	6.09	6.20	0.287	5.36	1008

* Values given are the average of 3 samples. M : amount of water (g/g solids) for monolayer formation;

C: energy constant related to heat of adsorption; SA : surface area (sq.m/g)

(Supplee 1926). However, later workers have related the discontinuity with lactose crystallization (Berlin et al. 1968; Buma 1966). Initially, the lactose in WPC is present as amorphous glass, which is very hygroscopic. However, once it absorbs sufficient water, the lactose crystallizes out as alpha-monohydrate, which is relatively non-hygroscopic, thus losing water upon crystallization. It is reported that the break is generally observed at low water activities (a_w) in lactose-rich whey powders. It ranged from a_w 0.35 to 0.50 for whey powders and whey protein concentrates (Berlin et al. 1968). It is concluded from these results that, perhaps, most of the lactose, present in these samples as free lactose, behaves independent of the other constituents. It is evident from Fig. 1 that the sorption of water vapour by WPC is quite appreciable (40%) even at low humidity, say upto a_w 0.4. Between a_w 0.4 and 0.7, it remains more or less constant and then there is an upward swing.

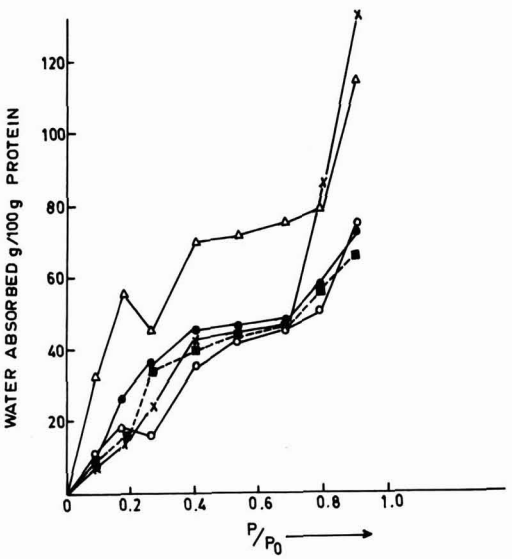

Fig. 1. Sorption isotherm of water vapours at 25°C
—o—o— SHMP Cheese WPC; —Δ—Δ— CMC Cheese WPC;
—●—● GF Cheese WPC; —×—×— IE Cheese WPC;
—■—■ UF Cheese WPC

Whey protein concentrates prepared by gel filtration, ultrafiltration and ion-exchange chromotography, though contained 1.35, 5.26 and 0.36% carbohydrates, respectively, gave a smooth sigmoid isotherm with no discontinuity (Fig. 1). This indicates that carbodydrates present in these WPCs, mainly lactose, are in crystalline form. It is of interest to apply BET equation (Brunauer et al. 1938) to these isotherms, which were sigmoid in shape. The BET equation used to describe the equilibrium isotherm for sorption is :

$$\frac{P}{V\,(P_0 - P)} = \frac{1}{V_m C} + \frac{C - 1}{V_m C} - \frac{P}{P_0}$$

where,

P = equilibrium vapour pressure,

P_0 = saturation vapour pressure, and

V = equilibrium moisture content.

V_m gives the number of molecules of water required to cover the surface of the WPC with a layer of one molecule thickness and C is an energy constant, which is related to that of sorption. The value of C is also indicative of the nature of sorption. $P/V(P_0 - P)$ plotted against P/P_0 for various WPCs is shown in Fig. 2 (Heldman 1965). From the intercept and the slope of the line shown in Fig. 2, the values of C and V_m were calculated (Table 1). Since the V_m represent the moisture of material, when the entire surface is covered with unimolecular water layer, this value is directly related to amount of surface area, calculated using the following equation :

$$S_A = \frac{V_m \times L}{M \times N}$$

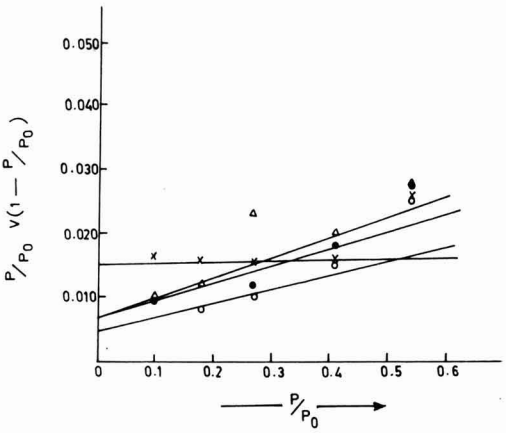

Fig.2. BET plots for moisture isotherms
—Δ—Δ— SHMP Cheese WPC; —o—o— GF Cheese WPC
—×—×— IE Cheese WPC; —●—●— IE Cheese WPC

where,

S_A = surface area, m^2/g,

M = molecular weight of water (g/g mole water),

N = Avogadro's number (molecules/g mole), and

L = area covered by a molecule of water (10.8 A^2)

It is observed from Table 1 that the values of C are in the range of 1.40 to 6.18, which are of the same order as computed by Kinsella and Fox (1987), while values of surface area, reported in the Table, are much higher, as compared to those reported by Heldman et al (1965) and Kinsellla and Fox (1987).

The differences in the surface area, as measured in the present studies and those reported earlier, may be due to differences in the method of preparation of the sample and the source of the whey. The method of preparation may influence the number and size of pores in the protein matrix. In this connection, it may be reported that the freeze and spray-dried powders possessed higher surface area and significantly higher monolayer values than the drum air and vacuum-dried whey proteins samples (Greig 1979). BET equations are not fully applicable to sorption isotherms of SHMP-WPC and CMC-WPC, because of molecular transformation (i.e., lactose crystallization), as shown in Fig.1. As indicated in Fig. 2, between water activity 0.05 to 0.4, all the WPCs, except SHMP-WPC, have given a straight line, which confirms the fitness of BET equations.

Marked disparities exist in published data on surface area of casein also. Geurts et al (1974) estimated approximate surface area of $1200m^2/g$ for casein *per se* and $800m^2/g$ for casein in cheese. In contrast, Berlin et al (1970) showed, by direct nitrogen sorption studies, that caseins dried by different methods had surface areas ranging from 5 to 71 m^2/g.

The whey protein concentrates, prepared by ion-exchange chromatography, show higher water absorption than other whey protein concentrate (above 0.7 water activity), because of high ash content. Berlin et al (1972) reported that whey concentrate powders, containing 73,83 and 87% whey protein, showed similar water sorption properties upto 0.6, but above this, only those samples containing higher levels of lactose and ash, absorbed more moisture.Although SHMP-WPCs have higher ash and lactose contents, these did not absorb more water, because pH of aqueous solution of SHMP-WPCs was nearer to the isolectric point, while IE-WPCs had higher pH (Table 1). At isoelectric pH, protein-protein interactions are maximal, the molecules are compact and hydration is minimal. At pH 3 and 7 (a_w 0.9), BSA binds 30 and 40 g water/100 g proteins, respectively (Kinsella and Fox 1986).

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Studies on Preparation, Packaging and Storage of *Ghewar* - An Indian Traditional Sweet

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Ghewar, an Indian traditional sweet, is prepared from *maida*, deep-fat-fried into honey comb structure and sweetened with sugar syrup. Optimum conditions of preparation and recipe were standardized in the laboratory. Laboratory samples of *ghewar* had optimum physico-chemical and sensory qualities. Samples were stored for 30 days in low density polyethylene (LDPE) 200 gauge bags and in open trays at ambient temperature, without any discernible change in sensory quality, except for a slight toughening of texture. Free fatty acid content showed negligible increase, but peroxide value decreased.

Keywords: *Ghewar*, Emulsion, Slurry, Deep-fat-frying, Syrup, Shelf-life.

In India, a number of traditional sweets are prepared from a variety of raw materials like *Bengal*gram flour *(Cicer arietinum L.), Urd dhal (Phaseolus mungo L.), moong dhal (Phaseolus aureus Roxb)*, fine wheat flour (*maida*) and rice flour. The quality of sweets available in the market varies significantly and it requires scientific approach with respect to the quality of ingredients, standardization of recipe and packaging of the products for longer shelf-life. Work has been done on sweets like *burfi* (Ramanna et al. 1983), *inderse* (Saxena et al. 1991), *gurdani* (Saxena et al. 1992) and on other products by a number of research workers. *Ghewar* is a traditional sweet prepared from a thin slurry of *maida* in emulsified fat, which is then deep-fat-fried into a doughnut shaped honey-comb structure and sweetened with sugar syrup. The emulsification of fat is done manually by rubbing ice into melted fat. Dressing it with dried fruits and nuts is optional. It is a delicious sweetmeat prepared and consumed mostly during rainy season. There is no published scientific information available on this sweet. This communication reports optimization of recipe, physico-chemical characteristics, packaging and storage behaviour of *ghewar*.

Raw materials: Fine wheat flour (*maida*), *vanaspati ghee* and sugar were purchased locally.

Preparation of Ghewar: The improved recipe comprised *maida* (10 kg), fat (2 kg), sugar (2 kg), ice (4 kg) and water (22 l). Melted *vanaspati ghee* was emulsified in a blender with gradual addition of ice. *Maida* was then gradually folded into the creamy emulsion along with 2 kg water, yielding a pliable dough, to which remaining quantity of water (18 l) was blended to obtain a thin free flowing emulsion/slurry. This slurry was added (drop by drop) directly into pre-heated (165°C) *vanaspati ghee* in a specially designed circular flat iron sauce pan (15 cm diam and 10 cm deep). The splattering slurry drops, as they are fried, were

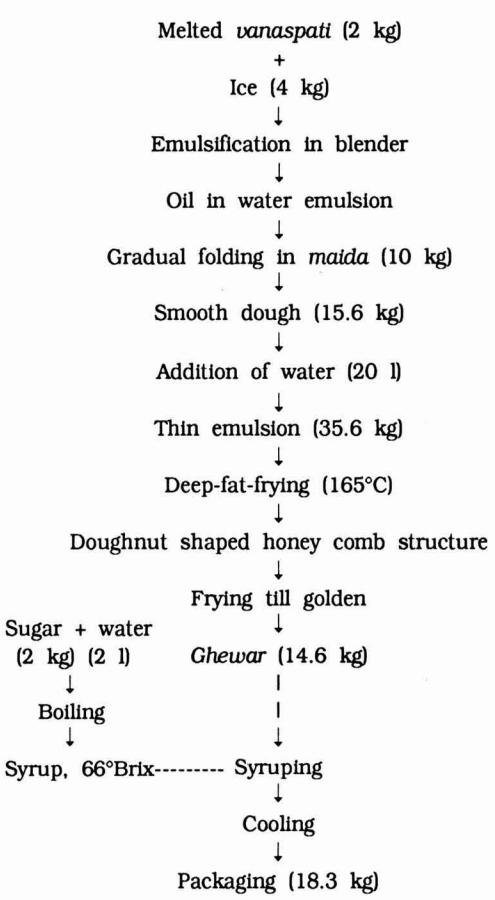

Fig. 1. Materials balance sheet on the preparation of *Ghewar*

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pushed towards the sides of the pan with the help of a flat ladle. This was continued, till a large doughnut shaped honeycomb golden colour structure (10-13 cm diam, 1.5-2 cm thick) was formed. This was followed by addition of melted *vanaspati ghee* into the pan to float the *ghewar*, which was then hooked out using an iron wire hook and placed on a rack to allow dripping of the excess fat. To get sugar syrup of 66° Brix, sugar (2 kg) was dissolved in water (2 l), boiled and clarified using a little quantity of milk. The hot syrup was slowly poured over the *ghewar*, cooled and packed. The material balance sheet on the preparation of *ghewar* is shown in Fig. 1.

Physico-chemical and sensory quality evaluation: Laboratory samples of *ghewar* were analyzed for physico-chemical characteristics, like shape, size, diam, unit weight, moisture, crude fat, reducing sugars, non-reducing sugars, total sugars, proteins, total ash, acid-insoluble ash, free fatty acid content and peroxide value at intervals of 0, 10, 20 and 30 days, employing standard methods (AOAC 1984). *Ghewar* samples were evaluated for quality parameters like colour, texture, aroma, taste and flavour and overall quality by a panel of 8 fellow scientists, who were well conversant with the product, using Hedonic scale.

Equilibrium relative humidity (ERH) studies: In order to ascertain the packaging requirements of *ghewar* samples, equilibrium relative humidity studies were conducted (Ranganna 1986) at room temperature (20±5°C). Known weights of samples were exposed to different relative humidities, ranging from 11 to 93% RH, for 12 days. Changes in colour, texture, acceptability and mould growth were recorded for different samples. ERH of *ghewar* samples was determined by plotting the graph of

TABLE 1. PHYSICO-CHEMICAL AND SENSORY QUALITY CHARACTERISTICS OF *GHEWAR* SAMPLES PREPARED IN THE LABORATORY.

Parameters/ characteristics	Values	Parameters/ characteristics	Values
Physical		**Chemical**	
Shape	Circular honey comb structure	Moisture, %	9.3
		Ether extractives, %	46.35
Diam, cm		Reducing sugars, %	1.62
Maximum	12.50	Non reducing	
Minimum	9.80	sugars, %	22.44
Average	11.15	Total sugars, %	24.24
Thickness, cm		Total ash, %	0.26
Maximum	1.80	Acid insoluble	
minimum	1.50	ash, %	0.02
Average	1.65	Proteins (N x 6.25), %	3.66
Unit weight, g			
Maximum	575.0	Free fatty acids, %	0.17
Minimum	450.0	(as oleic acid)	
Average	512.0	Peroxide value, Milli equiv. O_2/kg oil	9.0

TABLE 2. RELATIONSHIP BETWEEN RELATIVE HUMIDITY(RH), EQUILIBRIUM MOISTURE CONTENT(EMC) AND NUMBER OF DAYS TO ATTAIN EQUILIBRIUM FOR *GHEWAR*. INITIAL MOISTURE 9.3%, ERH-76% RH

RH, %	EMC, %	Days to attain equilibrium	Quality characteristics		
			Colour	Texture	Overall Quality
11	5.3	10	Golden no change	Very hard	Not acceptable due to hard texture
23	6.4	10	--do--	--do--	--do--
33	6.6	10	--do--	--do--	--do--
44	6.8	10	--do--	--do--	--do--
53	7.7	10		--do--	--do--
65	8.2	5	--do--	Slight crisp	Acceptable
76	9.3	5	--do--	Crisp original	Acceptable
86	17.8	12	Dark brown	Very soft	Not acceptable due to absorption of moisture
93	31.0	9	-do-	Very soft	Mould growth

Critical moisture content was 11% at 80% RH

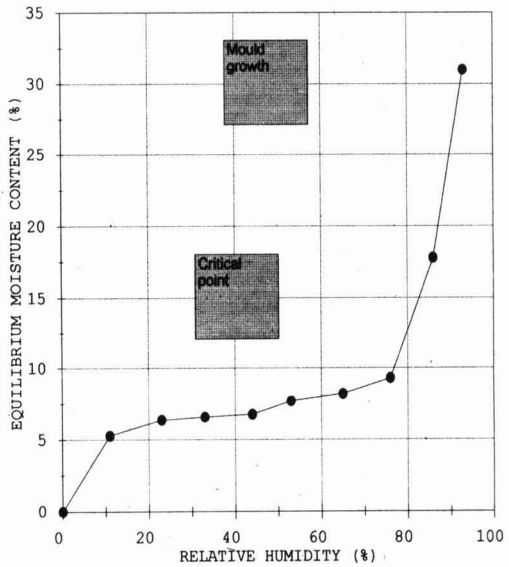

Fig. 2 Relationship between equilibrium moisture content and relative humidities for *ghewar* - Initial moisture 9.3%

TABLE 3. CHANGES IN MOISTURE, FFA AND PV IN *GHEWAR* STORED IN TWO PACKAGINGS AT ROOM TEMPERATURE (20 ± 5°C)

Characteristics	Initial	LDPE, 200 gauge, days			in open trays, days		
	0	10	20	30	10	20	30
Moisture, %	9.30	8.80	8.00	7.50	7.80	6.30	5.10
Free fatty acids, % (as oleic acid)	0.17	0.18	0.20	0.21	0.18	0.20	0.24
Peroxide value, meq O_2/kg oil	9.00	7.80	6.20	4.30	7.80	7.10	6.30
	Organoleptic evaluation						
Overall quality	Good highly acceptable	Acceptable	Acceptable, slightly hard	Acceptable, slightly hard	Acceptable, slightly hard	Acceptable, but hard	Not acceptable due to very hard texture

Colour of the product was golden and it had not changed in all the cases. The texture was soft and crisp initially and it changed to hard and crisp in all the cases. Aroma of the product was peculiar of *ghewar* initially, but it changed to slight *vanaspati*-like aroma in all the cases. Initial taste and flavour of the product was specific to *ghewar* and no off-flavour and taste were developed during storage in all the cases.

percentage loss or gain in weight, against number of days for different relative humidities, ranging from 11 to 93%.

Packaging and storage studies: One lot of laboratory samples of *ghewar* was packed in 200 gauge polyethylene bags and the second lot was kept in trays in the open, as practised commercially and stored at room temperature (20±5°C) in the laboratory.

The good quality *ghewar*, having crisp honeycomb structure, could be obtained, when optimal conditions for its preparation were observed scrupulously. The use of ice was a pre-requisite to make stable oil in water emulsion. Addition of slightly more *maida* in emulsion gave solid mass, while addition of little excess water did not form *ghewar* at all. Slight change in the method of preparation i.e., fast dropping of emulsion into the heated oil, did not form the honey comb structure, as peculiar to *ghewar*, while storing the emulsion for more than 30 min gave poor quality of *ghewar*. Syrup of 66 °Brix was found optimum, as it gave smooth and uniform coating of sugar on and in the *ghewar*, while syrup of 60 °Brix yielded a product, having loose texture. Best results were obtained from the recipe, comprising *vanaspati* 2 parts, ice 4 parts, *maida* 10 parts, water 22 parts and sugar 2 parts.

The physico-chemical characteristics of *ghewar* are given in Table 1. The *ghewar* possessed golden colour, soft and crisp texture, appropriate taste and aroma of the sweet.

Equilibrium relative humidity (ERH) of *ghewar* samples at initial moisture content of 9.28 was 75% RH (Table 2). Product became hard at 11 to 53% RH, making it unacceptable. But, the samples remained acceptable at equilibrium moisture content (EMC) of 8.2 to 9.3% at RH of 65 and 76%. Samples with EMC of 17.8% became very soft on the 12th day, but no mould appeared at 86% RH. Mould appeared in the samples, having EMC 31.0% at 93% RH on the 9th day (Fig. 2).

Samples packed in low density polyethylene (200 gauge) bags and those kept open in trays had shelf-life of 30 days at room temperature (20±5°C). There was no significant change in the sensory quality attributes in both the samples and remained acceptable. Moisture decreased from 9.0 to 7.6% (LDPE bags) and 5.1% (open trays). The samples remained free of rancidity and off-flavour during the period of storage. Free fatty acid content increased from 0.17 to 0.21% (LDPE packed) and 0.24% (open trays), but peroxide value decreased from 9.0 to 6.30 and 4.33 milli equiv. O_2/kg oil in open trays and LDPE packagings, respectively (Table 3).

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Candida curvata Biomass Production on Rapeseed Oil Meal Digests

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Growth and protein production by *Candida curvata* in utilization of various RSOM -extracts (water, saline, alkali and alcohol) and their residues, as nitrogenous ingredients in microbiological media were studied. The RSOM-acid digest proved to be the best medium in supporting the growth as well as yield, in comparison to all other RSOM-extracts and their respective residues. The results are of importance in improving the quality of rapeseed meal.

Keywords: Rapeseed oil meal, Acid-digest, RSOM-extracts, Residues, *Candida curvata*, Conversion efficiency, Yield.

Dietary deficiencies of proteins and calories are the major problems, prevailing all over the world. The majority of countries are engaged in improving their nutritional status by utilizing unconventional sources (Litchfield 1979). In this context, rapeseed is given the top most priority, because of its higher nutritive value than any other vegetable protein known and its comparability with that of animal proteins (Ohlson and Anjou 1979). Rapeseed oil meal (RSOM) consists of proteins and carbohydrates, but it is presently used mainly as animal feed. However, the potential animal feed utilization has been hindered by problems, such as palatability, digestibility and toxicity. Presently, utilization of RSOM in human food has a limited success (Phillipchuk and Jackson 1979).

Some microorganisms are capable of breaking down the toxic compounds, making RSOM acceptable as animal feed (Garg et al. 1983, 1985). Information on utilization of RSOM or its digests, as nitrogenous source for microbial fermentation, is scanty. Therefore, the present investigation was undertaken to study the growth of *Candida curvata* on RSOM digest (water, acid, saline, alkali, alcoholic) and their respective residues.

The untreated seeds of *Brassica campestris* local variety ('Toria'), grown in Amritsar district (Punjab), were pulverized into a fine powder and defatted by Soxlet's extraction (AOAC 1975), using petroleum ether (60-80 b.p.). The analysis of RSOM for moisture, crude proteins, crude fibre and ash content was carried out by standard methods (AOAC 1975).

The protein isolates were prepared by individually stirring 50 g RSOM in 700 ml of distilled water, salt (10% NaCl), alkali (0.1 N NaOH) and alcohol (70%) for 1 h at 25±1°C. The suspensions were centrifuged at 16,000 rpm (4°C) for 20 min and filtered through Whatman No. 1 filter paper. These extracts were designated as RSOM-WE, RSOM-SE, RSOM-AE and RSOM-alc E, as well as their respective residues. Nitrogen was determined by micro-Kjeldahl method (AOAC 1975) and converted into crude proteins.

The RSOM (25 g), its different extracts (250 ml) and their respective residues were hydrolyzed in 6 N HCl (250 ml) and autoclaved at 0.752 kg/sq. cm for 30 min (Phillipchuk and Jackson 1979). The acid hydrolysates were ice-cooled, filtered and pH was adjusted to 5.5 with 20% NaOH. The flasks were inoculated uniformly with *C. curvata* cell suspensions ($15x10^6$ cells/ml), in triplicate and incubated at 25±1°C on a rotary shaker (220 rpm/min). The growth was recorded by measuring the

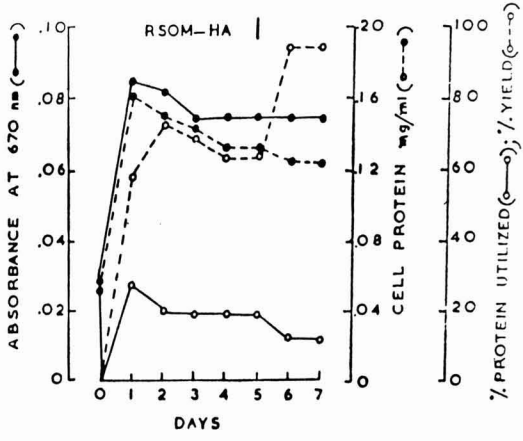

Fig. 1. Utilization of rapeseed oil meal-acid digest by *Candida curvata* showing biomass, cell protein, protein utilization and yield %

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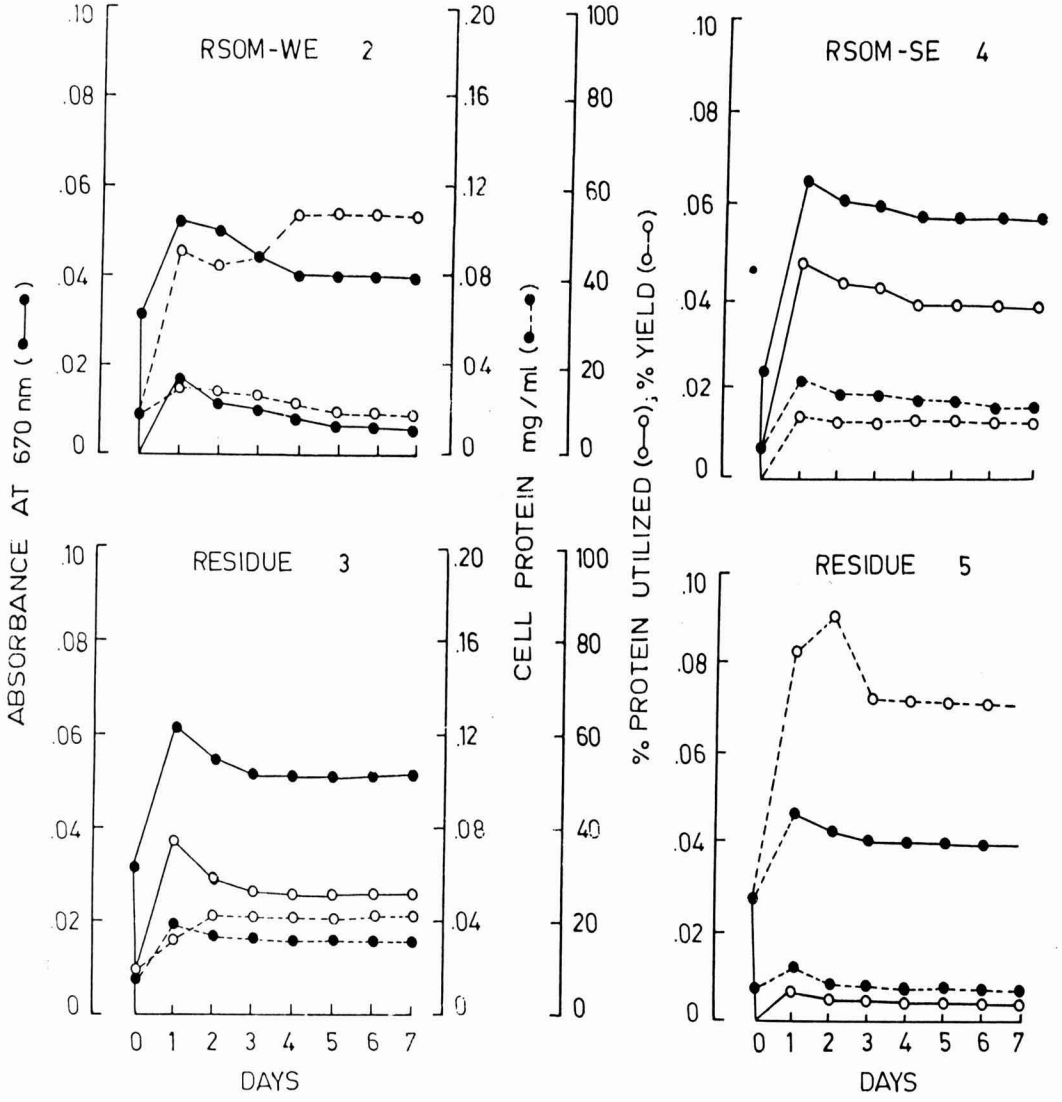

Fig. 2. Growth of *Candida curvata* on RSOM-WE, RSOM-RWE, RSOM-SE and RSOM-RSE
RSOM-WE : Rapeseed oil meal-water extract, RSOM-RWE : Rapeseed oil meal-residue-WE
RSOM-SE : Rapeseed oil meal-saline extract, RSOM-RSE : Rapeseed oil meal-residue-SE

aborbance at 670 nm at 24 h intervals for 7 days. The content of each flask was centrifuged, the residue containing yeast cells was washed and digested in 5 ml NaOH (0.2 N) solution. Cell protein was determined by Folin-phenol method (Lowry et al. 1951). Nitrogen content was estimated in the supernatant by Kjeldahl method (AOAC 1975). The conversion efficiency (CE) was determined as the ratio of cell protein to protein utilized. Yield was obtained by multiplying CE with 100.

The RSOM had the following composition (%): crude proteins, 31.99; crude fibre (cellulose), 14.89; ash (minerals), 3.85 and moisture, 4.85. The protein contents of RSOM-HA (acid digest), water, salt, alkali and alcohol extracts were 31.99, 14.63, 19.25, 23.48 and 4.23%, respectively, while the values for the respective residues were 16.75, 13.03, 9.30 and 28.00%, respectively (Sharma and Garg 1994).

Biomass and cell protein production: The highest cell growth observed in the present study, seems to be due to efficient utilization of proteins from

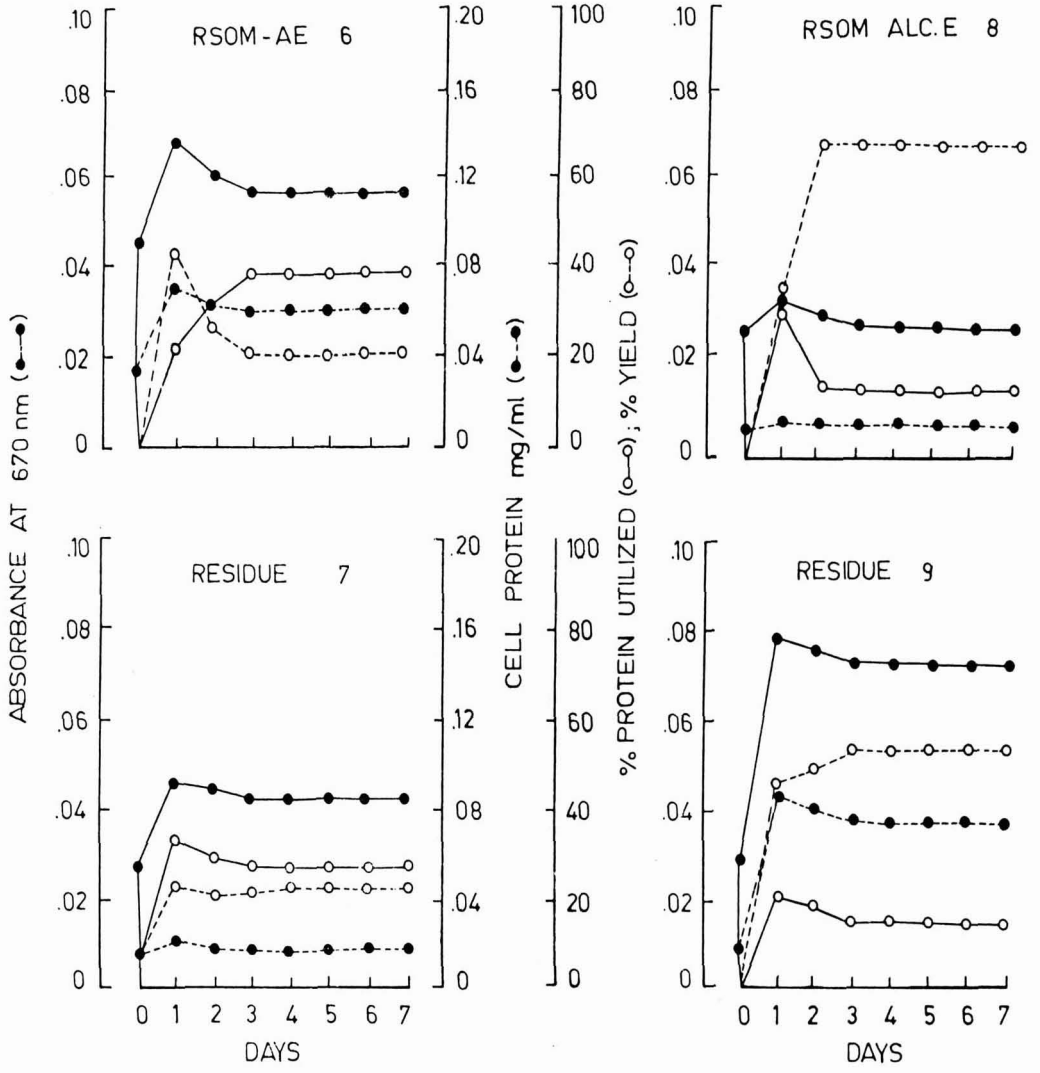

Fig. 3. Growth of *Candida curvata* on RSOM-AE, RSOM-RAE, RSOM-Alc.E and RSOM, RAlc.E
RSOM-AE : Rapeseed oil meal-Alkali extract, RSOM-RAE : Rapeseed oil meal-Residue-AE
RSOM-Alc.E : Rapeseed oil meal-Alcoholic extract, RSOM-RAlc.E : Rapeseed oil meal-Residue--RAlc.E

RSOM-acid digest by *Candida curvata*. Amongst the various hydrolysates, the RSOM-acid digest proved to be the most adequate protein source, as maximum biomass production (0.085) and cell protein (0.169 mg/ml) were obtained within 24 h incubation (Fig. 1). The minimum growth (0.036) and lowest cell production (0.017 mg/ml) was seen on RSOM-alcoholic extract in comparison to all other hydrolysates (Fig. 2-3).

The maximum growth on RSOM-HA might be due to sufficient levels of certain growth promoting amino acids, as lysine, histidine, serine, isoleucine and tyrosine are known for their ability in fulfilling the nutritional needs (Garg et al. 1985 a, b). Variable growth responses of *C. curvata*, grown on various RSOM digests and its residues, were probably due to differences in protein contents. It is likely that the differential growth of *C. curvata* might be due to variation in nitrogen utilization from RSOM digests for cell growth and protein synthesis (Garg et al. 1983). The different growth pattern and cell protein production seems to be due

to the fact that rapeseed contains certain toxic and antinutritional factors (Schuld and Bowland 1968; Slinger 1977), which probably alter its protein quality. Some of the researchers (Sarwar et al. 1979; Ohff et al. 1979) have suggested the activation of sulphur containing toxic compounds during autoclaving, thereby resulting in increased utilization of RSOM by microorganisms. However, the problems have been circumvented to some extent by growing *C. utilis* on RSOM-digests (Phillipchuk and Jackson 1979).

Protein utilization: C. curvata utilized maximum RSOM-saline extract protein (0.30 mg/ml), followed by RSOM-acid digests (0.29 mg/ml), the value being the lowest for residue of RSOM-SE (0.03 mg/ml) after 24 h growth. Yeast cells were able to utilize proteins from various RSOM-digests, thereby resulting in their increased growth and cell protein and decreasing protein content of the media. However, after optimum growth, the increase in medium protein might be due to autolysis of yeast cells, as evidenced by corresponding decrease in cell protein (Garg et al. 1983). It has been noticed that RSOM-SE was utilized more efficiently by *C. curvata*, than the other digests.

Conversion efficiency and yield: Conversion efficiency is expressed as the ratio of cell protein to protein utilized. Highest values of conversion efficiency and yield (0.95, 95%) were observed on RSOM-acid digest, after 6 days growth and minimum on RSOM-SE (0.14, 14.5%), after 1 day growth. However, *C. curvata*, grown on RSOM-digests, showed variable time for maximum conversion efficiency and yield. The variations in conversion efficiency and yield depend upon the efficient conversion of substrate protein into cell proteins. These observations provide support to earlier findings (Rotkowski 1972; Updegraff and Grant 1975).

From the present study, it is clear that *Candida curvata* is able to utilize all RSOM-digests, as nitrogenous substrate for its growth, but the degree of utilization varies with respect to the digest used. The RSOM-acid digest proved to be the best medium for the growth of yeast. This yeast utilized RSOM-acid digest more efficiently and showed maximum cell growth, cell protein production, conversion efficiency and yield, in comparison to other digests. *Candida curvata* grown on RSOM-SE revealed increased protein utilization, in comparison to all other digests.

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Apple Pomace Sauce - Development and Quality of Fresh and Stored Products

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Apple pomace from three stages of apple maturity (August, September, and October) and three levels of sugar (per kg of pulp) were used with final TSS of 15(T_1), 20(T_2) and 25(T_3) °B in the sauce. Sugars (reducing and non-reducing) Brix-acid ratio, starch, proteins and crude fibre increased, but ascorbic acid content declined in stage I to stage III. Apple pomace sauce from stage T_2 was found to be the best in sensory qualities. All the quality parameters showed increase except for starch, pectin, crude fibre and ascorbic acid, which reduced from T_1 to T_3. The TSS, sugars (reducing and total), titratable acidity, standard plate counts increased significantly during 6 months storage, whereas non-reducing sugars, starch, pectin, crude fibre and ascorbic acid content decreased at various storage intervals. The changes during storage, in general, were similar to any other sauce and were not specific for apple pomace sauce alone. The product remained acceptable for the whole period of 6 months storage at room temperature.

Keywords: Apple pomace, Sauce, Quality, Waste, Storage, Sensory evaluation, Microbial evaluation.

Apple is one of the important fruit crops produced all over the world. In India, its production is confined to the temperate climate and is grown mainly in the northern states including Himachal Pradesh (Anon 1993). It is utilized mostly for the table purpose, but a significant portion is processed into various products such as fruit juice concentrate, single strength apple juice and fermented products, viz., cider, wine and vermouth (Amerine et al. 1980; Downing 1989; Joshi et al. 1991; Joshi 1995).

After the production of juice, the leftover material is the pomace. The accumulation of apple pomace in the processing factories creates pollution problems. Apple pomace is a rich source of fibres, minerals and carbohydrates (Downing 1989) and has potential for its utilization. So far, no technology for its utilization has been developed by the processing industries. In the developed countries, it is utilized for the production of pectin, alcohol and citric acid. Some of these products require costly chemicals for extraction, as in case of pectin. Moreover, after extraction, it generates large quantity of waste, requiring further treatment before its discharge into the environment. Thus, the utilization of the entire apple pomace shall be one of the right approaches. Such an attempt has been made to utilize apple pomace for the production of edible products. Details on preparation and evaluation of apple pomace sauce are presented in this communication.

Apple pomace: Apple pomace from apples of the three stages of maturity, viz., August, September and October, 1991 was collected directly from the plant outlet of the Horticultural Produce Processing and Marketing Corporation (hpmc) and was brought to the laboratory in clean polyethylene bags. The pomace was converted into pulp by adding water at the standardized ratio of 1:3 of pomace and water. Such apple pomace pulp was utilized for the preparation of sauce.

Apple pomace sauce: Three different products with respect to varying ratios of pulp and sugar were evaluated for standardization purposes. Three sugar levels, viz., 90 g, (T_1), 120 g (T_2) and 150 g (T_3) per kg of pulp were used with final TSS of 15, 20 and 25°B of the prepared sauce. Apart from sugar, the recipe contained salt 20 g, spices 5 g, chillies 80 g, garlic (chopped) 5 g, ginger (chopped) 5 g, onion (chopped) 5 g per kg pulp used. Acetic acid was added to give final acidity of 1.2% (as acetic acid). Sauce was prepared according to the conventional method (Cruess 1958). It was filled hot (85°C) in clean sterilized bottles, which were processed in hot water (85°C) for 15-20 min.

Storage: The products from apple pomace, at different stages of apple maturity and using different recipes, were stored at ambient temperature (15-25°C) for a period of 6 months. Observations on different physico-chemical, microbiological and sensory qualities were made at an interval of 2 months.

Analyses: Total soluble solids (TSS) of the sauce were measured by hand refractometer and the results were expressed as °Brix. The titratable acidity was estimated as per the method of AOAC (1980). Starch was estimated by the method given by Ranganna (1986). Pectin was determined by

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Carre and Hayne's method as described by Ranganna (1986). Microbial counts were taken as standard plate counts by pour plate method, described by Harrigan and McCance (1966), while the counts were expressed as log colony forming units (cfu/g). Sensory analysis of fresh and stored sauce was carried out by a semi-trained panel of 10 judges. All precautions, including coding of samples, were taken to obtain unbiased evaluations (Ranganna 1986; Piggot 1988). Grading for colour, consistency, flavour, taste and absence of defects was done, based on the scoring procedure - not acceptable: 10, C grade: 10-12, B grade: 12-14, A grade: 14-16 and excellent grade: 16.

The data on physico-chemical characteristics of sauce were analyzed by CRD, while those of sensory evaluation were analyzed by RBD, as described by Mahony (1985). The significance of difference between mean values for main factors, irrespective of the other factors, is presented in Tables 1 and 2 (as reflected by critical difference required for 5% level of significance).

Effect of different stages: The stage of maturity of the apple significantly affected all the parameters, except TSS (Table 1). Reducing sugars and acidity increased, while TSS, total and non-reducing sugars, Brix-acid ratios, starch, pectin, crude fibre and ascorbic acid contents declined from stage I to III. The differences could be traced back to the initial values of these parameters, found in the fruits at different levels of maturity (Hulme 1971; Kilara and Buren 1989). The stages of pomace collection also affected significantly the sensory qualities of fresh apple pomace sauce. It is clear that sauce prepared from stage II pomace had the highest mean scores for all the sensory characteristics.

Effect of different treatments: A perusal of the data indicates that the different treatments had significant effect on the average TSS, total sugars, reducing sugars, non-reducing sugars, titratable acidity, Brix-acid ratio, starch, pectin, crude fibre and ascorbic acid contents of the fresh apple pomace sauce (Table 1). Among these, TSS, total sugars, reducing sugars, non-reducing sugars and Brix-acid ratio showed an increase, while starch, pectin, crude fibre and ascorbic acid contents registered a decrease from T_1 to T_3. The highest titratable acidity was recorded in T_2 and the lowest in T_1 or T_3.

The differences in TSS and sugars were evidently due to the treatment variation, viz., sugar and Brix. The Brix-acid ratio in apple sauce ranged from 25 to 60 (Downing 1989). However, based on F.P.O. specifications for sauce (minimum TSS of 15°Brix

TABLE 1. EFFECT OF DIFFERENT STAGES AND TREATMENTS ON THE PHYSICO-CHEMICAL AND SENSORY CHARACTERISTICS OF APPLE POMACE SAUCE

Quality parameters	Apple pomace sauce							
	Stages				Treatments			
	I	II	III	C.D.$_{0.05}$	T_1	T_2	T_3	C.D.$_{0.05}$
Physico-chemical								
Total soluble solids, °B	27.77	27.72	27.72	NS	15.65	20.66	25.90	0.05
Total sugars, %	17.26	17.19	17.19	0.060	12.88	16.89	21.86	0.01
Reducing sugars, %	12.90	12.94	13.00	0.030	9.37	12.72	16.75	0.03
Non-reducing sugars, %	4.13	4.01	3.97	0.005	3.31	3.95	4.84	0.01
Titratable acidity, %	1.22	1.24	1.25	0.004	1.23	1.24	1.23	0.01
Brix-Acid Ratio	17.05	16.68	16.57	0.360	12.71	16.61	20.97	0.36
Starch, %	0.83	0.88	0.73	0.003	0.86	0.81	0.78	0.01
Pectin, %	0.89	0.84	0.77	0.003	0.87	0.84	0.81	0.01
Crude fibre, %	4.69	4.19	3.86	0.004	4.33	4.24	4.17	0.01
Ascorbic acid, mg/100g	1.90	1.86	1.84	0.001	1.89	1.86	1.84	0.01
Sensory								
Colour	14.24	15.30	14.45	0.22	13.04	15.52	15.42	0.22
Consistency	14.00	14.30	13.84	0.22	12.95	14.81	13.39	0.22
Flavour	14.24	14.89	14.10	0.26	13.50	15.30	14.44	0.26
Taste	14.84	14.95	14.46	0.25	13.50	15.69	15.06	0.25
Absence of defects	14.91	15.00	14.44	0.24	13.56	15.75	15.05	0.24

Stages I, II & III - Apple pomace collected in August, September, October 1991

T_1 = 90 g sugar, 15° Brix, T_2 = 120 g sugar, 20° Brix, T_3 = 150 g sugar, 25° Brix

C.D.$_{0.05}$ = Critical difference at 5% level of significance

TABLE 2 EFFECT OF DIFFERENT STORAGE PERIODS ON THE PHYSICO-CHEMICAL CHARACTERISTICS AND TOTAL MICROBIAL COUNTS (cfu/g) OF APPLE POMACE SAUCE

Parameters	Storage period, month 0	2	4	6	$C.D._{0.05}$
Physico-chemical					
Total soluble solids, °B	20.00	20.66	20.94	21.42	0.05
Total sugars, %	17.15	17.20	17.23	17.26	0.008
Reducing sugars, %	11.69	12.28	13.18	14.63	0.03
Non-reducing sugars, %	5.18	4.65	3.81	2.49	0.006
Titratable acidity, %	1.20	1.22	1.24	1.27	0.004
°Brix-acid ratio	16.59	16.92	16.78	16.77	NS
Starch, %	0.92	0.83	0.78	0.74	0.004
Pectin, %	0.91	0.86	0.82	0.76	0.004
Crude fibre, %	4.31	4.27	4.23	4.18	0.005
Ascorbic acid, mg/100g	3.14	2.28	1.39	0.64	0.002
Sensory					
Colour	15.04	14.94	14.53	14.18	0.25
Consistency	14.55	14.28	13.90	13.46	0.26
Flavour	14.95	14.54	14.27	13.87	0.30
Taste	15.35	15.02	14.55	14.07	0.29
Absence of defects	15.41	15.11	14.55	14.07	0.28
Total microbial counts, cfu/g					
Treatments					
T_1 90 g sugar, 15° Brix	0	1.44	3.07	3.04	
T_2 120 g sugar, 25° Brix	0	1.44	3.11	3.14	NA
T_3 150 g sugar, 25° Brix	0	1.50	3.11	3.07	

NA - Not analyzed by CRD

and acid of 1.2%), the value works out to be 12.5. Hence, the product could be stated to be within the acceptable range of Brix-acid ratio. Considering the absolute value (0.46%) of crude fibres in apple sauce (Downing 1989), the apple pomace sauce contained higher amounts of crude fibre, due to the presence of the higher amounts of crude fibre in the apple pomace.

Different treatments significantly affected the sensory quality and treatment T_2 (120 g sugar, 20°Brix), which scored the maximum for all the sensory attributes, was adjudged to be the best.

Effect of different storage periods: Storage periods significantly affected all the parameters, except for the Brix-acid ratio of apple pomace sauce, whereas the TSS, total and reducing sugars and titratable acidity increased during storage for 6 months (Table 2). Other parameters, like non-reducing sugars, starch, pectin, crude fibre and ascorbic acid contents, decreased at various storage intervals. The increase in TSS was probably due to partial loss of moisture and partly to the conversion of insoluble constituents into soluble forms. Ragab (1987) has reported a similar trend in change in respect of TSS in the apricot jam during storage.

There were no drastic changes in total sugars, though it increased gradually as observed earlier (Heikal et al. 1964; Sarhan et al. 1971). The increase in reducing sugars and decrease in non-reducing sugars is the result of the hydrolysis of non-reducing sugars into reducing sugars (Ragab 1987). The results of titratable acidity are in accordance with those obtained by Ragab (1987), but are contrary to those reported by Bhatnagar et al (1984) and Bhatnagar (1991) for muskmelon jam. The decreases in starch, pectin and crude fibre contents during the storage are attributed to the hydrolysis of starch, conversion of insoluble pectin into soluble fractions and degradation of crude fibres (Heikal et al. 1964; Sarhan et al. 1971; Bhatnagar et al. 1984; Tripathi et al. 1988). Ascorbic acid content decreased during storage, due to its oxidation or degradation, as discussed earlier.

All the treatments showed absence of microbial population just after the preparation (0 month storage). Low counts were observed in the later stages of storage (Table 2), which could be due to the survival of microbial spores during the thermal processing conditions used for sauce processing or contamination during filling or from ingredients used. The storage periods had significantly affected the different sensory qualities of apple pomace sauce. The average scores decreased for all the parameters at the maximum storage of 6 months. Based upon the grade score limits, however, the product remained within the range of A and B grades.

It is evident that the storage behaviour of apple pomace sauce is not specific and the changes are similar to those in other products during the storage. Based on the findings, the apple pomace sauce from stage II (September maturity of apple) and treatment T_2 (120 g sugar, 20° Brix) was the best product, within the F.P.O. specifications. It could be stored for a period of 6 months, without significant deterioration of quality of the product.

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Physico-chemical Characteristics of Commercial Spiced *Papads*

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Physico-chemical characteristics of commercial spiced *papads*, being manufactured in Uttar Pradesh, were determined. Data revealed wide variations in moisture content (9.0 to 17.1%), total ash (7.2 to 11.8%), acid insoluble ash (0.18 to 0.52%), alkalinity of ash as Na_2CO_3 (1.25 to 3.37%), ether extract (2.2 to 5.8%) and pH of aqueous extract (7.4 to 9.1). Analysis of physical parameters of *papads* also showed wide variations in mean weight (6-24 g), average diam (9.4-21.5 cm) and mean thickness (0.5-1.2 mm). Frequency distribution was drawn for each physico-chemical characteristic of *papads*, and results were examined for compliance with the existing quality standards. Improvements in the existing manufacturing conditions have been suggested in order to improve the quality characteristics of *papads*.

Keywords: *Papads*, Savoury preparation, Physico-chemical composition, Deep-fat-frying, Frequency distribution.

Several indigenous traditional savoury preparations are being manufactured and extensively consumed in India. Among these, *papad* constitutes an important food adjunct, being manufactured on cottage scale. The manufacture of *papads* is not an organised industry. Generally, *papads* are made from a blend of pulse flour (blackgram, greengram or both), cereal flour and edible starch with other ingredients, viz., common salt, edible oil, spices and *papad khar*, containing sodium carbonate/ sodium bicarbonate. There are no systematic data available on production of *papads* in India. However, only export figures are available. There has been a growing demand of this important class of savoury product in India and abroad. During 1988-89, *papads* worth Rs. 64 millions were exported (Jasol 1990), in comparison to 3343 tonnes worth Rs. 49 millions in 1986-87 (Jasol 1988).

Extensive work on proximate composition, packaging, storage and quality control of *papads* in India has been reported (Shurpalekar et al. 1970; Pruthi et al. 1984; Manan et al. 1988). Systematic studies on the survey of *papad* manufacturing units in Uttar Pradesh, acceptability of commercial samples, its packaging and shelf-life have been reported recently (Manan et al. 1996). However, published information on the proximate composition of commercial spiced *papads* is rather scanty. The present communication deals with the proximate composition of spiced *papads*, being manufactured in the State of Uttar Pradesh and its compliance with the existing Indian standards.

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Physico-chemical analysis: Samples of freshly prepared spiced *papads*, based on blackgram and blend of blackgram and greengram flour, were procured directly from 20 manufacturing units, spread over 4 important towns of Uttar Pradesh, namely Agra, Allahabad, Kanpur and Lucknow. All the samples were taken immediately for subsequent physical and chemical analysis. These samples were analyzed in duplicate for moisture, total ash, acid insoluble ash, alkalinity, ether extracts, pH, weight, diam and thickness according to ISI methods (ISI 1972). Peroxide value (PV) and free fatty acid content of oil, extracted from *papad* by using ether were determined by AOCS (985) methods. Protein and common salt (Nacl) were estimated by AOAC (1976) methods. Diametric expansion of *papads* was determined by the difference in the diam before and after deep-fat frying and expressed as percentage. The results of these data were statistically analyzed for variance to find out the level of significance as per the method given by Steel and Torries (1980).

Frequency distribution of physico-chemical parameters, viz., moisture, total ash, acid insoluble ash, common salt, ether extractives, alkalinity of ash, and pH of 20 commercial spiced *papads* are given in Table 1. The results were assessed for compliance with ISI standards.

Physico-chemical composition of commercial papads: The range and mean values for each physico-chemical characteristics of *papads* are given in Table 1. Data revealed wide variations in physico-chemical characteristics of *papads*. Moisture content of *papads* ranged from 9.0 to 17.7%, total ash from 7.2 to 11.8%, acid insoluble ash from

0.18 to 0.52%, ether extractives from 2.2 to 5.8%, alkalinity from 1.25 to 3.37%, common salt (as sodium chloride) from 3.4 to 6.0%, pH from 7.4 to 9.1%, protein from 9.8 to 19.2%, peroxide value of solvent extracted fat from 0.21 to 0.32 meq O_2/kg product, free fatty acid content (as oleic acid) from 0.51 to 0.58%, diametric expansion of deep-fat-fried *papads* from 4.8 to 17.8%, average weight from 6.2 to 25.8% g, average diam from 9.4 to 21.5 cm and thickness from 0.5 to 1.2 mm.

Frequency distribution of each physico-chemical parameters of 20 samples of the commercial *papads* was drawn and studied for compliance with ISI standards. The data provided important information.

Moisture content of 11 samples fell between 12.0 and 15.0%, with an average of 13.1%, thereby conforming to the existing ISI standards for *papads* (ISI 1972), while 5 samples were having moisture contents more than the prescribed ISI limits. Total ash contents of all the 20 samples were within the limits (max. 12.0%) and conformed well to the existing standards. Wide variations (0.18-0.52%) were observed in acid insoluble ash contents. Out of 20 samples collected, only 4 samples were within ISI limit (0.2% max.), while the remaining 16 samples were having higher than the prescribed limit. Common salt contents of all the samples were between 4.0 and 6.0%, thereby conforming to ISI standards. Ether extractives of 6 samples conformed to the existing specifications (max. 3.0%), while the remaining 14 samples showed higher values. Alkalinity of ash of 8 samples conformed to the existing standards (max. 0.2%), whereas 12 samples had alkalinity above the specified limit. The pH values of aqueous extract of 7 samples were within the ISI standards. In remaining 13 samples, the pH values were above the prescribed limits. Average diam and thickness of 20 commercial samples were within the ISI limits, while wide variations (6.2-24.5 g) were observed in average weight of *papads*. Out of 20 samples, only 5 were within the limit prescribed by ISI.

The analysis of different commercial *papads* has shown that most of the chemical parameters do not conform to the ISI standards, except for the total ash and common salt contents.

Moisture is the most important factor to keep the product in good condition during storage. *Papads* should be dried to a desired level of moisture (13-14%), so that these would be pliable at the time of packaging. *Papads* should neither be over-dried nor under-dried. If they are over-dried, *papads* become brittle and break. If under-dried, fungal attack occurs during storage. Use of good quality blackgram or greengram *dhal* flour, salt, sodium carbonate or sodium bicarbonate

TABLE 1. VARIATION IN PHYSICO-CHEMICAL CHARACTERISTICS OF SPICED *PAPADS* MANUFACTURED IN UTTAR PRADESH

Characteristics	Range	Mean ± S E	ISI standard	No. of samples in conformation with ISI standards
Chemical parameters				
Moisture, %	9.0 - 17.7	13.1 ± 2.0	12 - 15	11
Total ash, %	7.2 - 11.8	9.1 ± 1.2	Max. 12.0	20
Acid insoluable ash, %	0.2 - 0.5	0.3 ± 0.1	Max. 0.2	4
Ether extractives, %	2.2 - 5.8	3.9 ± 1.1	Max. 3.0	6
Salt (as NaCl), %	3.4 - 6.0	4.8 ± 0.8	Max. 6.0	20
Alkalinity of ash as Na_2CO_3, %	1.3 - 3.4	2.4 ± 0.6	Max. 2.2	8
pH (aqueous extract)	7.4 - 9.1	8.4 ± 2.9	8.0	7
Protein (N x 6.25), %	9.8 - 19.3	16.0 ± 2.2	Nil	Nil
Peroxide value (meq O_2/kg product)	0.2 - 0.3	0.26 ± 0.02	Nil	Nil
Free fatty acid, % (as oleic acid)	0.5 - 0.6	0.55 ± 0.02	Nil	Nil
Physical parameters				
Weight, g	6.2 - 24.5	13.8 ± 6.32	15 - 23	5
Diam, cm	9.4 - 21.5	15.8 ± 3.11	5 - 23	20
Thickness, mm	0.5 - 1.2	0.81 ± 0.21	0.5 - 1.2	20
Expansion, %	4.8 - 17.8	10.7 ± 4.35	Nil	Nil

Each value is average of two determinations and each parameter had 20 replicates

helps to obtain *papads* with acid insolubles within the prescribed limits (0.2% max.). The undesirable quality parameters, like presence of holes, cracked edges and the visible foreign matter on the surface of *papads* should be avoided. Manufactures may use minimum quantity of edible oil in the dough during preparation of *papads*, so that not only ether extractives conform to the prescribed limits, but also development of rancidity is prevented during subsequent storage of *papads* at ambient conditions. Based on chemical analysis of commercial *papads*, it may be concluded that there is a need to improve the quality standard of *papads*, being produced in a few manufacturing units in the State of Uttar Pradesh.

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Detection of Wheat Protein in Sausages by DOT-EIA Technique

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A simple immunological technique (DOT-EIA) for the wheat protein detection in the heat processed meat products and sausages has been developed. It involves extraction of wheat protein with TRIS-NaCl buffer from the commercial samples, such as sausages and meat products (containing wheat flour) as well as subjecting the extract to an immunological test DOT-EIA. The quantitative evaluation of the test was by the spectrophotometric determination of the violet colour on the surfaces of the nitrocellulose (NC) strips, after the immunological staining of the samples and comparison with the spots of the calibration standards. The screening of the samples by DOT-EIA procedure proved to be an efficient method for wheat flour determination in the cooked meat products at 0.2% level of the wheat protein.

Keywords: Wheat flour, Wheat protein, DOT-EIA, Sausage, Immunodetection, Meat product.

Proteins of non-meat origin are added to meat products to improve the water binding capacity of the meat. Its use results in less water exudation upon sterilization and also provides a better emulsion of the fat particles in case of comminuted meat products (Janssen et al. 1994). The low cost of wheat gluten, together with its physico-chemical characteristics, makes it ideal to bind meat fragments in processed meats, thereby leading to widespread use of gluten or wheat flour as an extender (Skerritt and Hill 1990). Many other types of non-meat proteins have also been used in the past, of which casein and soy proteins are used frequently (Janssen et al. 1994). The correct identification of the wheat protein concentration in the heat processed meat products is important to the consumer for several reasons. For example, the possible economic loss due to fradulent substitution or adulteration, which is connected with the need of the quantitative control of the wheat protein in case of possible overdose or illegal addition. The large number of individuals are unable to tolerate wheat protein and gluten-like proteins from rye and barley (Skerritt and Hill 1990). The best example of such condition is the enteropathy - celiac disease (Marsch 1992). Non-immunochemical methods for the detection of vegetable proteins (Olsman and Hitchcock 1980; Kaiser and Krause 1985) are not adequately sensitive and specific (Medina 1988). It is difficult to quantify wheat protein for regulatory or quality control purposes, especially after foods have been cooked or processed (Skerritt and Hill 1990).

The immunological methods, like immunodiffusion and immunoelectrophoresis (Kaltwasser et al. 1984) have been extensively used to detect non-meat proteins in the raw meat products (Janssen et al. 1987). Hitchcock et al (1981) succeeded in overcoming this obstacle by using a highly sensitive enzyme-linked immunosorbent assay (ELISA) to determine soy protein in meat products. A more simple immunological method, based on dot immunoassay (DOT-EIA), to detect soy protein in the meat products was reported by Janssen et al (1985; 1987). The use of enzyme-immuno-assays in food analysis is finding an increasing application (Patterson and Jones 1985). DOT-EIA can be used accurately and reliably in the quality control and the quality assurance programs (Berkowitz 1990).

The aim of this study was to develop a simple, rapid, cheap and sufficiently sensitive immunological detection technique (DOT-EIA), that can measure wheat protein in the heat processed meat products.

The wheat protein was isolated by repeated extraction with TRIS/NaCl buffer (0.02 mol. l^{-1}, 0.5 mol. l^{-1}) from the wheat flour according to the method of Spencer et al (1988). The freeze-dried extract consists of the polypeptides with the molecular weights of 61, 36, 21 and 8 kD. It was confirmed by sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) (Laemmli 1970). The protein, after the heat treatment (100°C for 5 min) in the water bath, was used for the immunisation of four rabbits ('New Zealand white'), according to usual immunisation scheme (Dunbar and Schwoebel 1990). The achieved titre of wheat protein antiserum was 1:3000. The cross-reactions of the immunoglobulins prepared were tested with

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TABLE 1 PROTOCOL FOR IMMUNOPEROXIDASE STAINING PROCEDURE

Procedure	Solution	Dilution	time, min
Blocking of active sites	[a]	---	15
Primary antiserum	[b]	---	20
Washing	TBS-Tween 20	---	3 x 5
Linking antiserum	swine antirabbit IgG antiserum[c]	300	20
Washing	TBS-Tween 20	---	3 x 5
Substrate	4-chloro-1-naphthol and H_2O_2[d]		5 - 7[e]
Washing	TBS-Tween 20	---	3 x 5
Washing	bidistilled water		
Air drying of the NC plates in the dark			

[a] - 5% skim milk powder in TBS buffer (10 mM Tris-HCl, 0.9% NaCl, pH 7.2) plus Tween 20 (0.02%) (Serva),

[b] - Both the primary antisera were of rabbit allotype,

[c] - The available lot of the mentioned antiserum (SwaRPx - USOL Praha - Czech Republik) was used at a dilution of 1 : 300 with the TBS buffer (pH 7.2),

[d] - Substrate : 25 mg of 4-chloro-1-naphthol (Serva) was dissolved in 5 ml ethanol. and mixed with 45 ml of TBS buffer. It was filtered after 3 min and 0.1 ml of hydrogen peroxide (3%) was added to the filtrate,

[e] - Colour development took place within a few minutes

the proteins isolated from pork and beef. The antiserum as prepared above and also the antiserum provided by Research Institute of Plant Production, Piestany (Slovak Republic) were used in DOT-EIA as a primary antibody.

The model meat products (wheat flour added) were heat processed at 100°C for 5 min in water bath. The final concentrations of the added wheat flour were 3.2, 1.6, 0.8, 0.4 and 0.2%. Commercial cooked sausage products, S, P and PF (containing wheat protein) as well as D, L and P (wheat protein absent) were obtained from the local market. The commercial sausage products were chopped and ground at room temperature, until a paste was formed. The meat-paste was treated with acetone at the temperature 0°C for 60 min (meat-paste - acetone ratio 1:4). Acetone was decanted after centrifugation at 2000 g for 15 min. The wheat protein was isolated in two steps from the sediment by continuous stirring with TRIS-NaCl buffer (0.02 mol. l^{-1} TRIS and 0.5 mol. l^{-1} NaCl) for 60 min at the room temperature. The supernatants were decanted after centrifugations at 2000 **g** for 15 min. These were used as the extracts of the commercial cooked sausages for the DOT-EIA testing. The standards a) diluted freeze-dried wheat protein serial diluted in TRIS-NaCl buffer (1200, 600, 300, 150 and 75 ng. ml^{-1}) and b) wheat protein, isolated from the model meat products in the same way as from the commercial cooked sausage products, were applied to a dry nitrocellulose (NC) foil (Farby Laky n.p., Czech Republic) in triplicate (each drop of 5 µl). The extracts from the commercial cooked sausage products were also applied to NC foil. Three blanks containing TBS buffer, BSA (bovine

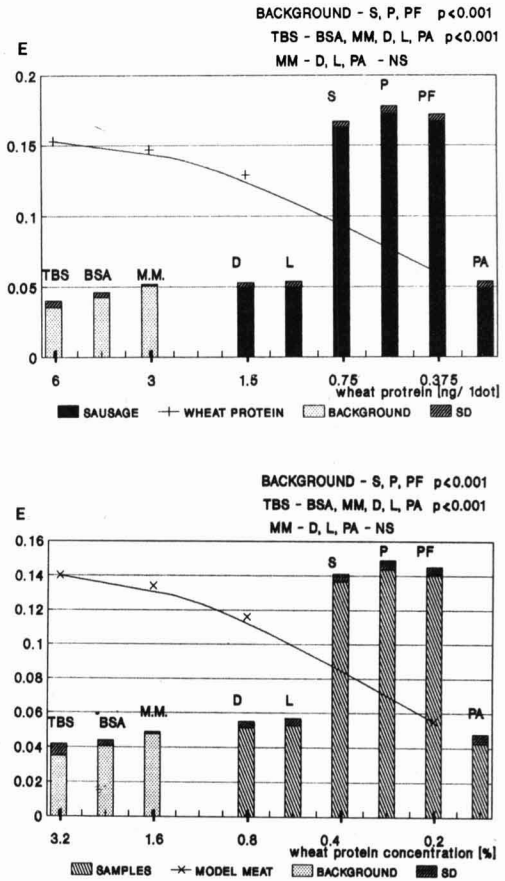

Fig. 1. The plot of amounts of wheat protein (albumin and globulin fraction) measured by dot-blot technique after spectrophotometric quantitation in :
Above : Commercial cooked sausage products by using diluted freeze dried wheat protein as a calibration standard.
Below : Commercial cooked sausage products - protein isolated from the model meat product was used as calibration standard.
MM - model meat (wheat protein absent)
D, P, PA, PF, S, L - commercial sausages
TBS buffer - (0, 02 mol.l^{-1} TRIS, 0,5 mol.l^{-1} NaCl)
BSA - bovine serum albumin (1 mg.ml^{-1}) (Merck)
[5 µl of the wheat protein extract was applied on 1 dot]

serum albumin) and model meat product (wheat flour absent) were also analyzed to determine non-specific binding to the solid phase.

The plates were incubated at room temperature (30 min) to allow binding of the antigen to the solid phase. The protocol of immunoperoxidase staining is illustrated in Table 1. Additionally, the NC plates were cut in strips. Each strip contained one sample applied in triplicate was kept in acetone (1 ml). The absorbances of the violet colour formed on the NC surfaces were determined spectrophotometrically at 580 nm (Volker et al. 1989). Statistical analysis of the data were performed by analysis of variance. The differences between the measurements were assessed by t-test.

Fig. 1 sumarises the results obtained in DOT-EIA study of the wheat protein determination in the commercial cooked sausage products by using a) freeze-dried wheat protein as a calibration standard and b) the extracts from the model meat products, after spectrophotometric evaluation of the intensity of the colour formed on the NC foil. The most suitable system for the calibration was the use of the extracts from the model meat products (wheat flour added). The background, created by the animal protein of the model meat products was identical to the background, created by the animal protein occurring in the commercial meat products. The tests carried out with the samples of antisera gave comparable results. The false positives from cross-reactivities and non-specific binding of immunochemicals were not observed.

The results show that wheat protein in the model meat products and in the sausage products can be determined directly from the standard curves. Significant differences between the absorbance of the heat processed sausages with the addition of the wheat protein (S, P, PF), sausages D, L, PA (wheat protein absent) and three blanks (TBS, BSA, model meat product without wheat protein) were observed. The sensitivity limit of the wheat protein detection was 0.2% (i.e., 0.375 ng of applied isolated wheat protein) in the immunological staining system developed and this is comparable with other known test methods. Janssen et al (1987) used electroblotting for the detection of soy protein and wheat gluten at 0.1% level. Medina (1988) applied an indirect ELISA procedure for detection and measurement of soy protein in the model frankfurters and commercially obtained cooked as well as uncooked sausages, after carbonate buffer extraction. He was able to quantify soy protein content in the range 0-5%. Thus, the direct dot blotting of the extracts on a nitrocellulose foil proves to be a very efficient and low-cost method for analysis of a number of samples with a very low content of the non-meat protein. The key to successful enhancement of the DOT-EIAs detection limit is the isolation of the native heat-resistant antigens and the preparation of the specific antisera.

In conclusion, a method which is a simple immunological assay (DOT-EIA) based on the rapid quantitative determination of wheat protein in the heat processed meat products has been described. This system made it possible to detect non-meat proteins at 0.2% level (i.e., 0.275 ng of applied isolated wheat protein). Since the antiwheat-antiserum showed no cross-reactivity or detectable binding with pork or beef protein, this technique can be used for the detection of wheat protein in meat products prepared from the above mentioned types of meat.

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Effect of Deep-frying on Cholesterol Oxidation in *Ghee*

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Formation of cholesterol oxidation products (COPs) in *ghee* during deep-frying was studied, as they were reported to cause arteriosclerotic lesions. COPs were formed, when *ghee* was used for deep-frying for 15 min. The level of COPs increased with frying time. *Ghee* residue, being a good antioxidant, delayed the formation of COPs during deep-frying.

Keywords: Cholesterol, Cholesterol oxidation, *Ghee*, Deep frying, Antioxidants.

Ghee, a major dairy product in India, contains 0.3-0.4% cholesterol. Dietary cholesterol is considered a risk factor in causing atherosclerosis. Studies have shown, however, that cholesterol oxidation products (COPs), which can result from processing and storage of foodstuffs may be the cause for arteriosclerotic lesions, while deposits of cholesterol merely represent a secondary process (Bosinger et al. 1993). Our earlier studies have shown that *ghee* manufactured and stored under normal conditions did not contain COPs and they were formed, only when the samples underwent autoxidation to such an extent that *ghee* became unacceptable for consumption (Nath and Murthy 1988). *Ghee* is used as a frying medium in the preparation of a number of Indian sweets, *purees* etc. in addition to its use in other culinary purposes. The fat gets thermally oxidized to a great extent during frying (Rai and Narayanan 1986). A number of detrimental changes such as formation of polymers, cyclic compounds, hydroxy acids, peroxides etc. take place in *ghee* during frying (Rai 1982). The present work was undertaken to study the effect of frying on cholesterol oxidation in *ghee* and the results are reported in this communication.

Ghee was prepared by clarifying butter at 120°C for 10 min and filtering through cheese cloth. Five hundred g *ghee*, taken in a stainless steel frying pan, was brought to the temperature of about 150°C with continuous heating on a heater. Wheat flour was made into dough by using about 65 ml water for every 150 g flour. The dough was divided into small balls and the balls were pressed in a *puree* press. The *purees* were deep-fried one after the other, continuously. Each frying took 30-40 sec. The *ghee* samples were collected from the frying pan, after every 15 min.

Five g *ghee* samples were saponified with 50 ml alcoholic potassium hydroxide (1.5 N) for 2 h under nitrogen. Unsaponifiable matter (USM) was then extracted with 4 x 100 ml diethyl ether and the extract was washed with 0.5 N aqueous potassium hydroxide (4 x 100 ml), followed by water, till the extract became alkali-free. Ether was evaporated under reduced pressure and the USM was extracted with 5 ml chloroform.

The USM was screened for COPs on silica gel TLC plates, developed in a mobile phase of ethyl ether and petroleum ether (60:40). Cholesterol and its oxides were visualised by spraying the plates with 10% copper sulphate in 8% orthophosphoric acid, followed by heating at 110-120°C. The chromatograms were also sprayed with 50% sulphuric acid, p-toluene sulphonic acid and 10% alcoholic phosphotungstic acid, to confirm the identity of cholesterol oxidation products by their characteristic colour reactions. The cholesterol

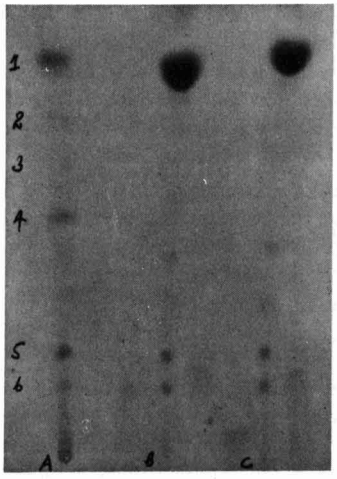

Fig. 1. TLC pattern of unsaponifiable matter of (A) *Ghee* fried for 30 min, (B) *Ghee* fried for 15 min and (C) *Ghee* fried for 60 min in the presence of *ghee* residue.
(1) Cholesterol (2) 3, 5 - Cholestadien-7-one
(3) 5-Cholesten-3-one (4) 5-Cholesten-3 ß-ol-7-one
(5) 5-Cholesten-3ß-7ß-diol (6) 5-Cholesten-3ß-7α-diol

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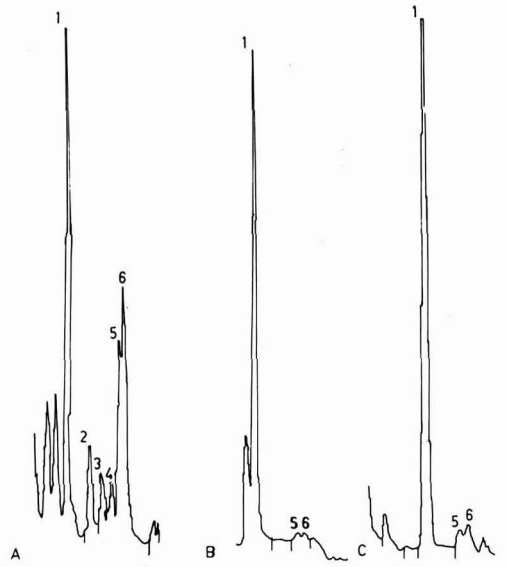

Fig. 2. TLC-FID pattern of unsaponifiable matter of (A) *Ghee* fried for 30 min, (B) Ghee fried for 15 min and (C) Ghee fried for 60 min in the presence of *ghee* residue.
(1) Cholesterol (2) 3, 5 - Cholestadien-7-one
(3) 5-Cholesten-3-one (4) 5-Cholesten-3 β-ol-7-one
(5) 5-Cholesten-3β-7β-diol (6) 5-Cholesten-3β-7α-diol

oxides, separated from the samples, were tentatively identified by comparison with authentic compounds, namely, 5-cholesten-3ß, 7 α-diol, 5-cholesten-3β, 7β-diol, 5-cholesten-3-one, 5-cholesten-3β-ol-7-one, 3, 5-cholestadien-7-one and 5-cholesten-3β, 25-diol (Steraloids Inc., USA). The cholesterol oxides were also separated on chromorods (SII), using a similar solvent system of TLC and scanned by a flame ionization detector, using the technique of TLC-FID (Iatroscan, Iatron Lab. Inc., Japan). Rate of oxidation was assessed by estimating peroxide values of *ghee* samples by ISI (1981) method.

The TLC screening of USM, isolated from fresh *ghee* and the samples collected in the beginning of frying, did not reveal the presence of cholesterol oxides. These samples have not undergone any autoxidation, as indicated by peroxide value, which was nil. The samples, collected after 15 min frying, showed presence of cholesterol oxides, which were tentatively identified as 5-cholesten-3β-7α-diol and 5-cholesten-3β, 7β-diol (Fig. 1). The peroxide value in the samples was 6.7. In an earlier work, formation of cholesterol oxides in *ghee* samples, stored at room temperature, has been reported at peroxide values of 10 and above (Nath and Murthy 1988).

In the present study, cholesterol oxides were formed, even before the peroxide value reached 10. This can be attributed to the drastic heating conditions, to which *ghee* is subjected during frying and the faster rate of peroxide decomposition, than their formation. *Ghee* fried for 30 min, showed the presence of 5-cholesten-3-one, 5-cholesten-3β-ol-7-one and 3, 5-cholesten-dien-7-one, in addition to the above mentioned two oxides (Fig. 1). The peroxide value of this sample was 10.8. The TLC-FID analyses also showed the presence of one peak of cholesterol, in case of fresh *ghee* and the sample collected at the beginning of frying, while the samples, collected after 15 min, showed the presence of cholesterol oxides, similar to the TLC pattern (Fig. 2). Both TLC and TLC-FID results also showed that there was an increase in the level of 5-cholesten-3β, 7 α-diol and 5-cholesten-3β, 7β-diol, with frying time. This indicated that cholesterol oxidation progressed during frying. Rai and Narayanan (1986) have observed that level of cholesterol decreased in *ghee* during frying.

The loss of cholesterol in *ghee* was more, when it was heated for frying in iron vessels, than when it was done in aluminium or stainless steel vessels. Iron, being a prooxidant, the mechanism of cholesterol autoxidation may be similar to that of unsaturated fatty acids. Parks and Addis (1985) have suggested that the oxidation of cholesterol may be inhibited by mechanisms similar to those, which exert an antioxidant effect upon unsaturated fatty acids. *Ghee* residue was reported to possess very good antioxidant properties (Murthy et al. 1969). In the present study, in the presence of *ghee* residue, cholesterol oxides were noticed, only when *ghee* was used for frying for 60 min. Further work is in progress to develop a method for delaying the formation of cholesterol oxides during frying of *ghee*.

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Hypoglycemic Effect of Processed Fenugreek Seeds in Humans

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Effect of raw, boiled and germinated fenugreek seeds *(Trigonella foenum graecum)* on post-prandial levels in normal (controls) and non-insulin dependent diabetic human subjects was studied. Experimental recipes wherein powdered seeds of raw, boiled and germinated fenugreek were incorporated into the *pongal* (a traditional recipe) at the levels of 12.5 g each were served to the subjects at breakfast. *Pongal* without fenugreek was used as a control. Fasting blood glucose, mean % peak rise, area under curve (AUC) and % glycemic response were studied in all the subjects, before and after consuming the control and experimental recipes. Raw and germinated fenugreek significantly ($P<0.05$) reduced the post-prandial blood glucose levels in all the subjects, as compared to control recipe (without fenugreek) and boiled fenugreek.

Keywords : Fenugreek, *Trigonella foenum graecum*, Raw, Boiled, Germinated, Hypoglycemic effect, Diabetes.

Fenugreek seeds *(Trigonella foenum graecum)*, a common condiment, is known to have anti-diabetic activity. Several studies with humans have shown the hypoglycemic effect of raw fenugreek seeds (Madar et al. 1988; Sharma 1986; Sharma and Raghuram 1990).

However, direct use of the seeds in the diet is limited because of its bitter taste. Traditional processing methods may effect reduction in bitterness of the seeds and make possible their incorporation into various recipes. The glycemic response of such incorporated recipes would have practical significance with reference to diabetic dietaries. Limited information is available on these aspects. The present study, therefore, was undertaken to determine the acceptable levels of incorporation of the raw and processed seeds on glycemic response.

Two kg fenugreek seeds were procured from Andhra Pradesh Seed Development Corporation, Hyderabad. Fenugreek seeds were sorted, cleaned of extraneous matter, washed and sun-dried for 2 h. The dried seeds were divided into three portions. One portion was left unprocessed, while other two portions were germinated or boiled separately.

Germination: Fenugreek seeds were soaked in water at the ratio of 1:5 (w/v) at room temperature for 12 h. Excess water was then discarded and the soaked seeds were kept in a closed container for germination in dark at room temperature for 48 h. The germinating seeds were washed intermittently with tap water every 6 h. The germinated seeds were sun-dried for 6 h and dry weight of the seeds was noted. The seeds were then ground to fine powder, using mortar and pestle.

Boiling: Fenugreek seeds were placed in a steel vessel containing water at the ratio of 1:4 (w/v) and boiled with lid on, for 20 min for softening the seeds. The cooking water was decanted and the seeds were sun-dried for 6 h and powdered in mortar and pestle.

Estimation of fibre: Soluble and insoluble fibre contents in raw, boiled and germinated fenugreek were estimated by using rapid enzymatic assay (Asp et al. 1983).

Feeding trials: Traditional recipe *pongal* was selected as a breakfast item. The effect of raw, boiled and germinated fenugreek on the post-prandial blood glucose levels was studied in normal (control) and non-insulin dependent diabetic subjects.

Preparation of pongal: Green chillies (2 Nos.) and onions (20 g) were chopped longitudinally and kept aside. Mustard (0.14 g) and cumin seeds (0.3 g) were spluttered in hot oil (5 g). Turmeric (0.12 g) was also added to it. Chopped onions and green chillies were then added and fried till the onions turned golden brown. Water (200 ml) was then added and allowed to boil. Rice (60 g) and greengram *dhal* (30 g) (in the proportion of 2:1) were added to boiling water along with salt to taste and pressure-cooked for 20 min.

Preparation of experimental recipes: Powdered seeds of each of raw, boiled and germinated fenugreek were incorporated into the recipe, *pongal* at different levels i.e., 12.5, 15, 18 and 20 g. To find the maximum acceptable levels, the recipes were subjected to evaluation by 20 trained taste

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panel members. The results indicated that germinated fenugreek was acceptable at higher levels, i.e., 18 g, whereas raw and boiled fenugreek seeds were acceptable at 12.5 g each. However, for feeding trials in the present study, the level of addition of raw and processed fenugreek was kept uniform, i.e., 12.5 g for the purpose of comparison of glycemic response in human subjects.

Nutrient composition of the control and experimental recipes was calculated (Narasinga Rao et al. 1990), using nutritive value of Indian Foods.

Selection of the subjects: Six normal healthy male volunteers in the age range of 27-31 years, with body weights ranging from 60-80 kg and with no sign and symptom of any nutritional deficiency along with 6 male, non-insulin dependent diabetic (for the past 2-11 years) volunteers in the range of 42-57 years, with body weights ranging from 51-76 kg were selected for the study. None of the normal controls was on any drug therapy during the course of the study. In diabetics, the drugs were withdrawn one day prior to the experiment to eliminate the residual effect of the drug on glycemia.

On their acceptance to participate in the study, the subjects were appraised of the purpose of the study, place of the study and their need for cooperation in maintaining the time schedule for the study, under the supervision of medical doctor.

Administration of experimental recipes: The subjects were requested to report to the Road Transport Corporation Hospital, Tarnaka, Hyderabad, Andhra Pradesh at 8.30 a.m. after overnight fasting on the day of the study. An interval of 7 days was given between the successive experimental recipes. The experimental recipes were prepared independently for each subject, after accurately weighing the required ingredients. The subjects were requested to consume the entire amount of the recipe and remain non-active, non-smoking during the 2 h test period.

Fasting blood was drawn intravenously from both normal (controls) and diabetic subjects, before consumption of control recipe (without fenugreek) and each of the experimental recipes. The post-prandial blood samples were drawn at 30, 60, 90 and 120 min intervals, after the consumption of control/experimental recipes. The blood samples (to which a pinch of non-agglutination factor (NAF) was added) were contrifuged immediately for the separation of plasma. Plasma glucose was estimated (Boehringer Manneheim Kit) by the glucose-oxidase peroxidase method (Trinder 1969).

The area under 2 glucose response curve (AUC) was calculated for each subject, using the Trapezoid rule for each breakfast item. The AUC of control recipe was taken as the index value of 100 and the ratio of each of the experimental recipes in relation to AUC was calculated. Glycemic response (GR) of each of the experimental recipes in normal (control) and diabetic subjects was computed using the formula.

$$GR = \frac{\text{AUC of experimental recipe}}{\text{AUC of control recipe}} \times 100$$

Statistical analysis: The results were expressed as mean ±SE of mean and the significance of the difference was calculated by the paired student's 't' test. The data were analyzed using the analysis of variance (one way classification). The critical difference was obtained by the least significant difference method (Snedecor 1950).

Nutrient composition of control and experimental recipes were similar with values, ranging as for calories 405-445 K cal, protein 15-18 g, fat 7 to 7.9 g and carbohydrate 71-76 g.

It is observed (Table 1) that the total and soluble fibre contents of raw fenugreek (g %) were higher, as compared to boiled and germinated seeds. In case of insoluble fibre content, no significant variations were found among raw, boiled and germinated seeds. Similar results with raw fenugreek were reported earlier (El-Mahdy and El-Sobaiy 1983; Udayasekhar Rao and Sharma 1987).

It is seen (Table 2) that the fasting blood glucose values in normal controls ranged between 60 and 80 mg/100 ml, with mean value 73.33 mg/100 ml. The peak levels for raw and germinated seeds were obtained after 90 min, as compared to the control recipe, i.e., 60 min, thereby indicating the slow rise in blood glucose levels with experimental recipes I and III. Compared to the control recipe, the blood glucose values and AUC were significantly ($P<0.05$) lower for raw and germinated seeds, than those for boiled seeds. Similar trend was also observed in diabetic subjects

TABLE 1. FIBRE CONTENT OF RAW AND PROCESSED FENUGREEK SEEDS

Type of process	Fibre content of fenugreek seeds, %		
	Total fibre	Soluble fibre	Insoluble fibre
Raw seeds	47.8	18.8	29.0
Boiled seeds	30.0	3.0	27.0
Germinated seeds	33.8	10.0	23.8

Mean of triplicates

TABLE 2. GLYCEMIC RESPONSE OF NORMAL AND DIABETIC HUMAN SUBJECTS TO CONTROL AND EXPERIMENTAL RECIPES (n = 6 EACH)

Blood glucose, mg %	Normal (control)				Diabetic			
	Control recipe	Experimental recipes			Control recipe	Experimental recipes		
	a	I b	II c	III d	a	I b	II c	III d
Fasting	73.3	73.3	74.2	74.0	154.7	157.7	174.2	160.8
	10.3	10.3	11.1	10.9	28.5	53.2	58.8	31.2
30 min	109.3	87.1	93.3	92.8	195.7	198.2	208.7	185.3
	11.5	8.8	11.0	11.6	42.7	66.4	64.5	32.9
60 min	126.5	107.0	113.5	108.3	238.3	215.2	247.7	221.0
	12.7	11.2	10.9	11.1	52.8	75.3	66.9	48.3
90 min	123.3	114.2	134.6	123.3	228.3	216.0	260.7	235.0
	15.2	14.9	18.7	12.7	50.1	60.5	69.6	48.9
180 min	96.5	87.0	102.8	95.3	214.0	212.8	243.3	224.8
	22.1	18.8	27.5	24.6	49.2	63.7	65.2	51.9
Mean % peak rise over fasting	102.4	60.7	83.3	68.5	60.8	45.8	59.6	51.3
	26.7	22.5	14.6	19.3	12.7	17.6	12.7	12.6
AUC, mg/h/dl	5128.3	2855.0	4120.0	3395.0	6840.0	5507.5	6872.5	5725.0
	1348.7	877.4	1040.2	891.8	2176.2	2613.9	947.8	1698.5
% Glycemic response	100	55.5^{ab}	80.8^{ac}	66.4^{ad}	100	78.8^{ab}	97.7^{aa}	84.9^{ad}

Mean values in last column with different superscripts differ significantly ($P < 0.05$) as compared to control.

Control recipe - *Pongal* without fenugreek seeds
Expt. recipe I *Pongal* with raw fenugreek seeds
II *Pongal* with boiled fenugreek seeds
III *Pongal* with germinated fenugreek seeds

(Table 2), though individual differences seem to vary widely.

The lower delayed peak value, reduced rise in plasma glucose and lower AUC observed in experimental recipe I may be due to impaired or delayed gastric emptying or decreased intestinal transit time, which can be ascribed to the high fibre content of fenugreek (Raghuram et al. 1991).

The beneficial effects of fibre in diabetics could be attributed to its effect on the increased efficiency of endogenous insulin to metabolise glucose (Viswanathan et al. 1983). It is also reported that fibre diminishes or translocates the absorption of carbohydrates to a point lower in the gut, where, after colonic conversion, it would be absorbed as volatile fatty acids and not as carbohydrates *per se* (Bond and Levitt 1976). The lower insulin response might be merely due to the lower glucose response. An unknown factor isolated from fenugreek was found to have hypoglycemic activity (Moorthy et al. 1989). The lowered blood glucose levels observed with raw fenugreek may be attributed to the combined effect of fibre and the unidentified hypoglycemic factor present in raw fenugreek seeds.

The reduced hypoglycemic effect of boiled seed over raw or germinated seed may be related to the fact that, during boiling of the seeds, the hypoglycemic principle and soluble fibre (gum) might have leached into the boiling water. Experiments with animals have shown that seed extract/decoction has hypoglycemic effect (Shani et al. 1974; Ghafghazi et al. 1977).

The beneficial effects of germination of fenugreek seed may be attributed to an increase in low methoxy salts of Ca and Mg as well as protopectin. It is probable that formation of these constituents has a role to play in reducing the blood sugar levels or it may also be likely that an active, hypoglycemic principle might have increased during germination (Moorthy et al. 1989). The present study reveals that incorporation of fenugreek (raw/germinated) into the recipe did have a positive effect in controlling blood glucose levels.

Contrary to the belief, regarding effectiveness of fibres with high carbohydrate-high protein diet, the fibre with normal level of carbohydrates and proteins seem to be equally effective. Therefore, a regular inclusion of raw or germinated fenugreek seeds without increasing the amount of carbohydrates or proteins can be advocated for diabetics in the control of blood sugar levels. This also works out to be inexpensive.

Inclusion of germinated fenugreek seeds in the diets of diabetic subjects has an added advantage over raw fenugreek seeds, as germinated fenugreek is less bitter and can also be incorporated into

various recipes, which are commonly consumed by the diabetics. Such incorporation can serve as an effective supportive therapy in the prevention and management of long term complications of diabetics.

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Viscosity and Nutrient Composition of Supplementary Foods Processed by Popping and Baking

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Supplementary foods have been formulated in powder and biscuit forms, using wheat, soya and sugar at a proportion of 70:10:20, by employing the processing techniques, such as popping, roasting and baking. These products, named *pushti*, were tested for proximate composition, viscosity and protein quality. The viscosity slurries with 20% solid concentration of powder and biscuit were 11×10^2 and 10.6×10^2 cp units, respectively, the values being comparable to the viscosity of commercial supplementary food mixes. The calorie contents of 100 g *pushti* powder and biscuit form were 377 and 456 kcal, respectively, while the protein contents were 13.0 and 9.0 g, respectively. The digestibility coefficients were 80.4 and 91.7 for powder and biscuit, as well as net protein utilization of powder (52.2) and biscuits (50.0), are comparable to the values of similar blends of supplementary foods.

Keywords: Supplementary food, Viscosity, Nutrient composition, Popping, Baking.

Several low cost supplementary foods have been formulated by using locally available raw materials and by employing simple processing techniques (Lina and Reddy 1982; Thomas and Kamath 1986; Thimmayamma et al. 1987). Method of processing the cereal and legume assumes importance in the formulation of supplementary foods, as it influences the volume, digestibility and cost of the final product. Pioneering work has been done in this area at CFTRI, Mysore and it was reported that addition of 5% malted barley flour reduced the viscosity of 15% hot paste slurry of the commercial supplementary foods (Desikachar 1980; 1982). A low cost malted supplementary food based on malted Ragi and greengram flour at the ratio of 70:30 was found to possess much lower viscosity from that of several proprietary brands of supplementary foods manufactured in India (Malleshi and Desikachar 1982).

Various amylase - rich foods were developed from bajra and wheat, in which addition of 4% amylase containing component was found to reduce the viscosity of traditional gruels (Gopaldas et al. 1986; John and Gopaldas 1988). Although malting was reported to yield a product of higher density and nutritive value, it needs longer processing time, more labour and adequate drying facilities. Malting involves soaking, germination and drying of cereals, millets, legumes and this process consumes about 36-72 h. On the other hand, popping, which is basically a dry process, requires only 5-10 min. Hence, the present study was undertaken to develop supplementary foods, with wheat and defatted soy flour, by employing popping and baking as preparatory techniques.

Preparation of supplementary foods: Supplemented foods were prepared in powder and biscuit forms. Dehulled wheat grain, with moisture content of 9%, was conditioned to a moisture level of 11 to 12%, by sprinkling little water and heaping the grains for sometime. The conditioned grain was popped with sand at 1:10 grain to sand ratio at 250-260°C, and the grains were stirred continuously to complete puffing within 100 sec. The popped wheat was milled in a flour mill (Lakshmi Works Ltd., Hyderabad) of 3 HP capacity and 550 rpm, with sieve mesh of 60 mm. Soy flour was roasted for 6 min at 80°C in a hot pan, with continuous stirring. Sugar was ground to fine powder. The supplementary food in powder form was prepared by blending wheat, soy flour and sugar at 7:1:2 ratio and was fortified with vitamin and mineral mix as per ISI (1969) standards. The supplementary food was prepared in the form of biscuit, by using dehulled wheat, soy flour and sugar at similar proportion.

Proximate analysis: Nitrogen was analyzed by the micro-Kjeldahl procedure (AOAC 1980). Moisture, ash, fat and crude fibre were determined according to standard AOAC (1980) methods. Energy was determined according to Weidner and Jacobson (1962), using adiabatic bomb colorimeter (IKA, United States of America).

Viscosity: It was determined by mixing the sample in cold water to obtain 10, 15 and 20% (weight/volume) slurry concentrations. The slurry was heated to boiling with constant stirring and then cooled to room temperature (30°C). The viscosity was measured in a viscometer (RVT Model,

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TABLE 1. PROXIMATE COMPOSITION OF PUSHTI POWDER AND BISCUIT.

Particulars	*Pushti* Powder	*Pushti* Biscuit	Commercial product	ISI (1969) specifications
Moisture, %	5.1	4.6	2.8	10.0**
Proteins, % (Nx6.25)	13.0	9.0	14.4	14.0*
Fat, %	1.2	17.8	9.2	7.5**
Ash, %	1.5	2.8	0.9	5.0**
Fibre, %	0.9	0.9	0.9	1.0**
Carbohydrates, %	78.3	64.9	68.9	45.0

Figures are the mean values of five samples. *Minimum level. **Maximum level.

Brookefield Viscometer, USA), using appropriate spindles at 60 rpm and expressed in centipoise units.

Protein quality: It was evaluated by animal experimentation. The digestibility coefficient value of supplementary food was calculated by the method of Eggum (1973). Nitrogen of carcass was determined and net protein utilization was calculated as per Campbell (1963).

The data on proximate composition have revealed that the powder and biscuit *pushti* contain the nutrients within the ISI specifications and these values are comparable to those of the commercial supplementary foods (Table 1).

The average energy intake of 1-3 years old children of low income group in Andhra Pradesh is 908 kcal/day (NNMB 1990), while that recommended by ICMR is 1220 kcal/day, thereby indicating an energy deficit of about 300 kcal/day. The recommendations of MOW (1985) for preschool children are 300 kcal of energy and 8-10 g protein/day from supplementary foods. The energy contents of powder and biscuit *pushti* are 377 and 456 kcal/100 g, respectively. Thus, daily administration of 60 to 100 g supplementary food *pushti* conform to the standards recommended by MOW (1985). The popping and baking unit operations might have contributed the lower moisture values. The lower values of fibre might be due to the use of dehulled wheat in the preparation of powder and biscuit.

The data on viscosity (Table 2) reveal that, at 20% solid concentration, both powder and biscuit were found to have the right and acceptable consistency. The viscosity values are comparable to those of a commercial food. It was reported that 10 and 20% solid concentrations of various blends of roasted and malted supplementary foods have the viscosity of 0.15×10^2 to 1.7×10^2 cp units (Desikachar 1980; Malleshi and Desikachar 1982). Lower viscosity value has been reported for popped grains, as compared to parboiling, flaking and roasting (Venkat Rao et al. 1985). In the present study, dehulling and popping of wheat, followed by roasting of soy flour, contributed to the low viscosity of the product.

The digestibility coefficient and net protein utilization values of powder and biscuit *pushti* are comparable to the values reported by Pushpamma and Anjalidevi (1979), Brandtzaeg et al (1981) and Venkat Rao et al (1985). The reported values of supplementary foods made from various cereal and legume combinations were 80-91% and 50-63%, respectively. However, the values are significantly lower than the values of casein and commercial product. The protein combination used in popping, roasting and baking might have destroyed the amino acid lysine, thereby resulting in lower net protein utilization values. These can be improved by the addition of skim milk powder. However, this was not attempted, owing to cost considerations of the supplementary food. Moreover, being highly hygroscopic, skim milk powder affects the shelf-life of the supplementary food.

The use of locally available wheat and soybean processed by a simple method of popping could yield a product of high nutritious and low viscous supplementary food. In spite of efforts made by the Government to promote the consumption of wheat, by making it available at subsidised rates, it is not purchased by most of rural families in Andhra Pradesh (Geervani 1990). Therefore, full utilization of wheat can be made possible by diverting it for the preparation of supplementary food. Moreover, the quality of wheat available through public distribution system has no detriment for popping, which is followed in the present study.

Soybean, with its high protein content, serves

TABLE 2. COMPARISON OF VISCOSITY, DIGESTIBILITY COEFFICIENT AND NET PROTEIN UTILISATION OF SUPPLEMENTARY FOODS WITH COMMERCIAL FOOD AND CASEIN

Particulars of diet	Viscosity at 20% solid concentration centipoise	Digestibility coefficient, %	Net protein utilisation
Pushti powder	11×10^2	80.38 ± 3.3^b	52.20 ± 8.6^b
Pusti biscuit	10.6×10^2	91.68 ± 2.5^a	49.96 ± 7.2^b
Commercial product	9.6×10^3	95.56 ± 0.9^a	77.35 ± 6.5^a
Casein, control	---	94.20 ± 0.88^a	81.62 ± 3.2^a

Figures having the same superscript do not differ significantly ($p<0.05$)

as substitute to other legumes generally used in the formulation of supplementary foods. The conversion of starch to dextrins during popping, helps the weaning infant to adjust more easily from a lactose-based milk diet to starch-based cereal diet.

The physico-chemical and biological data indicate that popping is an economical and potential method for preparation of supplementary foods. It can be carried out under various climatic conditions and is commercially feasible as well as easily adoptable for bulk production.

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Effect of Some Physical and Chemical Pretreatments on Improvement of Drying Characteristics of Hash-Brown Potatoes

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Potato shreds of 'Netted Gem' cultivar, approximately (12.7-38.1) x 8 x 1.5 mm in size, were precooked in calcium chloride (200 ppm as Ca^{2+}) solution, steam cooked (10 min), dipped in combined solution of glycerol (5%) and monoglyceride (0.1%) emulsion and then dried in a fluid-bed drier. The drying rate was found to increase through the extension of constant-rate period and the total drying time was shortened to 45 min, as compared to 1 h for a control sample. The product had lower bulk density of 0.15 g/cm^3, as compared to 0.31 g/cm^3 for a commercial sample. Breakage of the product on handling was also reduced from 19.3 to 3.6%.

Keywords: Potato dehydration, Hash-Brown potatoes, Calcium chloride pretreatment, Glycerol, Monoglyceride, Potato shreds.

Dehydration is one of the common methods of economical preservation of the potato (*Solanum tuberosum*, L) crop. Hash-brown potatoes are dehydrated in the form of shreds or pieces for utilization both as culinary products as well as processed raw materials (Englar and Dew 1972). There are many problems encountered in dehydration of potatoes and some of these include slow drying rate, shrinkage of the product, case hardening, fragile texture and brown discolouration (Smith and Davis 1968). Slow drying rate results in high energy consumption and often, inferior products (Borgolte and Simon 1981). In recent years, specific techniques have been developed to accelerate water removal during drying. The use of chemical additives such as acetylated monoglyceride to accelerate vacuum drying of ground mushrooms (Heyman 1968), nitrous oxide to preserve structure and to aid water removal in vacuum drying of vegetables (Miles 1970) and pretreatment of prepared vegetables with glycerol for improved textural qualities (Shipman and Rahman 1974), have been tried.

However, all these attempts hardly resulted in cheaper process, as most of these still rely on rather sophisticated and expensive techniques, such as vacuum drying (Heyman 1968; Miles 1970; Ooraikul 1973). Present work was undertaken to improve upon drying rate and structural integrity of the product by the application of different physical and chemical pretreatments. A fluid-bed dryer, which permits gentle and very efficient drying to a very low residual moisture content due to uniform temperature distribution and a large exchange areas between solid and gas was used (Borgolte and Simon 1981).

Potatoes used were cultivar 'Netted Gem' ('Russet Burbank'), with specific gravity of 1.098, corresponding to a dry matter content of 23.7%. Raw potatoes were stored at 4°C and before processing, these were reconditioned at 18°C for 2 weeks. All the chemicals used were of either food or reagent grades. The surfactant, Myvatex^R 3-50 (Type C-18), distilled monoglycerides (a blend of propylene glycol monostearate and glycol

Fig 1. Manesty Petrie Fluid-bed dryer, 1. Air-flow pipe, 2. Orifice slide, 3. Fan motor, 4. Fluidizing bowl 5. Collecting bag, 6. Stirrer motor, 7. Ratiotrol 8. Speedomax recorder 9. Manometer

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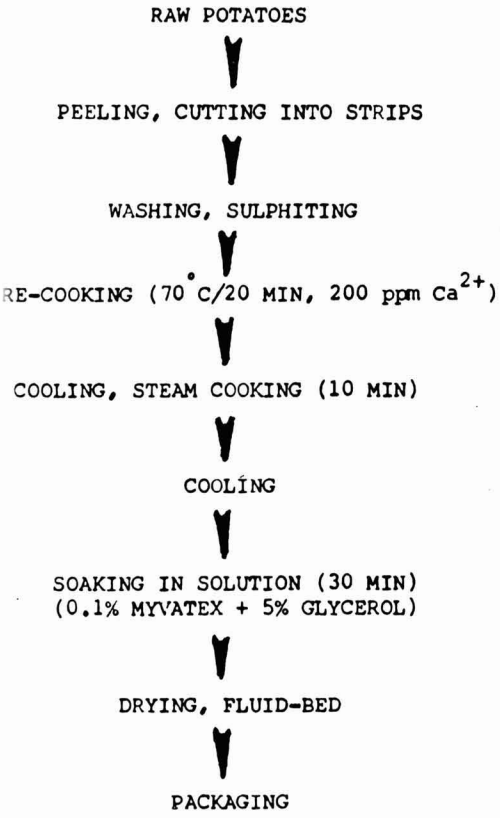

Fig 2. Flow chart for the proposed dehydrated Hash-Brown process

monostearate) was obtained from Eastman Kodak, Kingsport, USA. Petrie fluid-bed dryer (Model MP IOE, Manesty Machines Ltd., Speke, Liverpool, UK) was used for drying, as described by Ooraikul (1973), but with modifications (Fig. 1).

Specific gravity of potatoes was measured directly with the standard hydrometer (Potato Chip In'tl Hydrometer), using 3.63 kg (8 lb) potatoes in water. The proposed process flow-chart of the best combination of pretreatments is shown in Fig. 2. The drying rates were calculated at various steps of the drying process, from the air flow and temperature measurements and the rate of loss of moisture from the bed (Ooraikul 1973). Sieve No. 8 (Canadian Standard Sieves Series) was used to measure the extent of breakage of the dried products. The bulk density of the product was measured by filling the product into a 500 ml graduated cylinder upto the 500 ml mark, while gently tapping cylinder, until there was no further packing of the product. The moisture content of the dehydrated product was determined according to the method recommended by USDA (1982).

Drying rate: The results reported in Table 1 are those obtained under most ideal conditions with the usage of the present equipment. The drying rate curves of 4 samples with different pretreatments are given in Fig. 3. The drying was accomplished in 45 min, with moisture content between 6 and 7%. In the precooking treatment, calcium-treated samples gave better dehydration characteristics. This might be due to the fact that treated-potato pieces retained their integrity on account of strengthening of cell wall and middle lamella in the tissue (Haydar et al. 1980). Untreated samples were more fragile, and had greater degree of breakage as well as shrinkage, as indicated by its slightly higher bulk density (Table 2). The collapse of the internal structure of the tissue (control sample) would, therefore, impede the movement of water during drying.

Surfactant-treated samples showed improvement in drying rate. Monoglycerides are known to complex readily with solublized starch (Ooraikul and Hadziyev 1974). The exact mechanism of how the surfactant act to increase the drying rate is not clear. Potato tissue, though quite homogeneous, contains fibrous material, which forms the frame work of cell wall (Sterling 1965). On cooking, starch granules gelatinize to fill the cell and distend the cell wall (Reeve 1954). Part of the starch gel, especially amylose, leaks out from the cell pits (Reeve 1954). It is possible that the leaked gel would form an obstruction, against moisture transfer through interstitial voids and evaporation from the surface during drying. On the other hand, the

TABLE 1. PROCESSING CONDITIONS OF LABORATORY PREPARED HASH-BROWN POTATOES

Drying time, min	Drying air temp above the bed, °C	Drying rate, kg water/min
0	57	0.0699
1	53	0.0838
6	53	0.0838
14	66	0.0414
26	73	0.0083
36	74	0.0046
45	74.5	0.0018
60	74.5	0.0018

Drying air temperature below the bed and air mass flow rate were 75°C and 9.21 kg/min, respectively. Product moisture (observed) was 80.0 and 6.84% at 0 and 60 min drying time, as against calculated values of 71.98, 54.19 and 25.06% at 6, 14 and 26 min, respectively. Wet load in dryer was 1.75 kg with drying ratio of 5. Pretreatment included soaking in 0.1% surfactant + 5% glycerol, while inlet air velocity was 149 m/min. Dry and wet bulb temperatures of inlet air were 23 and 21°C, respectively.

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Comparison of Three Methods for the Preparation of *Soygari* from Cassava and Soybean Mash

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Of the 3 methods, involving wet mix, dry mix and soak mix, used for the production of *soygari* from cassava and soybean mash, the soak mix gave the best organoleptic results. The ratio of 7:3 (cassava: soybean mash) produced the best *soygari* in terms of organoleptic characteristics and protein content.

Keywords: Cassava, Soybean, Fermentation, *Soygari*, Organoleptic quality, Protein.

Cassava accounts for 57% of the total tropical root and tuber crop production and about 2 billion Africans depend on it as a staple food (Ofuya and Nnajiofor 1989). The popularity of cassava plant is due to its food uses, especially in West Africa (Gounelle de Pontanel 1972). Food items prepared from the tubers include *fufu*, *lafun* and *gari*. Cassava and its products contain very little amounts of proteins. The frequency of consumption of cassava and similar high carbohydrate staple foods has been attributed to the poor health conditions in the developing countries. There is a need, therefore, to fortify cassava with a protein-rich source, using a simple process that would not require strict aseptic conditions and amenability to easily performed processing in one single operation that can be practised at rural level. Thus, the objectives of this study were to produce a high protein *gari* and to determine the best method achieve this goal.

Source of cassava tubers and soybean: Cassava tubers (*Manihot esculenta*. Crantz) were purchased from Lagos State, Nigeria. Soybean samples (*Glycine max* (L) Merrill) were obtained from Gboko, Benue State of Nigeria. These were stored in grain silos of the Federal Institute of Industrial Research (FIIR) at 28±2°C, while the cassava tubers were used within 12 h of harvesting.

Preparation of fermentation substrate: Sound and uninfested cassava tubers were manually selected by removing the infested damaged tubers from others. These were cleaned by several washings with tap water, peeled, washed, grated and weighed. Similarly, sound and uninfested soybean seeds were manually selected and the seeds were washed, boiled for 1 h, dehulled, washed again to separate the seeds from the testa, weighed and blended.

Fermentation process: Cassava and soybeans were mixed together as shown in Fig. 1a, b, c, which represent wet mix, dry mix and soak mix methods of *soygari* production, respectively.

Analysis of organoleptic characteristics: Bench top observations and organoleptic tests of colour, aroma and taste were carried out on the final *soygari* products by three panelists. Swelling index and pH, as described below, were used to determine the quality of the *soygari*. Locally produced *gari* sample, purchased from the open market, was used as standard and control. The colour and aroma of the *soygari* products were compared with the cream colour and the sharp acidic aroma of the market sample by the panelists. The tastes of the wet and dry *soygari* products were compared with the sour taste of the market sample. The taste of the wet product was determined after 5 min soaking in water at 28±2°C.

The swelling index of *soygari* was determined by measuring its swelling capacity in a 250 ml graduated measuring cylinder. In this, 5 g *soygari* was introduced into the dry measuring cylinder and the level of the *soygari* was noted. Distilled water (100 ml) at 28±2°C was added and the content was stirred, using a sterile glass rod. Swelling was observed at 10 min intervals upto 60 min. The experiment was repeated for all the samples and the control market *gari*.

Determination of pH: Cassava mash (5 g) was put in 45 ml distilled water and mixed in a Waring blender for 1 min. The mixture was filtered through two layers of muslin cloth, to remove the coarse material and subsequently through Whatman No. 4 filter paper. The pH of the filtrate was determined, using an Acid-Base Analyzer type PHM 620 pH meter, equipped with glass electrodes (Metrohm-Herisau, Switzerland).

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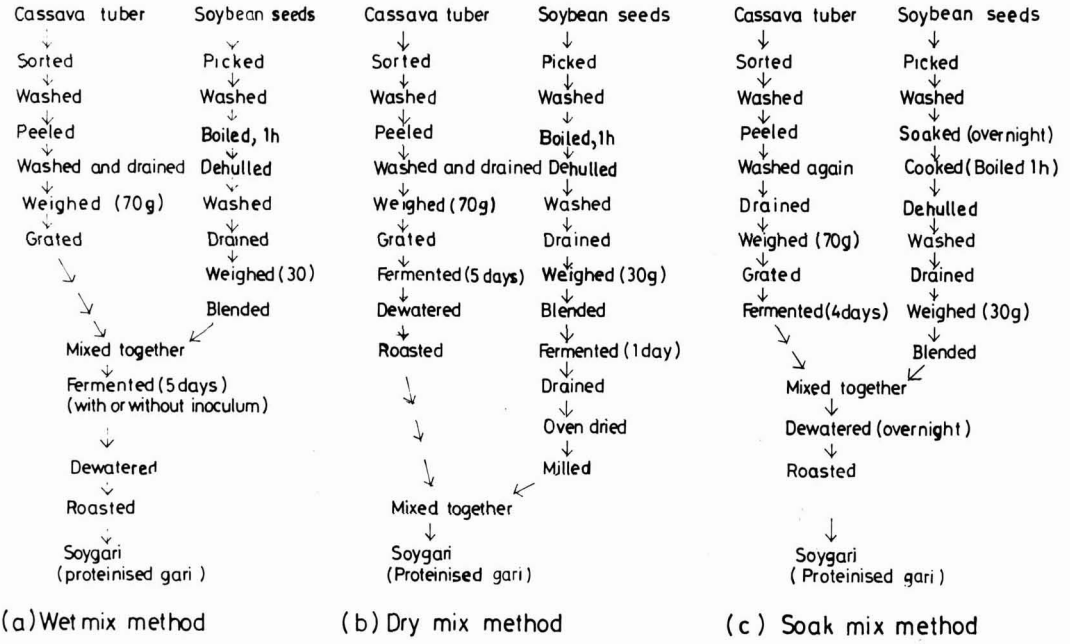

Fig. 1. *Soygari* (cassava - soybean mash) production methods. a: wet mix method, b: dry mix method, c: soak mix method

Determination of the best ratio of cassava and soybean for the production of soygari *using the soak mix method:* The 4 ratios of cassava-soybean mash mixtures, viz., 1:1, 3:2, 7:3 and 4:1, were mixed and fermented, using the soak mix method (Fig. 1c), to determine an ideal ratio, both in terms of protein yield and organoleptic characteristics.

The protein content of the *soygari* was determined by the method of Lowry et al (1951)

The *soygari* samples, produced by using the wet and dry-mix methods, had brown colour and were not acceptable. The *soygari* produced by using the soak-mix method, had cream colour and was acceptable to the panelists. The *soygari* produced by wet and dry-mix methods had unacceptable beany aroma, while the *soygari* produced by using the soak mix method had a sharp acidic acceptable aroma, similar to the standard market sample (Table 1). Although all the *soygari* samples had sour taste, those produced by using the wet and dry-mix method, in addition, had beany flavour, which was absent in the *soygari* produced by soak-mix method. Therefore, soak mix method was selected.

A rapid swelling in the first 10 min analysis of *soygari* product was observed in all the samples, followed by a more gradual swelling during the 1 h analysis. The market (control) sample had the highest swelling index, followed by the product made by the soak-mix sample. The *soygari* produced from the dry-mix method had the lowest swelling index.

All the *soygari* products had acidic pH in the range 4.1-4,8 (Table 1). The *soygari* produced by the soak-mix method and using cassava soybean ratio of 7:3, had pH value of 4.2, while the *soygari* produced by the same method, but using the ratio 50:50, had the highest pH value of 4.8.

Ideal ratio of cassava and soybean for soygari *production:* The ratio 1:1 of cassava:soybean mixture had the highest protein content of 20% and the ratio 3:2, cassava : soybean mixture had a protein content of 14%. Organoleptic qualities of both of these mixtures were not acceptable. The ratio 7:3 (cassava-soybean mixture) had 8% protein and acceptable organoleptic qualities. The ratio 4:1 (cassava:soybean mixture) had a relatively low protein content of 5% and acceptable organoleptic qualities. The pH values of all the *soygari* products were within the acidic range at 4:1-4:8 (Table 1).

Soaking soybeans and discarding the soak water, prior to fermentation, produced a high quality *soygari.* Soybeans contain a heat stable, water soluble compound, which inhibits the growth of microorganism and its proteolytic enzymes during fermentation (Nunomura and Sasaki 1986;

TABLE 1. PROTEIN, pH AND ORGANOLEPTIC PROFILE OF *SOYGARI* PRODUCED BY SOAK-MIX METHOD USING VARYING RATIOS OF CASSAVA AND SOYBEAN MASH.

Casava:soybean ratio	Protein	pH	Organoleptic profile			
			Colour	Aroma	Taste	Acceptability
50:50	20 ± 0.8	4.8 ± 0.3	Brown	Flat	Flat	NA*
60:40	14 ± 0.5	4.5 ± 0.12	Brown	Flat	Slightly sour	NA
70:30	8 ± 0.3	4.2 ± 0.04	Cream	Sharp, acidic	Sour	A**
80:20	5 ± 0.3	4.1 ± 0.05	Cream	Sharp, acidic	Sour	A
Control (Market *gari*)	1 ± 0.1	4.0 ± 0.10	Cream	Sharp, acidic	Sour	A

NA* : not acceptable, A** : acceptable

Hesseltine et al. 1963). This explains the high quality of *soygari* produced by using the soak-mix method. The control market *gari* had the highest swelling index, when compared with the *soygari* samples, indicating that the presence of soybean reduced the swelling of *gari*, which may be due to the reduction of the starch components (Akinrele 1967). The pH of the sample was within the acidic range, thereby resulting in the sour taste of the product. The acceptability of *gari* is to a large extent influenced by its sourness (Akinrele 1964). The addition of soybean, a protein-rich material, to cassave, a high carbohydrate foodstuff, resulted in a slight increase in pH of the product, which can be attributed to production of ammonia from soybean protein degradation (Reddy et al. 1986).

The protein contents of the mixture of cassava: soybean at ratio 1:1 and 3:2 were 20 and 14%, respectively. However, the products were not acceptable because the organoleptic properties differed greatly from those of the standard (control) *gari*. The products were probably not acceptable because of the high levels of soybean, which altered the starchy flavour and taste of fermented cassava. On the other hand, the ratio 7:3 and 4:1 (cassava-soybean mixtures) gave 8 and 5% proteins in *soygari* respectively, which were organoleptically acceptable. During the production of *idli* and miso, Reddy et al (1986) and Ebine (1986) observed that a mixture of a starchy substrate and a protein aqueous product in the ratio of 2:1, 3:1 or 4:1, respectively, resulted in a product with a predominant starchy flavour and taste. This supports the observations in Table 1.

The introduction of *soygari* to the diets of the population in the developing world may help solve the problem of protein malnutrition.

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FOOD TAINTS AND OFF-FLAVOURS, Edited by Dr. M.J. Saxby, 2nd Edition, Published by Blackie Academic and Professionals, Wester Cleddens Road, Bishopbriggs, Glasgow G642 MG, UK, 1996, pp 326, Price £ 75/-

The book entitled "Food taints and off-flavours", (second edition), edited by M.J. Saxby is a compendium by itself, presenting the major aspects of sensory evaluation of taints and off flavours with in-built chapters on survey of chemicals causing these sensory charactaristics and also their analysis and the odour problems of drinking water and dove-tailing with it is the undesirable flavours in dairy products with biochemical information and oxidative pathways to the formation of off flavours and information on packaging material as a source of taints and specific information for the consumers and the retailers' perspective, which is all wrapped up nicely, bringing in the microbiological and enzymatic action of off flavours both in many food products as well as specifically in alcoholic beverages. The book has loaded with information on the above chapters and draws the attention of the food scientists and technologists to the necessity of focussing oneself on food taints and off flavours.

In fact, the homogenous blending of sensory science to the instrumentation for developing certain tests is vitally addressed in this book. The expert authors, who have written different chapters, are all leading personnel in the field and have certainly put in their long experience for each chapter. The preventive measures and the early stages of detection are dealt in-depth in the first chapter. The authors have also taken lot of pains in totally revising the various chapters and updating the same. It is also very vital that today's market certainly depends upon the retailers' perspective such as what the problem in taints and off-flavours is, how widespread it is and what are the specific instances that have happened so that the manufacturer, the consumer and the sensory scientists are all aware of the problem and address to one pivotal question i.e., to manufacture, distribute and consume a very safe food. This book certainly adds another powerful dimension to food science and technology in bringing out the highlights of food taints and off flavours and certainly is recommended to professionals in the field and also to the faculty, who are interested in sensory science and also in general, to food scientists and technologists. The book also serves as a compendium to many industrialists, who may find its use as a well documented referendum, since it also describes, certain case studies and relates it to market and manufacture.

In complementing the Editor for an exceedingly pains-taking job that he has done in putting all the thoughts of the different contributors in an organised way along with his own contribution, this will be an added asset to many libraries and documentation centres, who have or planning to have data base in Food Science and Technology.

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COLD CHAIN REFRIGERATION EQUIPMENT BY DESIGN: Proceedings of the Symposium of the Commissions B1, B2, D1, D2/3 of IIR, held in Palmerston North (New Zealand), 1993, Published by International Institute of Refrigeration, 177, bd Malesherbes, F-75017, Paris, France, pp 576, Price US $ 64/-

It is well accepted that considerable quantities of perishable foods are wasted all over the world due to inadequate and improper processing, storage and handling. This problem is more acute in developing countries such as India. To overcome this, modern, efficient and economical equipments are essential. In this publication, the design aspects of cold-chain equipment are dealt with. It contains 61 papers grouped under 8 sections. Emphasis is on the new scenario due to the ban on chlorine containing CFCs and the introduction of new environment-friendly refrigerants.

In the plenary paper, the impact of new refrigerants on the various components of the refrigeration system and the current status of new refrigerants are discussed by Pearson Watanabe, who is a renown authority on refrigerant properties. Transport being a very important link of the cold-chain, Stera has discussed the component and equipment developments in sea and air transports.

Various aspects of CFC substitution are discussed in 9 papers in Section 1. The two most commonly used refrigerants, R12 and R502, need to be replaced by environment-friendly fluids. The consequences of using R134a as an alternative to R12, either in retrofitting of existing equipments or in newly designed ones, have been discussed in detail by many authors. Domestic refrigerators and freezers have been studied. For replacing R502, no single component pure fluid has so far been

identified. Hence, non- or near- azeotropic mixtures have been suggested. Application of such mixtures has been studied in 2 papers. Hardware (mainly compressor) changes required and lubrication aspects have also been discussed.

The thermodynamics and heat transfer section contains only 3 papers, one of which discusses the thermodynamic properties of absorption system working pair trifluoroethanol - 2 pyrrolidone. Prediction of diffusion resistance of mixture refrigerants during condensation and also the evaporation characteristics of R22 in a satraight tube have been presented.

Three papers deal with the important topic of energy consumption in the cold chain refrigeration equipment. Component and system design opportunities are discussed.

Analytical and experimental studies on air flow in air blast freezers and chillers and their performance are reported. These help in evaluating alternate chiller configurations and also in identifying optimum design and operating conditions both from energy consumption and from product quality points of view. Prediction of chilling and freezing times is very important for controlling product quality and also for estimating cooling loads. Such studies for mackerel in carton boxes, bakery products and bulk-stacked cheese are presented. A simple method for predicting chilling times of multi-dimensional regular shaped food products is also described.

The section on refrigeration equipments also covers the design and operational aspects of specific components such as condensers and compressors. Use of ammonia heat pumps is recommended with the example of a poultry abbatoir installation. One paper details the design procedure for both shell and tube and evaporative type of ammonia condensers. Frost formation is a common problem faced in the operation of air cooling coils. Modelling and performance testing of such coils have been given in detail. The importance of sensible heat ratio is highlighted. A relatively new food cooling technique, namely wet air cooling, which uses ice storage and pressure cooling, has been described and compared with conventional cooling techniques such as vacuum cooling, hydro-cooling and conventional air cooling.

The section on cool stores contains many papers on practical experiences with the operation of cool stores with emphasis on distribution of air velocity, temperature and humidity. An interesting paper by Drummond deals with the "Glass transition temperature", which is of importance to frozen food storage.

Controlled atmosphere (CA) transport in containers is gaining importance in recent years. Various aspects such as shipment of specific fruits, methods of achieving CA, system design, leakage rate measurements, etc. have been discussed. One paper gives a comprehensive modified atmosphere packaging model, which describes the fruit internal and package O_2 and CO_2 concentrations, N_2 diffusion and water vapour transport under uniform temperature conditions.

Temperature variations of air and the cargo inside refrigerated transport are the topics of discussion of many papers. Both land and marine transports are covered. One paper discusses the various aspects of packaging of perishables for transport, with particular reference to reusable or recyclable materials.

On the whole, this publication will be of good use to a refrigeration engineer, as it gives the latest developments in the design and operation of the different components of the cold chain are dealt in detail.

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NEW APPLICATIONS OF NATURAL WORKING FLUIDS IN REFRIGERATION AND AIR-CONDITIONING: Proceedings of the symposium of IIR Commission B2, held in Hannover, Germany, 1994, Published by International Institute of Refrigeration, 177, bd Malesherbes, F-75017, Paris, France. pp 966, Price US $74/-

Most of the new refrigerants with zero Ozone Depletion Potential introduced in the market by the major refrigerant manufacturers either in the form of pure components or as mixtures come under the category of Hydro-Fluoro-Carbons (HFCs). However, there is a significant move, pArticularly in Europe, to use the NATURAL WORKING FLUIDS such as hydrocarbons, ammonia, water, air, carbon dioxide, hydrogen, etc. as refrigerants in preference to HFCs. This publication is the proceedings of a conference on natural working fluids held in Germany during 1994. It contains 72 papers, out of which only 10 come from countries other than those in Europe, giving an indication of the importance given in natural fluids in Europe. In addition to the Plenary addresses, this book contains

9 sections. This reviewer had the opportunity to attend the conference to gain a first hand experience on this aspect.

In the opening plenary paper, the voluntary measures and CFC reduction policies are discussed, with particular reference to Germany and the European Union. Lorentzen has given a comprehensive overview of the application of air, ammonia, propane, carbon dioxide and water vapour. Next 2 papers discuss the application of hydrocarbons as refrigerants and insulation foam blowing agents in domestic appliances. Mosemann's paper discusses the economics, environmental acceptability, system concepts, operation and safety aspects of using ammonia for water chillers for air-conditioning. Paul has brought out the possibility of using water as refrigerant, including the concepts of FLO ICE and BINARY ICE.

The section on "Fundamentals" has 6 papers, which cover mainly the hydrocarbons, with emphasis on propane and isobutane and their mixtures. Equation of state, thermophysical properties, heat transfer correlations and lubrication are discussed. One paper makes a comparison of the performance of R290 and R134a.

The 8 papers in the section on "Air Cycle" deal mainly with the potential application areas of both refrigeration and heat pump systems. Thermodynamic analyses to study the effect of moisture and irreversibilities are also given. Holder and co-workers have shown by experimentation that the equipment originally designed for aircraft airconditioning can operate over a much wider range and therefore, can be used for many other ground-based applications. The interesting concept of pressure wave machine has been discussed by Engleking and Kruse.

Absorption systems are not only environment friendly, but also energy efficient, as they use heat as the main input. There are 8 papers in this section, covering both wet-absorption and dry-absorption systems, emphasizing the use of ammonia or water as refrigerant. Two papers discuss the open cycle adsoption cooling systems with hygroscopic desiccant wheel regenerators for air-conditioning applications, giving emphasis on the technological and design aspects. The papers deal with gas-fired systems, which are of significance to our country.

Under the section on "Compression Systems" also, use of hydrocarbons is highlighted. Propane has been recommended in place of HCFC22, particularly for heat pumps, giving emphasis on components, performance and safety aspects. One paper each on specialised systems such as a hydraulic refrigeration using n-Butane, a trans-critical system and a gas driven Vuilleumier system is given. There are promising concepts, but require further investigations, before being considered for use in practice.

Safety is an important consideration in using many natural fluids, particularly hydrocarbons, hydrogen and ammonia. This aspect is covered in 7 papers, 3 of which deal exclusively on ammonia. The paper on isobutane compressors for domestic refrigerators is of importance, as it concludes that the risk of accident damage is very low.

Carbon dioxide has been studied by 3 different authors as a possible working fluid for transport refrigeration, giving attention to high pressure control strategies. Two papers analyse air-cycle systems for mobile refrigeration. Other significant alternatives studied are based on absorption systems. A prototype of water - LiBr absorption system, using engine exhaust gases, has been described. Possibilities of water - zeolite adsorption system for deep-freezers and refrigerated trolleys are also discussed.

The section on "Domestic Refrigeration" is the largest one with 11 papers, 7 of which study the various aspects of application of hydrocarbons (propane, iso-butane and their mixtures). Techno-economic, thermodynamic and experimental performance, and safety aspects have been covered in detail. The paper on the flow of new refrigerants in capillary tubes is of practical importance. Two papers describe Stirling cooler prototypes along with some experimental results. The possibility of use of hydrogen as the working fluid in a metal hydride refrigerator has also been discussed.

For commercial refrigeration purposes, ammonia-based systems have been suggested and various aspects of their design and performance have been studied. Use of carbon dioxide has also been suggested.

In the use of water as refrigerant in compression systems, the main challenge is in the development of suitable compressors for water vapour, which has very high specific volume. The 3 papers in this section cover in detail a variety of options and discuss their technical status.

On the whole, this Proceedings contains papers of high technical quality, practical significance and topical interest. It will be of much use to academics,

researchers, refrigeration equipment manufacturers and practising engineers.

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INGREDIENT INTERACTIONS - EFFECTS ON FOOD QUALITY: Edited by Anilkumar G. Gaonkar, Published by Marcel Dekker Inc. 270, Madison Avenue, New York 1995, NY 10016, pp 595, price not mentioned.

Food, which is very vital, is a multi-component complex system. Food consists of many classes of molecular components. The major ingredients are water, lipids, starch and proteins. The minor ingredients are emulsifiers, hydrocolloids, minerals, vitamins, flavours and preservatives. The quality of food, which can not be compromised, depends on the quality of ingredients both major and minor and their interactions. The other factors, which have their effect on ingredient interactions, which could significantly affect the quality, are the degree of processing, type of packaging and conditions of storage.

One of the most important and challenging areas of food science is defining the structure-function relationships in foods and the key to the understanding of the above is the study of food component interactions. Quality improvement is possible through better understanding of food systems. The interactions that have a bearing on these are of great interest to food scientists. Books on food ingredients, which can be of great value to researchers, are very few. Therefore, this book is a valuable additional tool in this direction. It is also timely and formidable and provides state-of-art technical information in the area of ingredient interactions, pertaining to foods. For a multi-faceted topic, degree of coherence and comprehensiveness is commendable. This book, intended for students and faculty of food science, scientists, engineers and technologists in the area of food research, serves them well.

A major lacuna in the book is that it leaves the impression that 27 experts have put in their authoritative work in a disjointed way. Each chapter is quite independent of the other. The lack of central theme or focus is reflected in the organisation of the book.

The book, which is prefaced by Prof. Eric Dickinson, has 17 chapters by experts in the field with an index. The Introductory chapter by the editor sets the tone for reading and understanding the book. Advance instrumentation like nuclear magnetic resonance, physico-chemical techniques like rheology are covered in chapters 2 and 3. Functions and interactions of single type of major/ minor ingredients are covered in chapters 4, 5, 6. Commodity areas like dairy components, (chapter 7), wheat proteins (chapter 11), chocolate technology (chapter 16), egg proteins (chapter 12), have received due attention.

Schmidt and Rosett give an excellent account of Sodium^{23} NMR to study sodium-macro-molecular interactions with a brief theoretical account of sodium^{23} NMR theory, experimentation and applications in chapter 2. Metal ion NMR is an ideal technique to study the molecular behaviour of sodium ions in foods. Sodium^{23} NMR imaging could be an useful tool for monitoring food quality, and this treatment should be most welcome to researchers.

In chapter 3, Tung and Paulson have presented a number of fundamental concepts that are helpful in interpreting rheological behaviour of food systems. Due to ingredient interactions in food systems, the rheological properties that could serve as physical probe for events taking place at molecular level are affected. The authors provide background information and illustrations of rheological behaviour, which are applicable to studies on ingredient interactions. In chapter 4, the interactions of water with food components, one of the main concerns of food industries to make better use of functionality of water in food processing and storage, is brought out by Le Meste and co-workers Some features and consequences of the interactions of water with food ingredients, the functional role of water in relation to quality of food products are presented. The stability of low or intermediate moisture foods will depend on water interactions. The 3 relevant and related topics that are discussed are: (1) the transformations occurring in frozen foods, (2) the textural modifications during storage of foods, which are governed by dynamics and (3) the biosynthesis of aroma compounds under conditions of water stress, which is mainly governed by energetics.

In chapter 5, Phillips and Williams have discussed the interaction of hydrocolloids, mainly polyanionic carbohydrates with water and in their hydrated form with other constituents of food that produce the specific functionalities. The rheology and physical properties of food products are controlled through specific interactions of hydrocolloids. The interactions of hydrocolloids in

ice cream and allied foods as stabilisers are elegantly brought about.

The interaction of starches in foods is discussed in chapter 6 by Friedman. Food starches and starch derivatives have been employed in a wide array of diversified applications. Starch is not a single molecular entity, but rather a family of related biopolymers with a broad diversity of structure, components and function. The nature of starches and their structure-function relationship and their interactions with different chemical classes of food ingredients are reviewed.

It is important to understand the various ways in which proteins can interact and this can be tailored to meet the functionality of proteins. Chapter 7 by Dalgleish and Hunt on "Protein-Protein Interactions in Food Materials" appraises this. This chapter is concerned mainly with molecular aspects of the interactions between proteins in solutions and to understand these interactions in quantitative terms; Physical forces that cause interaction between molecules. Relationship between macroscopic properties such as gelation or water binding to structure and interactions is of significant interest. As the proteins change conformation, the range of possible reactions that they can undergo, becomes larger and subject to influences, such as solution composition and properties.

The coverage, lipid-protein interactions in foods (chapter 8) by Meste and Davidou sheds light on the enormous complexities arising because fats are complex mixtures of great number of different lipids. Proteins are often a mixture of soluble and aggregated molecules. Interactions can occur simultaneously in the aqueous phase and at the lipid/aqueous interface. The factors that control lipid-protein interaction in solution and at lipid/water interface affect the quality of food products. The use of ESR in the study of lipid-protein interaction related to food is presented.

In chapter 9, Howell discusses the interaction of proteins with selected small molecules such as formaldehyde, oxidizing/reducing agents such as ascorbic acid and cysteine and phenols. This chapter throws light on the presence, mechanism and effects on the quality of foods. The chapter on "Dairy Component Interactions in Food Products" by Haylock, Towler and Hewitt addresses dairy component interactions in foods. Dairy ingredients are used in a wide variety of different food products, ranging from full dairy systems to products that may consist of only 1-2% of dairy-based material. The application of rheology, textural and sensory techniques in following these ingredient interactions is presented. The understanding of interactions between dairy component and other components in the food system is vital to meet consumer expectations of these products.

Chapter 11 on "Interactions of Wheat Proteins, Carbohydrates and Lipids" by Ross and MacRitchie discusses the interaction of plant proteins with other plant components and ingredients, which are responsible for successful processing. The inadequacy of traditional techniques to define events at molecular level is very lucidly illustrated. In Chapter 12, on "Interactions of Egg White Proteins", Kato presents the interaction of egg white proteins; of their structural and functional properties and emphasizes the relationship between structural and functional properties on a molecular basis. The influence of protein interaction on gelation, foamability and emulsification, the novel and promising approaches in understanding these interactions are nicely illustrated.

"The Interaction of the Emulsifiers with other Components in Food" is presented by Niels Krog in chapter 13. Surface active lipids, emulsifiers, surfactants are used as processing aids and to improve the texture and shelf-life of manufactured foods. This chapter focusses on emulsifier interactions of food component in relation to their influence on improvement of the texture, shelf-life and quality of products with main emphasis on dairy-based emulsifiers and cereal and fat-based foods.

The understanding of the interactions of flavour with food and their effects on the flavour release for the formulation of new foods, using new composition or new ingredients, is pertinently brought out in chapter 14 by Jokie Bakker. This chapter reviews the interaction between the flavour component and major food components and influence of food composition and structure on the release of flavour and perception.

In chapter 15, Reineccius has discussed the effect of carbohydrate/protein-based fat replacers approved by the FDA on the interactions in food. The distinctions in flavour-protein interactions as different from fat-flavour interactions are well brought out. Carbohydrate-based fat replacer does not mimic the flavour interaction properties. The necessity to modify flavour systems to obtain the unique flavour interactions are stressed.

In chapter 16, Bouzas and Brown have

discussed the interactions affecting the microstructure, texture and rheology of chocolate confectionery products, The complex array of ingredients of chocolate like cocoa, fat, dairy ingredients affect the rheology, processing and sensory perception including the texture. The inter-relationships of the physical properties and phase transitions of crystalline sugars and sugar alcohols as a function of humidity and temperatures in eliciting chocolate behaviour are well covered.

The diverse range of reaction products that arise due to reactivity of sulphites, sorbic acid and their interaction with food ingredients are presented in chapter 17 by Wedzicha. The interaction of sulpur dioxide and sulphites, chemical nature of these species and reactivity, inhibition of non-enzymic and enzymic browning, reactivity of sulphites in fruit and vegetable dehydration and mechanism of anti-microbial action is presented.

Overall, the book makes a good impression despite its disjointed presentation. It serves the purpose for food scientists and technologists, who are involved in the product formulations and in the understanding of these various interactions.

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SCIENCE, AGRICULTURE AND FOOD SECURITY: by Dr. Joseph H, Hulse. Published by Evelyn M. Kidd, NRC Research Press, Monograph Publishing Program, National Research Council, Building M55, Ottawa, Ontario, Canada, KIA OR6, 1995, pp 242, price US $ 45/-

The book entitled "Science, Agriculture and Food Security" by Dr. Joseph H. Hulse is unique in many ways. In the first instance, the topic on "Food Security" is very vital today and is less addressed because of the nature of the subject itself. To relate Science, Agriculture and Food Security is not that easy and Dr. Hulse has done this in a remarkable way not only to assess the different areas, but also tried to converge these three areas in meaningful one area and i.e., Food for all. In fact, the amount of information that he has documented in the 8th chapter of the book is really overwhelming. In chapter 1, he deals very clearly with the self-sufficiency aspect of "Food Security" as well as the three 'As' i.e., adequacy, acceptability and availability. It is also important that he has addressed various components of "Food Security" in this chapter, which sets the platform for the rest of the chapters. Chapter 2 is a very important one, as the consumption patterns are very vividly described, classifying into developed nations and developing regions. May be, it would have been appropriate, if one more area in the consumption pattern of "Traditional Foods" was also included in the list, as it would have further enhanced the value of the book. In chapter 3, the nutritional aspects are dealt in greater detail in terms of availability of food, the composition, balanced diet and disease and unconventional diets, allergies as well as the imbalance even in developed countries and the subject is so vital. This chapter really is the core of the book and links "Science and Agriculture" with "Food Security". Chapters 4 and 5 deal with agricultural aspects in terms of water management, agricultural policies, energy saving and also genetic diversity, which he has remarkably dealt with in greater detail and this dovetails into chapters with various institutions being involved in agricultural research. He has also summarised very efficiently the role of these international institutions in such agricultural practices such as multiple cropping system, biological control, use of pesticides, integrated pest management (IPM) as well as policies of agricultural research both in developed and developing countries.

The last three chapters namely 6, 7 and 8 deal mainly with "Food Quality", "Food Safety" as well as "Marketing and Transportation" with an underpinning of 'farm to consumer', which is so vital. It is also important to recall that in chapter 6, he has highlighted the infrastructural systems that are needed for such a holistic approach. Chapters 7 and 8 specifically deal with Food Science and Human Resource.

Overall, this book is one that needs to be read by agriculturists, food scientists, policy makers as well as marketing personnel including University and Academic Institutions involved in Human Resources Development. This book, published by NRC-CNRC under the NRC Research Press, Ottawa will be a valuable addition to any library and is recommended for its broader perspectives of vision in the area of Food Science and Agriculture.

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NEW APPLICATION OF REFRIGERATION TO FRUIT AND VEGETABLE PROCESSING: Refrigeration Science and Technology Proceedings. Proceedings of the Symposium held in Istanbul, Turkey, 1994 (ISS NO151-1637) under the aegis of the International Institute of Refrigeration 177, bd Maleshbes, F 75017, Paris, France, 1994, pp 440, price US $ 48/-

This book contains all the papers presented in the symposium on refrigeration science and technology, held in Istanbul, Turkey. In all, there are 45 papers presented by participants from 12 countries. It covers various aspects of refrigeration technology including pre-cooling, cold storage, cooling and freezing processes, new developments in cold store management, quality control studies in minimally processed vegetables, sizing, packaging, distribution and transport systems in marketing of fresh and frozen fruits and vegetables, controlled atmosphere storage and modified atmosphere packaging, modelling of cooling, freezing and storage processes.

Fruits and vegetables have long been recognised as health foods, providing essential nutrients like vitamins and minerals. Their protective effects against coronary heart and neoplastic diseases have since been recognised. Consequently, consumption of fruits and vegetables has considerably increased throughout the world, among the health conscious consumers. Due to their highly perishable nature, fruits and vegetables are lost to the extent of 25-60% within the production consumption chain. Refrigeration is an effective method to contain the losses for which cold chain has been advocated and practised in many countries. Pre-cooling and cold storage of commodities under high humidity conditions, avoiding moisture loss is a major development. Modified atmosphere packaging, controlled atmosphere storage coupled with optimum low temperature have been shown to extend the storage life of the commodities even further. However, optimization of various parameters like gas composition is very critical for their success. Minimally processed vegetables in modified atmosphere packaging have added convenience to the consumer. However, the microbiological quality of the products needs to be evaluated stringently to safeguard public health. Various basic as well as applied aspects of these technologies are discussed in the papers.

This book will be useful to those engaged in research on post-harvest technology of fruits and vegetables and refrigeration engineers.

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ANALYTICAL TECHNIQUES FOR FOODS AND AGRICULTURAL PRODUCTS: Edited by G. Linden; Published by VCH Publishers Inc. and printed jointly by VCH Publishers Inc. U.S.A. 220 East 23rd Street, New York, New York 10010 U.S.A.; VCH Verlagsgesellschaftmbh, P.O. Box 101161, 69451 Weinheim, Germany and VCH Publishers (UK) Ltd., 8 Wellington Court Cambridge, CB11M2, United Kingdom 1996 pp 578, price DM. 215/

This book is a hard bound copy of one of the volumes of a reference set in 4 volumes, printed on a acid-free paper. It consists of 578 pages. This is an english translation of an original French volume on food analysis. The passage of NAFTA and GATT has shown the fall of various trade and commercial barriers and it has become increasingly important for those involved in food analysis to have universal approach to these determinations. Nutritional labelling is also gaining importance and therefore, the ability to perform accurate analysis is critical. The consumers are also becoming more demanding, but quality is presently (and in future) a fundamental factor in internal product exchanges. This book is divided into 4 general segments, focussing on physical techniques including spectroscopy, biochemical techniques, sensory evaluation and nutritional as well as toxicological techniques, with each of these larger segments divided into separate chapters, covering different aspects of the subject areas. In the process of translation, both English speaking scientists with expertise in food analysis as well as French editors have been involved to ensure that nothing was overlooked. There are 41 contributors to this book, consisting of Food Scientists and Engineers from France.

The first part, "Physical techniques" is the major one, containing 10 chapters, while second, third and fourth parts have three, one and three chapters, respectively. The different physical techniques discussed under various chapters in the first part include - spectrophotometric, optical, spectroscopic, image analysis, electrochemical, rheological, particle size analysis techniques as well as complex and expensive instrumental techniques

like nuclear magnetic resonance, X-ray diffraction electron microscopy applied to food technology, mass spectrometry and radiochemical techniques. Each chapter deals in detail with the basics, recent developments and applications of the respective physical techniques in food industry. Chapter 10, on "Complex and expensive instrumental techniques" takes care of some of the latest costly techniques with special reference to their applications to food technology. Section 'C' of this chapter covers fundamental aspects of electron microscopy and discusses both transmission and scanning electron microscopy with reference to image and micro analysis as well.

The second part, "Biochemical techniques" discusses in detail, the various aspects of techniques like enzymatic analysis, immunochemical analysis, microbiological and chemical analysis. The chapter 1 of this part covers-properties of various enzymes, measurement of their activities determination of substrate concentration as well as techniques of their detection and analysis. The chapter on "Immunochemical analysis" explains how to obtain antibodies and apply agglutination, precipitation and labelled (Ag or Ab) reagent techniques in food and agriculture industry. The part III of this book covers sensory evaluation of foods under various rules like defining - the characteristics of the group evaluating the samples as well as its size; sample to be evaluated and conditions of evaluation; choosing an appropriate test; management and interpretation of results with rigor etc.

The fourth part consists of 3 chapters, explaining the various nutritional and toxicological analysis techniques under the chapters as; nutritional analysis techniques, toxic analysis principles and mutagenicity analysis techniques. The chapter on nutritional analysis techniques describes the characteristics and purpose of nutritional analysis, analytical principles, animal techniques as well as significance of physical and chemical analysis techniques, while the next chapter explains the principles of analysing heavy metals, mycotoxins in foods. The third chapter in this part deals with mutagenicity analysis and discusses basics of mutagenicity, detection of mutagens and assays for genetic toxicology. The book has also a well planned subject index. At the end of each chapter, references, articles and books for suggested reading have been mentioned as a ready reckener for the reader to enhance his/her knowledge about the subject.

This book will be very useful and serve as a reference material for food scientists, chemists, analysts as well as technologists. The simplicity of language and clarity of presentation are important features of this book, which along with presentation of all the available analytical techniques for food products in a compact form, will make this book very useful and popular among the students of Food Technology as well.

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NUTRITION LABELING HANDBOOK: Edited by Ralph Shapiro, Published by Marcel Dekker Inc. P. Box 5019, Cimarron Road, Monticello, NY 12701-5178, New York, 1995, pp. 704, price US $195/-

The United States Food and Drugs Administration (FDA) published the final regulations, implementing the Nutrition Labeling and Education Act (NLEA) with effect from 6th January 1993. This far reaching legislation has made the labeling of all foods with 'Nutrition Facts' mandatory. Whereas, enough food is a daily challenge to the poor, achieving a healthy diet is a universal challenge for people . Success of nutrition labeling is dependent on certain level of literary and educational attainment of people. The vision of NLEA is to achieve healthier food supply and a more nutritionally informed consumer. In this direction, Nutrition Handbook written by over 20 experts and edited by Ralph Shapiro, Nutritionist, with expertise in protein and amino acid metabolism, toxicology and nutrition labeling is an invaluable contribution on a subject that has generated wide interest for a more healthful society. Out of 24 chapters in the book, 2 chapters are contributed by the editor himself, namely, chapter 7 entitled "A comprehensive review of the nutrition labeling and education act regulations" and chapter 24, on "Analytical methods and databases for nutrition labeling". The editor has given a comprehensive review of the NLEA regulations (chapter 4), minimising the cumbersome legal terminology, as it appears in Code of Federal Regulations (CFR) and the Federal Register (FR). Incidentally, this chapter happens to be the big chapter, wherein the subject matter is divided into 15 sections and covered in over 100 pages. Sections 1-3, give an overview of NLEA followed by relevant rules for mandatory and voluntary nutrient declarations, label format for 'Nutrition Facts', Recommended Daily Intake (RDI) and Daily Reference

Value (DRV), serving size, nutrient content claims and ingredient declarations. Analytical methods and databases are discussed in chapter 24, providing an overview on chemical methods available for mandatory ingredients, viz., fat, fatty acids, cholesterol, dietary fibre, sugars, vitamin A, vitamin C, calcium, iron and sodium. Use of databases for gathering nutrient data for labeling is also discussed. Methodology for validation of analytical methods based on Food, matrix triangle with protein, fat and carbohydrate contents of food, as detailed in AOAC International 1993 has been pointed out.

The remaining 22 chapters contributed by experts in the field give their best on topics, namely, brief history of FDA regulation relating to the nutrient content of food, perspectives on nutrition labeling and education act, nutrition labeling of meat and poultry products, effects of the nutrition labeling and education act on federal advertising commission, advertising enforcement policy, International harmonisation and compliance, food labeling - the agony and the ecstasy: an industry perspective on NLEA, strategic planning and management of changing packages to comply with nutrition. regulations, designing packages for a healthier America and the NLEA, NLEA - linking education on regulation, loss in the supermarket: consumer confusion and marketing mania, impact of NLEA - an industry perspective; dairy foods, frozen foods, meat and poultry, functional foods, cereal and bakery products, and compliance with nutrient content declaration. In addition, the book gives reference amounts customarily consumed per eating occasion - general food supply, protein digestibility coefficient and FDA/USDA regulations and contacts, enforcement policy statement on food advertising and analytical methods and databases in Appendices 1, 2 and 3.

The book provides valuable perspectives on nutrition labeling regulations from the points of view of government, industry and consumer, and also gives practical guidelines for compliance. All these points make the text an essential resource book for food scientists, quality control and regulatory personnel and is a very timely and useful publication.

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Felicitation Function in Honour of Dr. V. Prakash, Director, CFTRI, Mysore

The Association of Food Scientists and Technologists (India) arranged a function on 18th October 1996 to honour and felicitate Dr. V. Prakash, Director, Central Food Technological Research Institute, Mysore, for having received the prestigious Sir Shanti Swaroop Bhatnagar Prize for the year 1996 in Biological Sciences for his significant contributions in the area of Seed Proteins. Dr. C.L. Nagarsekar, the President of the Association welcomed the gathering and congratulated Dr. Prakash on his achievements. Sri C.P. Natarajan, Former Director, CFTRI, and Dr. S.S. Arya, President-elect, AFST(I) and Director, DFRL, Mysore, spoke and offered felicitations to Dr. Prakash on behalf of themselves as well as the Association. Dr. V. Prakash, the chief guest, while replying to the felicitations urged the scientists and technologists of CFTRI and the members of AFST(I) to work devotedly with purpose and bring more laurels to the Institute and the Association in the years to come.

Annual Convention and Colloquium on "Food Safety and Quality"

The Association of Food Scientists and Technologists (India), AFST(I), organized a half day colloquium on "Food Safety and Quality", which was followed by the Annual General Body Meeting on 7th September 1996 at IFTTC Auditorium, Central Food Technological Research Institute (CFTRI), Mysore, Dr. V. Prakash, Director, CFTRI was the Chairman of the colloquium sessions. Dr. Anjana Murthy, Vice-Chancellor, Karnataka Open University, Mysore, was the Chief Guest at the convention. The Colloquium was spread in 2 sessions. Dr. M. Mohal Ram, Director, National Institute of Nutrition, Hyderabad, spoke on the health implications vis-a-vis food quality and safety. He stressed the need for reappraisal of management of food quality control system, which is being implemented by several agencies of different ministries of Union and State Governments. He felt that a safe and adequate quality of food supply is required for proper nutrition, which in turn, is essential for sound health of the people.

Dr. P.R. Krishnaswamy, Manipal Medical Centre, Bangalore, spoke on many aspects of Food Safety. Dr. Anjana Murthy, the Chief Guest, said that the country could increase its foreign exchange earnings, if it insured safety and quality of foods, particularly in the area of spices.

Dr. V. Prakash in his presidential address, said that the job of defining "food safety" had become difficult in the present context and it was the responsibility of food scientists and technologists, to make efforts to ensure compliance of the food products to safety standards. On the role of AFST(I), he felt that industry had failed to utilise the services of the Organization and wanted that the former should use the national level body as its mouthpiece for all its problems and grievances.

At the Annual Convention, a number of different awards were presented to distinguished scientists, who excelled in their areas of specializations. Sri C.P. Natarajan and Dr. S. Ranganna, The Editors, who took pains to bring out the Proceedings of IFCON-93 were felicitated at the convention. Earlier, Dr. Rugmini Sankaran, President, AFST(I) introduced the guests and welcomed the delegates. Mr. C.T. Murthy, Hon. Treasurer, AFST(I) presented the finance statement, while Mr. P.C.S. Nambiar proposed a vote of thanks.

Association of Food Scientists and Technologists (India)
CFTRI Campus, Mysore-570 013

Annual General Body Meeting

The 31st Annual General Body Meeting (AGBM) of the Association was held on 7th September 1996 at 3.30 p.m. in the IFTTC Auditorium, CFTRI, Mysore.

Dr. (Mrs.) Rugmini Sankaran, President AFST(I) welcomed the members present. In the welcome address, she reiterated that AFST(I) should pursue efforts in a more accelerated way, to get representation in the scientific policy making body of the Government of India. It was mentioned that it was a good augury that the Association's representative was invited to participate in the Core Committee Meeting of DGHS on 'Food colours' in New Delhi this year.

Mr. P.C.S. Nambiar, Hony. Executive Secretary read out the reports of the last AGBM and SGBM. Minutes of the AGBM were approved as proposed by Dr. T.S. Satyanarayana Rao and seconded by Mr. P.S. Balakrishna. Minutes of the SGBM were approved as proposed by Dr. S.R. Padwal Desai and seconded by Dr. R.R. Mohite.

Since the report was circulated to the members prior to the present AGBM, it was opined by the members that only the important features may be highlighted. As a major salient point, the Secretary informed that the award money for various awards instituted by the AFST(I) has been enhanced from 1996 onwards. Best Feature Article Award for Feature Articles published in *Indian Food Industry* has been instituted from the calendar year 1996. A similar award is already existing for the best paper published in *Journal of Food Science and Technology*. He also informed that M/s. Laljee Godhoo have agreed to enhance the award money from 1996 onwards. After an indepth discussion, the Secretary's report was approved by the members. The Treasurer's report along with the audited statement of accounts and budget estimate, which was circulated already, has also been approved by the General Body.

As proposed by Dr. T.S. Satyanarayana Rao and Dr. A.M. Nanjundaswamy, the AGBM decided to bring out 2 amendments to the existing constitution of AFST(I).

1. According to Clause 3, 4, 4 of the existing constitution of AFST(I), the Editor-in-Chief, *Journal of Food Science and Technology* is one of the members of the Central Executive Committee. In a similar way, the Chief Editor, "Indian Food Industry" should also be treated as one of the members of the Central Executive Committee.

2. No person can hold two positions in the Central Executive Committee.

The above amendments were approved by the General Body, Mr. R.S. Matche proposed that Mr. A.K. Krishnamoorthy may be continued as our Auditor for the coming year also. The General Body agreed to this proposal.

Elections were conducted as per the constitution, with Dr. Vidyasagar as the Returning Officer. The election results were announced amidst protests from some members on a point raised by Dr. T.S. Satyanarayana Rao.

The Secretary Mr. P.C.S. Nambiar announced the results of the election for the year 1996-97.

1. President-Designate	: Dr. S.S. Arya
2. Vice-President (HQ)	: Mrs. Sreemathi Hariprasad
3. Vice-Presidents (Chapters)	Dr. H.R. Adhikari, Mumbai
	Prof. R.K. Mukherjee, Kharagpur
	Prof. D.K. Gupta, Pantnagar
	Dr. P.I. Geeverghese, Thrissur
4. Joint Secretary	: Mr. Rajesh S. Matche
5. Hon. Treasurer	: Mr. S. Baldev Raj

In addition to the above elected office bearers, President: Dr. C.L. Nagarsekar; Immediate Past President: Dr. Rugmini Sankaran; Hony. Executive Secretary: Dr. M.S. Krishnaprakash; Immediate Past Secretary: Mr. P.C.S. Nambiar; Editor-in-Chief, JFST: Dr. B.K. Lonsane; Chief Editor, IFI: Dr. Rugmini Sankaran will form the members of the Central Executive Committee for the year 1996-97.

AFST(I) AWARDS

The other highlight of the meeting was the presentation of AFST(I) Annual Awards. The Secretary briefed the distinguished gathering on various awards instituted by AFST(I) and read the citation of the award recipients.

The following persons received the awards of the AFST(I) for the year 1995:

I. AFST(I) Fellow Award

1. Dr. Anantharaman S. Aiyar, Bangalore
2. Prof. Jiwan S. Sidhu, Kuwait Institute for Scientific Research, Kuwait
3. Prof. (Mrs.) Pushpa R. Kulkarni, UDCT, Mumbay
4. Dr. J.S. Pruthi, UNDP Consultant/Advisor, New Delhi
5. Dr. P. Narasimham, Scientist, CFTRI, Mysore

II. Laljee Godhoo Smarak Nidhi Award

Dr. B.R. Thakur, Defence Food Research Laboratory, Mysore

III. Young Scientist Award

Ms. Rekha Satischandra Singhal, Thane

IV. Best Student Award

Ms. Sonia Dang, Haryana Agricultural University, Hisar

V. Best Paper Award

Prof. H. Das and Mr. K. Ten Hove for their paper on "Evaluation on Yield Texture and Cooking Time of *Rasogolla*", published in Vol. 32, No. 2 1995, pp 109-114, of the *Journal of Food Science and Technology.*

The outgoing President Dr. (Mrs.) Rugmini Sankaran inducted Dr. C.L. Nagarsekar, President-Designate as President AFST(I) and rest of the incoming CEC members were also introduced to the AGBM.

After taking over as President AFST(I), Dr. C.L. Nagarsekar placed on record the services of Past-President and other CEC members. He thanked the members for electing him as the President. He stressed the point that AFST(I) should enrol more and more members. He called for the cooperation of all the members to take the Association to still greater heights. Referring to the participation of AFST(I) in the DGHS Committee Meeting on Food Colours, he said that it was a good beginning and the voices of scientists and technologists should be heard in the policy making bodies of the Government of India in future also. He also said that members from surrounding places of a chapter should be drawn to work unitedly for the benefit of the Association. He promised to coordinate in this task.

Dr. A.M. Nanjundaswamy mentioned that AFST(I) could think of having its own building either outside the CFTRI campus or a site within the campus to construct its own office premises with all facilities, since a substantial amount has already earmarked for this purpose.

Dr. R.R. Mohite, while congratulating the newly elected President, wanted to know the status regarding the preparation of a Compendium of AFST(I) members. The Secretary explained that the same could not be brought out as envisaged, because a majority of members, who had 10 years of continuous membership of the Association had not responded to the Headquarters' request to send the details of their expertise in time. However, members' list will be brought out every year, he said. Mr. P.S. Balakrishna suggested that Database of the expertise of all the members should be kept in AFST(I) office for ready reference.

Dr. S.R. Padwal Desai congratulated the incoming office bearers and expressed the view that the term of office bearers could be for 2 years so that they could coordinate the activities of the Association by working more efficiently. Mr. N. Keshava suggested that a copy of the constitution of AFST(I) may be supplied to the office - bearers so that they will have a clear knowledge about the clauses. Ms. Sonia Dang, Best Student Awardee for the year 1995 requested that TA/DA should be given to the awardees, coming from distant places to receive the award.

Dr. P. Narasimham suggested that a 10-year action plan may be formulated, covering all aspects, which could go a long way in achieving the objectives of the Association.

The AGBM ended with a vote of thanks to the chair and all the members.

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Publications of AFST (I)

		INDIA		FOREIGN	
		Price (Rs.)	Postage (Rs.)	Price (US$)	Postage (US $)
1.	Symposium on the status & prospects of the confectionery industry in India 1979	30	18	12	8
2.	Symposium on by-products from food industries: Utilization and disposal 1980	30	12	12	6
3.	2nd ICFoST-1981: Sensory analysis, Contaminants and Nutrition	40	18	15	7
4.	Symposium on recent developments in food packaging 1986	65	18	35	8
5.	Prof. V. Subrahmanyan Commemoration Issue 1980 (Part of Journal of Food Science & Technology) contains write-up on various aspects of Food Science & Technology	30	18	12	8
6.	Production & processing of meat & poultry products	100	18	45*	-
7.	IFCON-88, 2nd International Food Convention & Exhibition: Food Technology Overview	100	18	45*	-
8.	IFCON-88, 2nd International Food Convention & Exhibition: Abstracts of papers	100	18	45*	-
9.	Trends in Food Science & Technology: IFCON-88 Proceedings, 1988	300*	-	105* or £57*	-
10.	Collective Index (Volumes 1-25) Journal of Food Science & Technology	200*	-	30* or £15*	-
11.	Pollution management in food industries 1989	200	12	30* or £15*	
12.	Developments in milling and baking technology	125*	-	30*	-
13.	Trends in Food Science & Technology: IFCON-93 Proceedings, 1993	1250*	-	200*	-

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