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C O N T E N T S

REVIEW

Commensal Rodents as Pests and Methods for Their Control - A Critical Appraisal
M. Muktha Bai 175

RESEARCH PAPERS

Efficiency of Inactivation of Trypsin Inhibitors and Haemagglutinins by Roasting of Soybean *(Glycine max)*
S. Ramamani, H.N. Chandrasekhara and K. Narasimhamurthy 197

Studies on Some Functional Characteristics of Whey Protein-Polysaccharide Complex
Bimlesh Mann and R.C. Malik 202

Gas Retention in Fermented Doughs Obtained from a 'Landrace' and 'Durum' Wheat Cultivars
K.I. Ereifej 207

Evaluation of Blanching Quality in Groundnut (*Arachis hypogaea* L.)
U. Singh, R. Sridhar, S.L. Dwivedi, S.N. Nigam and R. Jambunathan 211

Studies on the Changes in Peroxidase, Acid Phosphatase, Phenols and Degree of Colouration of Eight Cultivars of Red Onion (*Allium cepa* L.) Bulbs During Development
D.R. Sood and Ashish Kalra 215

Optimization of Process Parameters in the Manufacture of *Churpi*
P.K. Pal, S.A. Hossain and P.K. Sarkar 219

Pasting and *Papad* Quality of Rice, Wheat and *Mung* Flour
Narpinder Singh, Usha Bajwa and K.S. Sekhon 224

RESEARCH NOTES

Comparative Study of Meat Quality of 'Giriraja' and Broiler Birds
K. Syed Ziauddin, K.C. Singh, H. Subba Rao and

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Antibacterial Activity of Lactic Acid Bacterial Isolates Obtained from Natural Habitats
Prabir K. Sarkar and Sharmistha Banerjee **231**

Effect of Dehulling and Genotypes of Sorghum (*Sorghum vulgare*) on *Roti*
V. Vimala, P. Geervani, Uma Pradeep and Ramadevi **234**

Studies on Rice and Turkey Meat Blend *Papads*
J.S. Berwal, J.S. Dhanda and R.K. Berwal **237**

Studies on Caustic Peeling of Apples
Levent Bayindirli, Alev Bayindirli, Serpil Sahin, Gulum Sumnu and Selcuk Gider **240**

Sensory Characteristics of Some Fast Foods Prepared with Cow Milk *Paneer* and Soy *Paneer* (*Tofu*)
Alok Pant, G.S. Chauhan and N.S. Tomar **243**

Sand-drying of Paddy Parboiled Under Different Conditions
P. Pillaiyar, K. Singaravadivel and H.S.R. Desikachar **246**

Incidence and Characteristics of *Bacillus cereus* Isolated from Indian Foods
R.C. Shah, B.J. Wadher and G.L. Bhoosreddy **249**

Prevalence of Enteropathogens of Zoonotic Significance in Meat, Milk and Their Products
B.R. Singh, K.N. Kapoor, Ashok Kumar, R.K. Agarwal and K.N. Bhilegaonkar **251**

Effect of Organic Acids and Spices on Quality and Shelf-life of Meats at Ambient Temperature
K. Syed Ziauddin, H. Subba Rao and Nadeem Fairoze **255**

Effect of Sprouting, Cooking and Dehulling on Polyphenols of Redgram (*Cajanus cajan*. L.)
S. Paramjyothi and V.H. Mulimani **259**

BOOK REVIEWS **261**

ANNOUNCEMENTS **267**

INDIAN FOOD INDUSTRY- CONTENTS

Commensal Rodents as Pests and Methods for Their Control - A Critical Appraisal

K. MUKTHA BAI

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Although the role of commensal rodents (rats, mice, and bandicoots), as destroyers of human foods and feeds and as carriers of communicable diseases, has been recognised, not much efforts have been made to control them successfully, until recent years. The resurgence of the dreaded disease plague in the year 1994 at Surat and other parts of the country, nearly after three decades, is an eye opener to the nuisance caused by these commensal rodents. Hence, the need of the hour is to create an awareness among the people to tackle the problem efficiently. In order to achieve this, proper dissemination of the knowledge regarding all aspects of rodent pests, besides their control is highly desirable. Keeping this in view, an attempt has been made to spell out not only the important role of these commensal rodents as pests in destroying man's food and agricultural produce, but also strategies which are ecocompatible and practical for keeping them under threshold limits of injury level more effectively in different environments.

Keywords : Commensal rodents, Losses, Pollution, Diseases, Strategies, Integrated approach.

Among the mammals, which are parasitic on man, the more damaging ones are the rats and mice. The magnitude of the havoc they cause is due not so much to any peculiar viciousness, but to their great multitude. They are considered as one of the formidable pests, as they are secretive, prolific and opportunistic creatures, quick to sense and avoid danger. They can live under a wide range of climatic conditions and adopt themselves remarkably. While omnivorous in nature, they do not relish insect-infested, mouldy foods that make them ill. These remarkable features added to their shrewdness, intelligence, nocturnal behaviour and their high rate of breeding potential, usually prevent to succeed in attempts to control or exterminate them. The struggle between man and rodents (rats and mice), began long before the dawn of civilization, has continued without cessation to the present time and will continue, no doubt, as long as human race endures these creatures. The destructive role of the rodents is known since time immemorial and is mentioned even in *Vedas*, and *Bhagwat Puranas* written sometime in 10-11th century A.D. Although the competition between man and rats started about 5000 years ago (Barnett 1947), it became intense, when agriculture came into practice and when he started storing the produce, for use during times of droughts and other natural calamities.

With the sole exception of man, the most successful and abundant mammals on earth today are the commensal rats and mice. They would never have enjoyed this success without man's inadvertent help. Commensal rodents have taken advantage of human transport and trade routes and moved from their ancestral home in Asia, to all continents of the world.

Rodents, specially those of economic importance, have been the subject of considerable interest in India. But their study has been greatly intensified only in the last two decades, especially after the Second World War. Of some 130 species of rodents known from the Indian region, hardly a dozen or so have been regarded as of economic importance. All of them are associated with man in one way or another and some are commensal.

The three most important commensal species that are distributed worldwide are i) the Norway or brown rat *(Rattus norvegicus*, Berk), ii) the roof rat or ship rat or black rat *(Rattus rattus*, Linn) and iii) the house mouse *(Mus musculus* Linn). However, some others, which are developing into commensals, are the lesser bandicoot rat *(Bandicota bengalensis*, Gray), the Polynesian rat *(Rattus exulens)* and the multi mammate rat, *(Mastomys natalensis)*. Most of the work done in recent years has been confined to the former three species of commensal rodents.

The aim of the present review is to discuss not only the important role of these commensal rodents as pests of man, but also to plan the possible strategy to keep them under threshold limits of injury level more effectively in urban and rural environments and also other places of food storage and handling.

Rodent distribution

Rodents are living in every part of the globe, except in the extreme polar regions (Prater 1975). High altitudes are no barrier to some of the order. Marmots live all the year round on the bleak Plateaux of Tibet, 18,000 ft (5500 m) and more above sea level. They are among the highest dwelling mammals in the world. Other rodents display the most remarkable adaptability to the most varied surroundings. Wandering or carried by human agency, the common house rat *(R. rattus)* and the brown rat *(R. norvegicus)* have adopted themselves to life in every part of the world. According to Dykstra (1966), next to man, rodents are considered the most destructive vertebrate pests on earth. The rats and mice belong to the Order: Rodentia, Family: Muridae, Sub-family: Gerbillinae (consisting of gerbils) and Murinae (consisting of rats and mice). As may be expected in a country like India, where diverse ecological conditions exist, the rodent fauna is fairly variable. According to Ellerman (1961), six families, 36 genera, 84 species and about 265 sub-species of rodents are known in India. Ghosh (1980) has noted that rodents in India are represented by 6 families, 39 genera, 90 species and about 200 sub-species, while Roonwal (1987) has reported that the rodents of Indian region comprise 46 genera, 128 species and 260 sub-species and their estimated population number vary between 5000-15,000 million. Although, the lists of economic rodent species that are documented by various workers in India include at least 23 species, according to Prakash (1976), based on the damages inflicted by them on food and fodder crops, at least about 10 predominant rodent species are of major concern and need greater attention. These include i) Striped squirrel, *Fanambulus pennanti* and *F. palmarum;* ii) Indian crested porcupine, *Hystrix indica;* iii) Indian gerbil, *Tatera indica;* iv) Indian desert gerbil, *Meriones hurrianae;* v) House rat, *Rattus rattus;* vi) Soft haired field rat, *Rattus meltada;* vii) House mouse, *Mus musculus;* viii) Short-tailed "Mole rats", *Nesokia indica:* ix) Lesser bandicoot rat, *Bandicota bengalensis:* x) and Large bandicoot rat, *Bandicota indica.*

Rodent pollution and contamination

In addition to damaging crops in the fields and stores, rats contaminate the foodgrains and seeds with their excreta and hairs. The contamination is ten times greater than what they consume (Davis 1956). Each rat excretes 25 to 150 pellets and 10 to 20 ml of urine every day and constantly sheds some of its coat of 500,000 hairs (Mills 1953). According to Dykstra (1955), 78 droppings, 16 ml of urine and 10,000 hairs are shed by rats within 24 h. Majumder (1964) has reported that a rat voids 70-80 droppings, 40-50 ml of urine and 4000-5000 hairs per day in warehouses and rat pens. Rats eat about 10% of their body weight each day (Dykstra 1966), some 20 to 40 pounds (10 to 20 kg) in a year, while contaminating the food with their urine and faeces. It is exemplified best by Barnett (1951) and Dubock (1978), who noted that in a year's time, a single rat *(R. norvegicus)*, when left free in a warehouse, had excreted about 50,000 droppings and 3.5 litres of urine and consumed approximately 27 lbs (12 kg) of food. In the same period, a single house mouse *(M. musculus)* would eat about 4 lbs (2 kg) of food and excrete 17,500 droppings. (Dykstra 1966; Harris and Baur 1982). Thus, the pollution and filth caused by these pests are of great concern, other than actual consumption.

Disease and health hazards

Rats are known to spread various diseases to man and livestock (Mallis 1963; Cotton 1963; Deoras 1966a; Pingale et al. 1967, Nimbalkar and Deoras 1966; Webster 1973). Although 130 types of diseases are attributed to them, the important one is the bubonic plague, carried primarily by the rat flea, *Xenopsilla cheopis*. The flea bites an infected rat and then carries the bacillus to man. Apart from roof rat *(Rattus rattus)*, the mole rat, *(B. bengalensis)* is also reported to be the major carrier of plague. (Deoras 1964; Nimbalkar and Deoras 1966; Webster 1973). The Indian gerbils (*Tatera indica*) also appears to play an important role in the spread of plague, while *R. rattus* possibly acts as the liaison rodent between man and wild rodents (Bhatnagar 1966). Urban rat borne plague remains a potential threat, wherever commensals come into contact with either enzootic rodent species (those that carry the plague organism in a latent state) or epizootic plague-susceptible rodents in urban or semi-urban areas. The transfer of *Y. pestis* or *pseudo tuberculosis* organism from native rodents to commensal rats by exchange of fleas occurs easily. Once commensal rodents become infected, the risk to the human populace is greatly increased (WHO 1987).

Plague, termed black death, which once killed 25 million people during the 14th century in Europe and almost 10 million deaths in the Indian sub-continent between 1896-1917, is still endemic

in several areas of the world. The first recorded outbreak of plague in India was in Agra during the reign of Emperor Jehangir. Since then, the disease was prevalent in endemic form in different parts of the country, particularly in the northern regions. Plague became a serious problem in early 19th century and the situation worsened, when the pandemic of 1894-1896 involved India. The epidemic from Hong Kong first spread to Bombay and paralyzed life in that city. By one description, Bombay reminded of the desolate streets of London during the plague of 1665 (Jaggi 1979). From Bombay, the disease extended to other cities, resulting in heavy casualties. During the year 1897, it was estimated that 57,965 people had died of plague and the figure rose to 950,863 in 1905. Then slowly, the incidence began to decline. In 1968, no deaths from plague were reported. (Park and Park 1991). However, suspected plague outbreaks in India were reported in 1975 in Maharashtra (Renepurkar 1986) and in 1985, in Himachal Pradesh. Nearly three decades later, i.e., in 1994, there has been a resurgence of pneumonic plague at Surat (Kartha and Jeetendra 1994) and of the suspected 1,500 cases nationwide, the death toll touched 47 (Friese et al. 1994).

During the decade 1976-1985, a total of 7948 cases of human plague were reported to WHO from 19 countries, of whom 7% died, compared with 28,000 cases in the previous decade (WHO 1987). Of special interest is the reappearance of human cases in the same area after long years of quiescence. Such cases were seen in the republic of South Africa and Uganda after an interval of 10 years, in Libya in 1976/77 and again in 1984 (Brookes and Rowe 1987). Pollitzer (1954) mentioned of the spread of salmonellosis, leptospirosis, jaundice, amoebiasis, trichinellosis and tape worm infections caused by rats. Other diseases carried by them include rabies, rat bite fever, rickettsial pox, tularemia and probably Kysanur Forest Disease (KFD) also (Cotton 1963; Rajagopalan 1966). Several thousands of people were reported to have been bitten by rats, specially the infants, who are more vulnerable (Scott and Boron 1965) and 20,000 cases per year of rat bites were admitted in Bombay city alone (Deoras 1964). Outbreaks in Vietnam, South America and East Africa have demonstrated that, when large rodent populations are allowed to exist, it is difficult to eradicate the disease and prevent its recurrence. Baltazard (1966) has given an exhaustive list of parasites, microbes and viruses, for which rats can be vectors. They also carry at least 18 different kinds of lice, fleas, ticks and mites.

Characteristics of field crop losses by rodents

In many places, no sooner seeds are sown, the rodents dig them out and eat them. The presence of rodents at this stage is usually undetected by the farmer and when few seeds germinate, the quality of the seed is blamed. In Rajasthan, during 1970, the sown grains of millet and sorghum were eaten by *Gerbillus gleadovi* in such huge quantities that the summer crop was sown three or four times in the districts. The last sowing was thus so much delayed that the kharif crops failed (Barnett and Prakash 1975).

The early shoots of crop plants are a favourite delicacy for field rodents. At this stage, all crops in dry fields are vulnerable. Once the plant has grown to about 400 mm height, it is unlikely to be damaged by rodents until the time of flowering. After flowering, the seeds are subject to heavy attack. The smaller rodents climb up the plant and feed there; but the larger ones cut down the entire plant from the bottom and then eat the seeds. Such losses occur both tin the khariff (rain-fed) and *ragi* (winter - irrigated) crops. Losses to sugarcane are usually due to nipping off the growing points and the apical buds and then cutting the main cane. Groundnuts (ripe or unripe) are dug out and consumed. At the same time, the rodents cut the branches of the plants and check their further growth. The losses in threshing yards are incalculable. Rodents from the field migrate and burrow near the yard, open their tunnels under the heaps of drying grains and damage them (Barnett and Prakash 1975). In coconut plantations, rats (usually *R. rattus)* chew the buds, cut the unripe nuts, cut holes in the ripe nuts and scoop out the contents. The wastage due to cutting is reckoned to be many times more than the loss from feeding. *Bandicota bengalensis* is another species, which is responsible for the damage of coconut saplings (Yashoda Urs 1978; Guruprasad and Srihari 1978). Similarly, coffee pods are damaged by this species.

The mature trees are debarked by field rodents *(Meriones hurrianae)* and 'girdled' by them. In the hills, the rock rat, *R. cutchicus*, feeds on flowers and seeds in the plantations. Sometimes, the rat population is so high that no seed remains. This may make the plantation programme a complete failure. In the sand dunes of Rajasthan desert, the girdling activity of desert gerbils, *Meriones hurrianae*,

on the trees of *Prosopis juliflora*, *Albizzia lebbek* and *Acacia tortilis*, aged one to seven years, is so severe that about 20% of these are lost (Barnett and Prakash 1975).

In natural ranges, whenever seeds of high-yielding grasses are sown to enhance productivity, rodents dig and feed upon them. This is particularly true in arid and semi-arid regions. Standing grasses are also severely damaged and their inflorescences are eaten during the monsoon in preference to any other part of the grass. If the rodents cannot reach the grass panicle, the entire plant is cut down. The choicest part is then consumed and the rest of it is left to dry and be blown away (Prakash 1969). When the seeds of the grasses ripen, the rodents turn to them. The adaptable feeding on the various parts of the plants in different seasons makes the rodents an effective obstacle to the regeneration of natural and sown pastures (Prakash 1962).

Among fodder crops, which are usually raised by irrigation, *Tatera indica* (Indian gerbil) causes severe damage to barseem, cowpea, lucerene and giant napier. A single gerbil can clear most of a fodder patch during a night. Their extensive tunnels damage the fibrous root system of grasses. While digging, the rodents also gnaw at the roots and kill them by exposing them to the dry air (Barnett and Prakash 1975). Apart from this, the damages caused to various types of vegetables, plantation crops and cash crops, as documented by different workers, are given in Table 1.

Losses caused by rodents to stored seeds and grains

Losses caused by rodents and other vertebrate pests are often believed to be great, but are difficult to assess, since grains or seed stocks are frequently, physically removed from the store. The usual method of estimation is to attribute all losses, that cannot be accounted for in any other way, to vertebrate rodent pests. A recent review of the literature on pre-and post-harvest food losses caused by rodents indicated that lack of adequate data and appropriate survey of sampling techniques had lowered the satisfactory estimates of the losses (Jackson 1977). Surveys throughout the world show a wide range of post-harvest losses caused by rodents and estimates for India range from 2.5% (Huysmans 1970) to 5.9% (Deoras 1975); 25 to 30% (Girish et al. 1974) and 8-25% (Majumder and Parpia 1966). A WHO document (1987) has pointed out that often the amount consumed and spoiled by rats (they spoil as much as 20 times the food they eat) made all the differences between famine and adequacy. While it is difficult to calculate the damages done by these rodent pests, attempts to estimate the damages to different food crops in different parts of world, including India, are presented in Table 2. Estimates of the damages or losses of stored crops and other foodstuffs, due to commensal rodents in tropical and sub-tropical areas, are listed in Table 3. Post-harvest damages to grains by different rodent species and their attack on different storage structures are classified in Tables 4 and 5.

Control measures

Control of rodent pests is essential from viewpoint of not only safeguarding human health, but also to prevent economic, structural and other losses caused by these pests. The usual or common control procedures that are employed throughout the world are directed mainly to prevent or discourage them from living in and around human habitats or kill them (Muktha Bai 1971, 1992; Muktha Bai and Majumder 1987; Brookes 1973; Frantz and Davis 1991). The common control practices thus evolved are (i) improvement in environmental sanitation (ii) protection of buildings and structures by proofing (iii) use of rodenticides (iv) fumigants and traps to kill the adult and young ones of migratory, surplus or existing rodent population. However, use of repellents, attractants and predators are mainly adopted, as an adjunct to other methods of control, for yielding better results (Majumder et al. 1968; Muktha Bai 1992; Krishnakumari 1968).

Environmental sanitation

Human food wastes, providing both food and water, can attract and then support rodent populations. Rodents occupying human or other establishments are often largely maintained on garbage available around, that are spilled and unprotected. Therefore, it is essential to see that food wastes are stored in rodent-proof containers, until they are cleaned or cleared off. The surrounding debris also provides shelter to rodents, apart from propagation. Hence, they should be cleared off as early as possible to discourage rodent establishments. Care should be taken to store always the food materials (human or animal) in containers or bins that are rodent-proof. Food protection and sanitation committee of the National Pest Control Association (1982) and many other workers in the field, viz., Penn (1971), Pingale et al (1967), Majumder (1968) have reported that good house

TABLE 1. SOME ESTIMATES OF THE PRE-HARVEST DAMAGE CAUSED BY RODENTS TO DIFFERENT FOOD/CROPS IN DIFFERENT PARTS OF INDIA

Place	Crop/ materials	Rodent species	Damage, %	Reference
Ludhiana	Almond nurseries	*B.b,T.i. G.e.;M.m.*	14.9-26.8	Prasad et al (1984)
Karnataka	Cashew	Rats, squirrels bandicoots, porcupines	-	Naidu (1962) Bhat (1982)
		R.r	gnaw cashew nuts in and eat away the cotyledons of the germinating cashew in the field	
		B.b	Damage cashewnuts in the field	Bhat and Mathew (1982)
		B.b *R. blanfordi*	Cashew seedlings damage	Rai (1984)
	Cocoa pods	*F. palmarum*	20.2	Keshav Bhat (1978)
Arasikere	Coconut nurseries	*B.b.*	6-8	Guruprasad and Srihari (1978)
Mysore	Coconut nurseries	*B.b.*	0.97-8.26 Rs. 71-3230/ha	Yashoda Urs (1978)
	Coconut	*R.r*	20-30	Krishnakumari et al (1968)
	Tomato	*B.i.*	-	Muktha Bai (1989)
Bellary	Hybrid rice	*B.b*	0.44-100	Prakash and Prakash (1985)
Bangalore	Hybrid rice	*B.b*	6.15-79.72	Prakash et al (1986)
Andhra Pradesh	Coconut, Paddy	*B.b*	20-25	Expert Committe of CPPTRI (1977)
	Sugarcane	*R.r*	10-60 (2-3 tonnes/acre)	Mohan Rao and Subbiah (1982)
	Coconut,	*R.r*	15.5 nuts/tree	
	Sugarcane	Field rats	9.0 (seedlings stage) 18-28 (growth stage)	Barnett and Prakash (1975)
Hyderabad	Rice, ('Tella hamsa', variety)	*R.r*	1-2 wk nil harvest	
		R.m	4-8 wk growth: 9.27 ± 2.77	Mohan Rao and Singh (1983)
		M.b	8-10 wk, 15.48 ± 2.77	
		V.O	10 wk growth: harvest 12.38 ± 1.74	
Kerala	Cocoa pods	*R.r*	8.51	Keshava Bhat (1978)*
Tamil Nadu	Cocoa pods	*F.tristriatus*	30.2	Keshava Bhat (1978)*
Pune	Food grains	*R.r*	25.0	Pradhan (1980)*
Hapur	Stored food grains (*in villages)	*R.r, R.n, M.m*	63.85g/day/house	Diwakar et al (1984)

TABLE 1. CON'T'D FROM PREVIOUS PAGE

Place	Crop/ materials	Rodent species	Damage, %	Reference
Andaman	Oil palm plantation	*Rattus* spp. *R.r.w.*	10-40/nurseries mature palms	Subaiah (1983)* Bhat *et al.* (1990)*
Uttar Pradesh	Stored food grains (villages)	*R.r*	1.3-2.22 (1.36-3.59 tonnes annually)	Krishnamurthy et al (1967)
Lucknow	Sugarcane	Field rats	15-30 (2-4"from ground level)	Brar and Avasthy, (1982)
	Sugarcane	Field rats	180-600	Omprakash and Avasthy (1980)*
Faizabad	Barley		5.4-12.4	
	Wheat		29	
	Sugarcane	Field rats	167	
	Groundnut		6.3-12.12	Srivastava (1977)
	Paddy		42.0-59.6	
	Cajanus cajana		6.48	
	Sorghum		6.25	
	Gram		30.5	
	Coconut	*R.r.r*	5.7-16	
Punjab	Bajra,		0.02-0.87	Bindra and Sagar
	Groundnuts		30-76 kg/ha	(1968)
	Jaggery, Groundnuts		200 kg/ha	
		Field rats	19.2-30.6 kg/acre	Atwal (1965)
	Wheat crop	Field rats	19.0 kg/acre	
Rajasthan	Tomato (green, unripe)	Field rats	12.56	Ram Singh and Saxena (1984*)
South Gujarat	Vilayati ambli *(Pithecolobium dulse)*	*R.r*	Pods (Heavy damage)	Jhala and Shah (1989)
	Yam (*Dioscorea L*)	*B.b*	22.36-26.92	Jhala et al (1984)*
Laccadive Islands	Coconuts	*R.r*	50.0	Barnett and Prakash (1975)
Lakshadweep Islands	Coconut plantations	Rats	3.50 or 60 lakh of nuts worth Rs. 35 lakhs/yr	Shah and Subaiah (1978*)
Assam	Arecanut	Rat and Squirrel	20%	Nambiar (1949)

R.r - *Rattus rattus* *M.m*-*Mus musculus*

R.r.r. - *Rattus rattus rattus* *G.e*- *Golunda eliott*

B.b -*Bandicota bengalensis* *R.n* - *Rattus norvegicus*

T.i - *Tatera indica* *M.b* - *Mus booduga*

R.r.w. - *ratttus rattus wrorughtoni* *V.o* - *Vandeleuria oleraceae*

R.m. - *Rattus meltada* *B.i* - *Bandicota indica*

*Rodent Newsletter (ICAR) Vol 1 to 12, 1978 to 1989.

TABLE 2. SOME ESTIMATES OF LOSSES CAUSED BY RODENTS IN VARIOUS COUNTRIES

Country	Crop	% loss or value	Reference
India	Rice	28.8%	Hussain (1922).
	All crops	Rs. 1242 crores for 20 years	Kunhardt (1919)
	All crops	Rs. 776 million	Ghosh (1945).
	Khariff	50%	Singh (1955)
	Grains	2.4 million tonnes	Srivastava (1966)
	Paddy	27	Deoras (1966)
	Stored food	25-30 (post harvest)	Parpia (1966)
	Stored food and foodgrains	1,000,000 tonnes	Garg and Agarwas, (1963) Parrack (1967) Sinha and Ram (1963)
England	All crops	£ 100 million	Holden (1947)
Fakarave, French	Coconut	75-100	Dumbleton (1955)
Oceania World	All crops	55 million tonnes	Dobrovsky (1959)
Jamaica	Coconut	5-36	Smith (1964)
U.S.A.	All crops	189 million	Dykstra (1966)
Liberia	Paddy	10	Hall (1964)
Hawaii	Sugar	$ 4,500000	Robinson (1965)
Italy	All crops	Libras 45, 00 in	Singh (1966)
France	All crops	Francs, 24,000	Singh (1966)
Switzerland	All crops	Swiss Francs £ 20	
Great Britain	All crops	£ 20 million	
Germany	All crops	Dimes *300 miillion	
Europe	All crops	£ 2000 million	
Japan	All crops	$ 280 million	Anon (1966)
Mindanova Islands (Philippines)	Rice	50	Dobrovsky (1966)

Source: Krishnakumari (1968), Srivatsava (1968) * DM

keeping and sanitation, both inside and out, are the most important factors in the control of pests in most of the environment, including food stores or plants. In warehouses, godowns, grain mills, silos and bulk storages, the materials, viz., cereal grains, flours, sugar, dried or fresh fruits, vegetables, etc., must be held in screened rodent- proof rooms or buildings to prevent their access to these materials from getting consumed and contaminated.

According to Pratt et al (980) as well as Frantz and Davis (1991), stacks of foodgrains should be placed on racks raised from the ground at least 0.5 m for inspecting and detecting the damages, spoilages and any signs of infestation or contamination. Apart from this, it is quite essential that these are stacked neatly in rows and it is advisable to keep the stacks narrow for regular and proper inspection of the commodities and in case of rodent infestation to plan for controlling them. It is equally important to prevent the rodent pests from getting access to water through leaky taps, drainages, water spouts and pool of water assembling

TABLE 3. ESTIMATED DAMAGE AND LOSSES OF STORED CROPS AND OTHER FOOD STUFFS DUE TO COMMENSAL RODENTS IN TROPICAL AND SUB-TROPICAL AREAS.

Area	Types of storage	Commodities attacked	Damage or loss, %
Brazil	Stacks, sacks, cribs	Rice, Maize, Beans	4-8
Bangladesh	--	Rice, Pulses, Grains	2-5
Egypt	Open and cLosed stores	Cereal grains	0.5-1.0
Ghana	--	Maize, Rice, Grains	2-3
India	Warehouses, sacked	Cereal grains	5-15
Korea	Sacks in houses and stores	Rice, Barley	20.0
Laos	Stores	Rice, Maize	1-7
Mexico	Granaries, sacks, cribs	Maize, Rice, Groundnuts	5-10
Malaysia (Sarawak)	Cribs	Rice	5-10
Nepal	Sacks	Maize	3-5
New Hebrides	Covered platform	Yams	10.0
Nigeria	Temporary or closed stores	Pulses, Groundnuts	3-5
Philippines	Warehouses, sacks	Rice, Maize, Legumes	2-5
Sierraleone	Temporary cribs or sacks	Rice, Maize, Groundnuts	2-3
Solomon Islands	--	Yams	5.0
Thailand	Sacks, cribs	Maize, Rice, Copra	5.0
Turkey	Warehouses, sacks	Wheat, Rice, Maize, Legumes	5-15
Tunisia	Warehouses	Cereal grains, Legumes	6-8

Source: WHO/VBC/79.726 p 28.

in small pits, discarded tins, cans, unattended water tanks, etc., around homes or buildings.

Rodent exclusion

Rodent exclusion or proofing is the technique of preventing rodent access to buildings and places of food supplies. This could be achieved or carried out by using physical, chemical or other barriers to keep the rats away from getting inside the establishments, buildings or fields. Since food, water and harbourages are the main sources of attraction to rodents, first precaution to exercise is to see that all places, where food is stored, processed, prepared or served, should be of rodent-proof in nature. Secondly, cracks and openings in buildings, foundation, basement of the wall, etc., which are the entry points of rodents to gain access into buildings, must be closed. All other openings such as water pipes, electric wires, telephone wires, sewer pipes, drain spouts and vents, which enter a building, should be tightly sealed to prevent rodent entry. Doors, windows and screens should be tight fitting. Use of plank, wood and other materials that could be gnawed by rodents are of no use, when used as rodent proofing materials. It is also well documented that the enamel on the rodents' (Norway rat) four continuously growing incisor teeth are rated at 5.5 Moh's hardness scale. This seems to be comparable to the hardness of the lower incisors of number of other rodents, including the ship rat and house mouse (Jenson 1979; Knote 1980). In practice, however, they only

TABLE 4. POST-HARVEST DAMAGE IN FARM AND VILLAGE STORAGE DUE TO RODENTS IN INDIA

Part of the country	Type of storage	Commodities attacked	Rodent species reported	Extent of damage caused
West Godavari District, (Andhra Pradesh)	Ryot godowns	Rice, cereals grams, coconuts	*R. rattus* *B. indica*	10% by weight of food in store, 10% cost of stored grain, Widespread
All regions	Bag/bulk storage and mill premises, not rodent proof	Foodgrains, oilseeds, jaggery, processed and cooked foods	*R. rattus* *R. norvegicus* *B. bengalensis* *B. indica* *M. musculus*	Survey near Hapur showed range of 1.36-3.59 tonnes/ village or 1.69% in stores Av population of rodents = 9.8/house and 1.29/person.
Cuttack, Orissa State Research Farm	Gunny bags	Raw paddy as well as polished rice	*R. rattus* *B. bengalensis* *M. musculus*	10-20 kg/tonne of stored food 1-5% of stored grain, £ 0.27-1.34/tonne of paddy lost in producers' godowns and grain traders.
Punjab	Bulk stores and gunny bags	Wheat grain	*R. rattus* *M. musculus*	5-10% of store (estimated)
Himachal Pradesh	In big wooden boxes and mud bins in bulk after threshing	Wheat, barley Maize, pulses Rice, etc	*R. rattus* *M. musculus*	10,000 tonnes lost, 5-10% of stored grain, (£ 5347), widespread
Tamil Nadu, Southern Districts	Jute bags	Rice, millet, Legumes, seed cotton	*R. rattus* *M. musculus* *Bandicota spp.* *F. palmarum*	5% of stores, otherwise extent unknown
Mysore	Gunny bags in stores made of straw, etc.	Rice, wheat, pulses	*R. rattus* *B. indica* *R. norvegicus* *M. musculus*	35 tonnes 3.5% of stored grain, widespread
South (Coastal)	Stlits, sheds open sheds	Coconuts	*R. rattus* and others	-
Rajasthan	"Khatti" type in villages and sacks in pucca godown	Wheat, jowar	*M. musculus* *B. indica* *R. rattus*	1.5-3.5 tonnes p.a. 3-4% of store/all over state.
Palghat District (Kerala)		Stored paddy groundnuts	*R. rattus* *M. musculus*	Unknown, Absence of reliable data on quantity stored
Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra	Godowns	Wheat, gram, barley, rice,	*R. ratttus* *M. musculus*	Approximately 11 million tonnes, 15% of store, £ 534,
Nilgiris District	Farmhouses	Potatoes, Cabbage, Raddish	*R. rattus* *B. bengalensis*	200-400 tonnes, 0.33-0.66% (£10,695-21,390) widespread

Contd...

TABLE 4. CONT'D FROM PREVIOUS PAGE

Part of the Country	Type of storage	Commodities	Rodent species	Extent of damage
West Bengal	Gunny bags, storage structures of bamboo and rice	Rice, Wheat, pulses	*B. bengalensis* *R. norvegicus* *R. rattus*	Estimated damage 2-3% of store quantitative loss only) £6.700.000 Fairly wide spread
All regions	Brick rooms, Mud storage bins reinforced with bamboo	Wheat, rice maize, sorghum, bulrush, millet barley, pulses, Linseed, guar bean	*Rattus sp.* *Bandicota spp.* *M. musculus*	1.96 million tonnes per annum of grain (1967 estimate), 2.5-5% of stored grain
New Delhi	Mud bins, Thatched bins, metal, concrete and brick bins, jute bags and small pots	Cereal grains, oilseeds, mustard, ground nut, pulses, grams, etc.	*Ratus ratus* *M. musculus* *B. bengralensis* *Fanambulus spp*	5-6% by rodents, 9-12% by roents insects and moulds. All farm villages infested
All regions	Mud and Bamboo bins	Paddy, vegetables, clothing cattle fodder	R. rattus *B. bengalensis* *B. indica* *M. musculus*	5% of stored items
(Gujarat, Siddapur Taluk Mehasana Dist)	Open mud bins Open brick and cement plaster bins, and in bags without dunnage and in open houses	Wheat Bulrush millet castor, sorghum	*R. rattus* *M. musculus*	30,000 tonnes, 5-10% in store 160,420 widespread

Source: Hopf et al (1976).

effectively gnaw anything with a value lower than about 3.5 for example, lead (1.5), aluminium (2.0) and copper (2.5-3.0). According to Jenson (1979), one of the most important approaches of effective management of stored food pests is to design and construct food management facilities and equipment. Apart from preventing rodents' establishment, good house keeping practices should be encouraged. Kitchens, bathrooms, basements and garages are of greatest importance and need constant vigilance for pest prevention in most of the residential areas. In conjunction with good sanitation, rodent proofing techniques give better control than any other approach.

Poison baiting

Among the various methods of controlling rodent pests, poison baiting is one of the most popular, effective and widely used techniques to combat the rodent pests successfully. The earliest form of rodent control was probably through the use of arsenic compounds during the 14th century in Britain (Chitty and Southern 1954; Elton 1954). A number of rodenticides were developed since then in Germany, France and USA; but by the outbreak of the second World War, only red squill and arsenic remained in much demand (Greaves 1971). Zinc phosphide (Marsh 1966; Srivastava 1966; Deoras et al. 1969; Chaturvedi 1970; Krishnakumari and Majumder 1966; Majumder 1975), sodium monofluoroacetate (Kalambach 1945) and some of the anticoagulants, viz., Warfarin, Chlorophocinone, Diphacinone, Pival and Coumatetralyl, that are used in different parts of the world, are given in Table 6. However, Bromadiolone, Brodifacoum (Marsh 1977; Gorenzel et al. 1982; Dubock and Kaukeinen 1978; Hadler 1979) and Flocoumafen Shell Company, UK), which are single feed second generation anticoagulants, are some of the rodenticides that are gaining importance and are introduced in different countries. The usage of rodenticide (%) in baits in different countries and

TABLE 5. POST-HARVEST LOSSES* OF GRAINS STORED IN DIFFERENT STORAGE STRUCTURES DUE TO PESTS IN INDIA

Store type *	Average period of storage, months	% Weight loss due to				
		Insects	Other agents			Total
Indoor *gade*	6.69	2.26	Rodents	3.15	3.97	6.23
			Mould	0.82		
Outdoor *gade*	6.82	1.74	Rodents	2.45	2.79	4.53
			Mould	0.34		
Puri	7.75	2.02	Rodents	1.12	1.63	3.65
			Mould	0.51		
Patera	5.33	1.17	Rodents	0.13	2.22	3.39
			Mould	2.09		
Mud pots	6.13	2.01	Rodents	0.72	2.15	4.16
			Mould	0.25		
			Theft	1.14		
Indoor *puri*	8.60	1.73	Rodents	2.53	2.82	4.55
			Mould	0.29		
Moola	4.40	1.64	Rodents birds mould	-	4.44	6.08
Kotlu	9.00	1.27	Rodents, birds, moulds	-	1.41	2.68
Garise	7.00	1.23	Rodents		2.42	3.65
Bags	6.37	1.45	Rodents		2.37	3.28
Katta	6.00	2.39	Rodents		0.58	2.96
All stores	6.65	1.85	Rodents		2.97	4.82

N.B. No statistically significant differences (at 95% level). * Storage losses as percentage of initial quantity stored.

Sourced: IDS Research Reports (The prevention of farm-level foodgrain storage losses in India :A Social cost-benefit analysis- Boxall et al (1978).

a- Andhra Pradesh

also some of their useful characteristics in controlling rats and mice are listed in Tables 7 and 8.

Mostly, rodenticides are mammalicides and for their effective use, they have to be incorporated along with food materials to be ingested by rodent pests. Various types of food materials, viz., cereals, pulses and oilseeds are in wide use, as baits or bait ingredients (Cornwell and Bull 1967). All bait formulations, like meal, pellet, place pack, wax block, liquid, tracking dust are designed to introduce the active ingredient into the gut of the target species (Fitzwater 1989). This is achieved either directly in the form of a bait, which may be solid, liquid or gel, or indirectly by the use of 'contact' formulations. Among these, solid baits are by far the most commonly used formulations, wherein the substantial portion/quantity forms the bait base. Therefore, the choice of bait base is critical and most important. So far, the bait bases have always been based on food materials, viz., whole or cracked cereals, mixture of cereals and flours, dried fruits and vegetables, bread crumbs, meat and fish, freshly cut and cubed apple, carrot, rolled or potted barley, walnut, meats, etc. (Chitty and Southern

TABLE 6. LIST OF ANTICOAGULANT RODENTICIDES FAVOURED FOR USE IN DIFFERENT PARTS OF THE WORLD

Country	Anticoagulant
Canada	Coumachlor, Pindone
Federal Republic of Germany	Coumachlor, Coumafuryl, Coumatetralyl
Finland	Dicoumarol
France	Chlorophocinone, Coumachlor
India	Coumatetralyl, Warfarin, Coumafuryl, Bromodiolone
Israel	Pindone sodium
Malaysia	Coumachlor
Mexico	Coumafuryl
Philippines	Pindone
Poland	Diphacinone
United Kingdom	Coumatetralyl, Chlorophacinone
USA	Coumafuryl, Diphacinone, Pindone
USSR	Chlorophacinone, Diphacinone

Source : Bently (1972); Prakash and Ghosh (1992); Marsh (1977).

1954; Harris and Baur 1982; Krishnakumari 1968). Use of food materials as bait bases of carriers also gives rise to problems of insect and mould infestations, thereby affecting the stability and palatability of baits. Bases with high natural oil contents are subject to rancidity, particularly in warm climates. Also, use of food bases might attract the attention of other animals, pets and children, resulting in health hazards to non-target species. It has been observed that, though certain ingredients are best liked by rodents, there is no guarantee that it would be similarly acceptable to them, when mixed with poison due to the interaction with the bait materials, containing fats, minerals, amino acids, etc. (Muktha Bai and Krishnakumari 1975; Harris and Baur 1982). In order to overcome problems, which are associated with food, a novel approach of presenting these poisons effectively, when carried in non-food bases, has been reported for the first time (Muktha Bai and Majumder 1987; Muktha Bai 1992). Apart from this, use of various additives and attractants is reported to improve the bait palatability by the target rodent species. Vegetable oils and sweeteners have been commonly added to improve the bait acceptance, if the bait itself is palatable (Muktha Bai et al. 1975; Krishnakumari and Majumder 1966; Pingale et al. 1967; Barnett and Prakash 1975). Brookes and Rowe (1987) have reported that dexide (a carbohydrate with flavour) improves the palatability as well as consumption of baits, containing anticoagulants. Artificial flavourings of several kinds have been proposed as attractants, but their efficacies have not been assessed properly. Coloured dyes or pigments viz., chlorazol sky blue, alkali fast green, aqua green, methylene blue and monastral green have also been frequently added to rodent baits, as warning agents to deter humans or birds from feeding on them. Nigrosine black is rarely used (Chitty and Southern 1954; Pingale et al. 1967; Howard and Marsh 1974). While chemicals, viz., paranitrophenol and dehydroacetic acid are included as mould inhibitors in cereal baits, paraffin has been recommended to moisture proof them for use in sewers and warm or humid tropical environments (Sipaila 1975).

An effective or ideal rat poison that meets all requirements under all conditions has not yet been produced. Most of the materials now available have one shortcoming or another. At least three important attributes such as acceptability, efficacy and safety to non-target species are essential for its use as a rodenticide. Though a number of rodenticides have been evaluated and used, paucity of satisfactory compounds is striking. The efficacy of a rodenticide under field conditions depends upon some important criteria such as toxicity, dosage levels, degree of acceptance, reacceptance, development of tolerance, bait shyness, odour as well as taste. Most of the times, apart from the availability of rodenticide, the species to be controlled and the possible health hazard to non-target species and the environment of its use often dictate the selection or choice of poison. Among various types of rodenticides, which are in use, zinc phosphide (an acute poison) and bromadiolone (a second generation anticoagulant poison), which has replaced warfarin (a first generation anticoagulant), are being recommended and used widely in our country as well as many parts of the world. Hence, these two rodenticides are reviewed in detail.

1. Acute rodenticide

Zinc phosphide: It is an efficient acute rodenticide, widely used at different concentrations, ranging from 0.5 to 20.0%, all over the world (Schoof 1970; Brom 1968). According to Martelli (1919), zinc phosphide was first used by Grandi and Ghetti in the year 1912 to eliminate plague caused by field rodents in an Indian province. Then, its popularity grew slowly and extensively spread to Germany, Great Britain and United States of

TABLE 7. RODENTICIDE (%) USAGE IN BAITS IN DIFFERENT COUNTRIES

Rodenticides	USA	UK	USSR	Europe	India	Far East	Israel
ANTU	1-3	-	-	-	2-3	-	-
Arsenic trioxide*	1.0 1.5-3	-	-	-	1.5-3.0	-	-
Barium carbonate*	10-25	-	-	-	10-25	-	-
Norbramide	1.0	0.5-1	-	0.5	0.5-1	0.5-1	
Sodium flouroacetamide [b]	0.025	0.25	0.05	-	0.025	0.32	-
	0.01-2	2.0	-	-	-	-	0.2
Strychninea	0.3-0.6	-	-	-	-	-	-
Red squill	5-10	-	10.0	-	-	-	-
Thallium sulphate**	1.5	-	-	1.0	2-4	-	1.5-2
Zinc phosphide	0.5-3	2	7-15 upto 30	-	2	1-5 upto 10	2-2.5
Warfarin	0.005	0.0125	0.01-0.2	0.005	-	-	-
	0.025	-	-	-	-	-	-
Diphacinone	0.005- 0.025	0.0125	0.01-0.2	0.005	-	-	-
Fumarin	0.025- 0.05	-	-	-	0.025	-	-
Pival	0.025- 0.5	0.025-0.5	0.05	-	-	-	-
Racumin	-	-	-	0.025	0.0375	-	-
Coumatetralyl	-	0.050	-	-	-	-	-
Chlorophacinone	0.005	0.005	-	0.005	0.005	0.005	-
Bromodiolone	0.005	0.005	0.005	0.005	0.005	0.005	-
Brodifacoum	0.005	0.005	0.005	0.005	0.005	0.005	-

Source: (i) Rodent control manual (1975), CFTRI; (ii) WHO Manual (1987); Bentley, (1972)

* Rarely used; **Banned from use; a. Not recommended for rats.

b. Given under supervision and to trained technical persons only.

America. The oral LD_{50} value of this compound to the laboratory rat *(R. norvegicus)* has been reported as 40.5 mg/kg (Dieke and Richter 1946); 41.3 mg/kg (Chitty and Southern 1954) and 43 to 56 mg/kg depending on the purity of the compound (Krishnakumari et al. 1980). The sub-acute study has shown that growing rats were susceptible to this rodenticide even at 50 ppm level, as indicated by significant reductions in food intakes and body weights, as compared to those of controls and 500 ppm level resulted in 83% mortality of the test rats and death to many animals (Muktha Bai et al. 1980). The LD_{50} values to other rodents reported by Prakash and Ghosh (1992) are a) *T. indica indica*: 35.0 mg/kg (Prakash et al.1969), b) *T. indica cuvieri*: 2.21 mg/kg (Srivastava 1965), c) *M. hurrianae* : 35.0 mg/kg (Prakash et al. 1969), d) *R. rattus*: 300.0 mg/kg (Paranjothy 1939), e) *R.rattus*: 40.0 mg/kg (Barnett et al. 1975 b), f) *R. norvegicus* wild: 25.0 mg/kg (Garlough 1941), g) *M. musculus*: 250.0 mg/kg (Rao and Prakash 1981), h) *B. bengalensis*: 2.51 mg/kg (Srivastava 1965) and i) *B. bengalensis* : 25.0 mg/kg (Htun and Brookes 1979).

The major disadvantage of not using this poison widely is the rapid onset of poisoning symptoms, which may begin to occur, before the animals have taken a lethal dose, thus causing them to stop feeding. It has been shown that rodents can associate the unpleasant symptoms of the ingestion, due to a sub-lethal dose of poison, with the poison bait for perhaps three to four

TABLE 8. NONANTICOAGULANT AND ANTICOAGULANT RODENTICIDES AND SOME OF THEIR USEFUL CHARACTERISTICS FOR CONTROLLING RATS AND MICE

Common name	Chemical name	Active ingredient used in food bait, %	Mode of action	Time to death	Bait acceptance	Bait shyness	Humen hazard	Rodents controlled		
								House Mice	Norway rats	Roof rats
Brome-thalin	n-methyl-2, 4-dinitro -n-(2,4, 6-tribromo-phenyl)-6-trifluo romethyl benzenamine	0.01	Central nervous system depression and paralysis	2-4 days	good	none	moderate	yes	yes	yes
Choleca-lciferol	9,10-Seco-5Z,7E,10(19) -choisestatrien-3β -01	0.075	Mobilizes calcium resulting in death from hypercalcemia	3-4 days	fair-good	none	low to moderate	yes	yes	yes
Red squill	Scilliroside glycoside[a]	10.0	Heart paralysis	24hr	poor-fair	moderate to high	low	no	yes	no
Stry-chnine	Strychnine	0.25-1.0	Tetanic convulsions leading to respi-ratory failure	0.25 3 hr	fair	moderate to high	moderate to high	yes	no	no
Zinc phosphide	Zinc phosphide	1.0-2.0	Phosphine gas enters circulatory system heart paralysis, gastrointestinal and liver damage	0.5-20 hr	fair	moderate	moderate	yes	yes	yes
Brodi-faccum	3-(3-(4-bromobiphenyl -4-yl) 1,2,3, 4-tetra hydro-1-naphtha-lenyl) -4-hydroxy-2H-1-benzo-pyran-2-one	0.005	Interferes with its conversion of prothrombin in the liver. Blood loses its clotting ability and capillaries are destroyed	3-7 days	good	none	low to moderate	yes	yes	yes
Broma-diolone	3-(3-(4-bromo(1,1-biphenyl)-4yl)-3-hydroxy-1-phenyl propyl)-4-hydroxy-2H-1-benzyopyran-2-one	0.005	Haemorrhage may occur in any part of the body prior to death, the animal exhibits increasing weakness due to blood loss and increasing pallor	3-7 days	good	none	low to moderate	yes	yes	yes
Flocou-mafen	3-(3-(4-trifluro-methyl benzyloxy-phenyl-4-yl)-1,2,3,4-tetrahydro-1-naphthyl)-4-hydroxy-coumarin	0.005		2-5 days	good	none	low to moderate	yes	yes	yes
Warfarin	3 (alpha-phenyl-beta-acetyl ethyl)-4-hydro-xycoumarin	0.025		5-9 days	good	none	low to moderate	no	yes	yes

Note: Rodenticides such as ANIU, arsenic trioside, and phosphorus are registered and available in some states:they are rarely used today because of their limited availability and low efficacy in most situations. [a]Principal active ingredient.

months (Barnett 1947) during which time, they will be shy of that particular bait. Although various workers have reported the occurrence of bait shyness in different rodent species by feedings of zinc phosphide baits in sub-lethal doses, the author opines that these type of studies are of academic

interest, and their applicability under practical condition is poor. This is because 90-95% of the rats, which succumb to this poison, definitely would have consumed the lethal doses due to prebaiting phenomena and usage of optimum concentration of the rodenticide. The small sector of the population, which does not come to bait (5-10% of the population) always exists in any natural habitat. The unpublished work of the author indicates that zinc phosphide baiting, carried out for two or three times in a year spread over a period of 10 years in atleast 20-25 premises, where roof rat infestation prevailed, rodent population had not exhibited any shyness to this poison.

2. Anticoagulant rodenticides

With the introduction of the first anticoagulant rodenticide, warfarin, in 1948 by O' Connor, the demand for the most acute poisons declined almost to zero and hence became obsolete. The remarkable popularity enjoyed by this rodenticide was mainly due to its effectiveness against rodents, when ingested in small multiple doses, which reduced the hazards of acute poisons and increased the degree of safety to higher animals (Hagan and Rodomski 1973; Fitzwater and Prakash 1977; Thomson 1976). Birds are relatively resistant to this anticoagulant with an LD_{50} of 1000 mg/kg b.w. (Muktha Bai and Krishnakumari 1986). Besides, secondary hazards are also minimized, which is an added advantage over other acute rodenticides. However, the continuous dependance and indiscriminate use of this anticoagulant for more than a decade has created the problem of resistance in various rodent species (Boyle 1960; Greaves et al. 1976). This is a matter of major concern all over the world. Attempts made by various workers to combat warfarin resistance by utilizing acute, chronic or specific rodenticides (Marsh 1977), additives such as sulphaquinoxaline, phenyl butazone, reserpine, vitamin A, vitamin D_2 (Rowe and Redfern 1965; Muktha Bai et al. 1978), vitamin K additives and compounds, such as L-histidine, capable of affecting the blood capillaries to increase warfarin toxicity, are also well documented (Muktha Bai 1979). Currently, the development of second generation anticoagulant rodenticides, viz., difenacoum, broadifacoum, bromadiolone and flocoumafen, which combine the advantages of the older anticoagulants (first generation) with the additional and novel characteristics of single or limited lethal feeding potential and efficacy against rodents resistant and generally more tolerant to other anticoagulants, are favoured in most countries.

Bromadiolone: Of the several anticoagulant compounds, this is the first second generation anticoagulant rodentidice, which got registered in Indian market in the year 1988. This anticoagulant, similar to brodifacoum or flocoumafen, is shown to possess exceptional potency and capability of controlling both resistant and non-resistant rodents. The information on acute oral LD_{50} to several commensal and other species of rodents collated, as reported by Prakash and Ghosh (1992), is given in Table 9. Muktha Bai (1984), Marsh (1977) have also reported the efficacy of this compound to various rodent species and found it to be a potent and highly palatable anticoagulant, capable of achieving 100% mortality in Norway rats *(R. norvegicus* Berk) with 1 day feeding and requiring 1-5 feeding (bait containing 0.005% bromadiolone) for other commensal and agricultural pests.

Repellents

Rats have an initial aversion to some odours, but the use of repellents to solve rodent problem is seldom practical. Odour producing substances, if effective, generally have only short-term effects. Where a rat population is high and is on the increase, any attempt to protect the area, food commodities or other gnawable materials with odour repellants, cannot be expected to succeed (United States Agricultural University leaflet 1976). Although, a number of compounds have been found to possess repellent properties, majority of them are also odorous or toxic to man (Majumder et al. 1964; WHO 1987; Prakash 1976; Krishnakumari 1968). As early as in 1954, Welch (1954) noticed that many chemicals were used in the form of dusts, sprays and other formulations to repel rodents of different types from attacking stored grains, seeds sown in the field, cables, etc., all over the world. Majumder et al (1964) reported that malathion, along with DDT and gamma BHC in high viscosity oil (Durobase oil) as a formulation, when treated on commodities in jute bags, was an effective rat repellent for atleast 3-4 weeks. Muralidhara et al (1975) noted that the above formulation was also useful in protecting the grains for seed purposes.

Other commonly used repellents are thiram, cyclohexamide, tributylin salts and rotran (R-55), for protecting agricultural crops, wiring and cables. According to Gutteridge (1972), rotran has been successfully utilised for protecting buried telephone cables from rodent damage. On the other hand, Krishnakumari and Jackson (1973) found that it had shorter period (25-96 days) of effect against

TABLE 9. ACUTE ORAL LD_{50} TO COMMENSAL AND OTHER SPECIES OF RODENTS.

Species	LD_{50} (mg/kg)	Reference*
House mice (*M. musculus*)	1.75	Marsh (1977)
Rats (*R.norvegicus*)	1.125	"
Rabbits	1.0	"
Dogs (MTD)	10.0	"
Cats (MTD)	25.0	"
Swine (MTD)	25.0	"
Poultry	more sensitive	"
F. pennanti	2.5	Anon (1986)
M. hurrianae	0.55	
R. rattus	3 x 0.16	Maddaiah et al
	1.0	(1988)
B. bengalensis	1.58	Sridhara et al
		(1988)
B. indica	2.10	

*Prakash and Ghosh (1992)

both Norway rats and house mice, thereby resulting in partial protection of paper bags, containing attractive foods. However, it is opined that repellents, detected by taste, may be somewhat more rewarding and practical, if they can be coated onto or impregnated into packaging materials or other items to be protected from rats. These may be particularly effective repellents, if they are able to create some physiological ill feeling in rats, which they associate with the initial contact. However, indepth studies are needed for their practical application, as the compounds used as repellents should possess properties such as stability, lack of objectionable odour and essentially non-toxic in nature. Also, it should not interact or have any harmful effect upon the packaged goods, besides the handler.

Ultra sound

Sound has been used experimentally to control the activities of insects as well as rodents. The audible range for the normal human ear is 20 hertz (Hz) to 20 kilohertz (KHz). Certain insects and rodents have hearing ranges that extend beyond those of humans and which can be detected only by special instruments. However, use of very high frequency sound and ultrasound has been proposed as a means of preventing rats from entering or gaining access into buildings or from one area to another (Pinel 1972). For this purpose, various ultrasound devices have been developed and studied to expel rodents from godowns, where food is stored. The studies conducted by Lavoie and Glahn (1977) on two selected types (out of five commercially available types) of ultrasonic generators, having the frequency ranges 41-48 KHz, on the effect of feeding activity of Norway rats in an infested building, showed that neither type of generators was effective in expelling the rats from warehouses and preventing them from feeding at distances of 1.5 to 31.3 meters from the sound source. Greaves and Rowe (1969) also were of the opinion that high frequency sound and ultrasound were not repelling enough to keep the rats from food and water. Because of considerable controversy regarding the efficacy claims of these devices (Howard and Marsh 1985; National Pest Control Association 1978), many manufacturers/ distributors in the USA have ceased their operations, as a result of government enforcement activities. Canadian Government has developed guidelines to restrict sales of such devices, unless efficacy claims are substantiated (Laidlaw 1984). Studies carried out by Muktha Bai (1992) have shown that the neurophysiological responses of the laboratory rat *(R. norvegicus)* , kept at 0.5 m from the ultrasound generator, having a frequency range of 20-25 KHz and sound output of 80-110 dB at one meter (Maser Electronics (P) Ltd, Bombay), were positive in nature, but they were short-lived. Hence, the author is of the opinion that indepth studies are essential with regard to the efficacy claims made by different ultrasound manufacturers for their proper use in alleviating the problems of rodent pests, when used alone or in combination with other control measures.

Biological control

Worldwide, commensal rodents are attacked by a wide variety of predators, including Indian false vampire bats *(Megaderma lyra)*, house shrews *(Suncus murinus)*, various raptors, carnivorous mammals and reptiles (Barnett and Prakash 1975; Brookes and Rowe 1987; Deoras 1966a; Erlinge 1975; Frantz 1973; Marshall Jr 1977; Nader 1969). Various predators have also been introduced to function as biological control agents, viz., ferrets *(Mustela putorius)*, monitor lizards *(Varanus indicus)*, small Indian mongooses *(Herpestes auropunctatus)*, Japanese weasels *(Musca sibricaitats)*, barn owls *(Tyto alba)*, domestic cats and dogs (Young et al. 1950; Jackson 1951; Elton 1953; Davis 1956; Uchida 1966; Farhang-Azad and Southwick 1979; Laird 1966). Eventhough domestic cats and dogs and other animals have been used as predators, they are found to be effective in killing or removing the surplus population, leaving behind the breeding stock unharmed. Hence, buildup of population is

quick, as often experienced by many, who have adopted such methods. However, cats (if kept unfed) can keep the immediate environment rodent free, if the population is low and are successful in modifying the composition, but not the size of population. Deoras (1964) noticed that kites, owls or snakes, which prey on rodents in the field also act as natural check on rodent population. Japanese weasels apparently kill rats, even when they are well-fed and they tend to consume more murids, even when other preys are available. Uchida (1966), is of the opinion that these weasels would probably not represent a rabies risk, if brought from and introduced to areas that are rabies-free. Fitzwater and Prakash (1966) and Laird (1966) have reported that potential health hazard like rabies is associated with the field use of these mammals. Hence, this method of control is handicapped with a number of limitations.

The biological control potentialities of disease agents have been investigated by many workers (Prokhorov and Serebrayakova 1965; Laird, 1966; Fitzwater and Prakash 1966). At the end of 19th century, *Salmonella typhymurium* and *S. enteritidis* var. *danysz* were used against mice. Although, they readily killed rats under controlled conditions, variable results were obtained in the field trials. Many bacteria which have been studied or tested for commercial rodent control are serotypes of *Salmonella*, which are also dangerous to humans and domestic animals. Therefore, widespread application, especially in grain warehouses, food industries and residential places, has to be viewed with conservation.

Trapping

This is one of the oldest methods of controlling the rodent pests and for this purpose, various types of traps are in use throughout the world. In India, box trap, break-back trap, snap or guillotine trap, well trap, pit trap, pot trap, barrel trap, wonder trap, cage trap and bamboo arrow traps have been used (Pingale et al. 1967). According to Fitzwater (1970), snares, pitfalls and deadfalls were the first traps to be used. Some of the earliest mechanical traps were pottery traps, which either strangled the rats with a noose, or enclosed rats alive by releasing a door (Drummond 1980, 1982).

Trapping is one of the effective methods of controlling the rats, but requires more skill and labour than baiting. Trapping is recommended, where use of rodenticides is not advisable or feasible and it is the preferred method in situation, where the rodent population is at low level or at the beginning of infestation. It is quite useful in situation, where dead rat odour is undesirable and capture of live rats is useful for experimental purposes and also as a feed to snakes kept in zoo. Moreover, since trapping permits the user to view his success, it creates psychologically the sense of success/happiness or achievement. Improper use of traps without the knowledge of species to be captured, their behaviour, population density, etc., might result in trap-shy rats and only a partial removal of the rodents.

In trapping, the kinds of baits used are of great importance. Baits of proven acceptability include bacon, peanut butter, fresh or smoked or dried fish, ground meat or bread for Norway rats and nuts, meat, apples, carrot, melon, bread, fried stuffs such as, *masala vada*, fried fish, fresh coconut, rolled groundnuts, etc., for roof rats (Brookes and Rowe 1987; Muktha Bai 1971). It is sometimes necessary to use an exotic food to compete with the available food supplies (Pingale et al. 1967). Rats rely on concealment for protection, avoiding open spaces as much as possible. Therefore, the best places for setting traps are near walls, corners, harbourages, nesting and hiding places, runaways, etc. Success with traps will be more, if they are set within the home range of rodents, viz., 5-10 feet for house mouse and 10-20 feet for rats. In most of the situations, trapping combined with other methods of control, viz., poison baiting, rodent proofing and sanitation, yields long lasting or better relief from rodent pests, than when trapping alone is carried.

Fumigation

Rodents, especially the field rodents, can be effectively controlled with poisonous gases, where other methods, viz., trapping and baiting may not be effective or economical. Many local fumigants have been suggested, like burning pine needles, dry leaves with chillies and cowdung, but with various degrees of success (Fitzwater and Prakash 1966; Majumder 1968). Fumigation of the burrows is successfully carried out with calcium cyanide, carbon monoxide, carbon disulphide, chloropicrin, methyl bromide, ethylene dibromide and aluminium phosphide (Pingale et al. 1967). Liquid fumigant has been suggested by Krishnakumari et al (1968) to kill the rodents in field and domestic areas successfully, as they can reach the animal, percolating through the plugs made by them to escape from the predators, such as snakes etc.,

and also the poisonous gases aimed at them. Narasimhan et al (1978) have tried, adding chloroform to acrylonitrile as rodent fumigant, with an idea to stupefy the animals first by chloroform and subsequently killing them due to action of fumigant on them. However, before they are recommended for practical application, studies on other rodent species are essential.

In general, fumigants are quite dangerous both to the persons using and to other human or animals in the immediate area. Experience and skill are required, therefore, to their proper application. The three fumigants that are frequently used for rat control are i) calcium cyanide, ii) methyl bromide and iii) carbon disulphide. However, currently aluminium phosphide is gaining more popularity in Asia and other areas (WHO 1987).

Since most of the rodent species are nocturnal in habit and reside in their burrows during day time, fumigation will kill not only the adults, but also the young ones, which are otherwise, difficult to be controlled by trapping or baiting techniques.

Integrated rodent control measures

So far, there is no single or universal method, which is applicable or suitable under all conditions of ecosystems and for all species of rodents. Each ecosystem is different from one another and hence needs careful evaluation of the situation, before any control method is suggested or employed. With changes in man's ecosystem due to industrial, social, cultural, scientific, technological and related activities, the magnitude of the rodent problem is also equally challenging. Rural and urban habitats as well as industrial and cultural complexes provide different ecosystems. Therefore, new or different strategies have to be evolved for their successful control in various habitats, particularly in complex situations like multi-storeyed buildings, residential quarters in towns and cities, hospitals, restaurants, poultry farms, plantations, food industries, seed stores, etc. Integrated approach of rodent control in rural areas by combining repellant spraying in order to protect the existing food material and driving the rats towards poison baits, killing adult population by poison baiting and disinfesting the burrows with fumigant emulsions, thereby killing the sub-adults and young ones and use of quinine hydrochloride as optical attractant on the bamboo containers, are reported earlier (Majumder 1964; Krishnakumari and Majumder 1965).

Integrated pest management is a strategy, which requires blending of various control techniques in an integral fashion, depending upon the requirement as well as the environment to keep the post population below threshold of economic injury level (Muktha Bai 1991). However, it should be kept in mind that such integrated control approaches, which have to be evolved, should be economical, ecologically compatible and practicable. Various methods of control, viz., environmental, chemical, biological, mechanical, sterilization and other ancillary methods, viz., sex pheromone, attractants, repellents, ultrasonic sound, hypotensive drugs, etc., have to be evaluated for their incorporation as integrated approach. In agriculture, for practical purposes of application, selection or recommendation of these methods in an integral manner has not been reported. The author feels that, among various methods of control, prophylactic (rodent proofing) and changing the environment, followed by either physical or chemical or biological methods will yield better results in terms of relief for longer periods from these pests.

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Efficiency of Inactivation of Trypsin Inhibitors and Haemagglutinins by Roasting of Soybean (*Glycine max.*)

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In vitro and *in vivo* studies were conducted to determine the efficiency of inactivation of trypsin inhibitors and haemagglutinins by roasting of soybean (*Glycine max*). The results showed that roasted soybean was free of trypsin inhibitor activity upto a level of an average value of 95 ± 2 %. Haemagglutinin was found to be much more heat labile and 98-100% could be inactivated by roasting at 115°C for 10 to 15 min. However, PER of autoclaved soybean was found to be superior to that of roasted soybean, as indicated by *in vivo* studies. As a result of roasting, pancreatic hypertrophy could be eliminated, as indicated by short term trials with rat feeding studies.

Keywords : Soybean, Roasting, Trypsin inhibitors, Haemagglutinins, Protein efficiency ratio, Pancreatic hypertrophy

Heat processing improves the quality of the final product nutritionally, functionally and organoleptically. These effects are dependent on whether the processing is by wet heating or dry heating (e.g., roasting). However, foods based on extrusion cooking or roller drying are costly, due to considerable capital outlay and cannot be adopted under rural conditions. Thus, simple roasting is a good heat processing method to prepare ready- to- eat products. Ready-to-eat bakery products like biscuits are expensive and lower economic strata of people may not be able to afford.

A ready-to-eat food supplement based on cereals, oilseed meals, pulses, unrefined sugar and vitamins has been developed at Central Food Technological Research Institute, Mysore under the name "Energy Food", which is being produced in collaboration with the State Government for School Feeding and Social Welfare Programmes (Narasinga Rao 1978; Prasannappa and Jagannath 1985). In the " Energy Food", the ingredients are roasted for enhancement of flavour, to inactivate antinutritional factors and improve the protein digestibility. Roasting of sunflower seeds not only improves flavour, but also functional properties of the proteins (Aruna Venkatesh and Prakash 1993).

Roasting of proteinaceous oilseed causes recemisation of essential amino acids as well as reduction in availability of lysine (Whitaker and Tannenbaum 1977).

However, heat treatment inactivates antinutritional factors, such as trypsin inhibitors and haemagglutinins (Singh et al. 1994). Soybean (*Glycine max.*), the major oilseed of the world, although a rich source of proteins, is associated with antinutritional factors, such as trypsin inhibitors and haemagglutinins in addition to others (Liener 1953). Raw soybean does not promote growth of albino rats. But, soaking and cooking under steam pressure make soybean a very nutritious source of proteins (Kakade and Liener 1957). However, soybean would still be associated with strong raw beany flavour. Processing of soybeans needs complicated equipments such as extrusion cookers, which are expensive. Roasted soybean powder has been in use in oriental foods under the name 'Kinako' (Wang 1981). The effects of roasting time, initial temperature and the ratio of batch size to capacity of roaster have to be emphasised, when the process has to be scaled up, as these have been shown to be affecting the quality of the product. In this paper, the effect of roasting of soybeans on antinutritional factors such as trypsin inhibitors and haemagglutinins is reported.

Materials and Methods

Soybean 'Bragg' 'Ankur' and 'Kalitur' varieties were procured from JNKVV, Jabalpur, India. Benzoyl-DL-arginine-P-nitroanilide (BAPNA), crystalline trypsin, pancreatin, pepsin, soybean haemagglutinin, FDNB were procured form Sigma Co, USA. All other chemical reagents were of analar grade or unless otherwise stated.

Preparation of roasted soy grits: Cleaned soybeans were pre-warmed, dehulled and split. Husk was separated by winnowing. For dry heating, the dehulled splits were roasted in different batch sizes.

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Batch size and roasters used: Roasting of dehulled soy splits was carried out, using different roasters according to batch size. For a 120 g batch size, a skillet was used, roasting having been done manually. Initial temperature of the air above skillet metal inner surface was recorded along with the minimum temperature reached by the splits as well as the maximum temperature, just before stopping roasting, were also recorded.

With 120 g batch size, the splits were manually roasted with starting temperature of (a) 40°C and (b) 100°C for 5 min each and 4 replicates were tried.

In another set of experiments, 120 g of soy splits were pretreated with 12-15% moisture, or a chemical solution of same amount. After 90 min, the pretreated seeds were roasted for 8 min manually (initial temperature 100°C, as 140°C condition nearly charred the splits). All the samples were air cooled, converted to grits for defatting by hexane extraction. The colour of the fine grits was measured in a Shimadzu U.V. visible recording spectrophotometer 2100, before defatting. All the trials were carried out in quadruplicates.

For 1 kg batches, an electrically operated roaster (4 kg maximum capacity) with and rpm of 1390 and two heating coils of 2 Kw and 0.37 Kw with a H. P. of 0.5 was used. The maximum temperature that could be reached was 250°C.

For 15 and 25 Kg capacity batches, an electrically operated batch roaster with a maximum capacity of 30 Kg and rpm of 920, with 3 heating coils of 6 Kw each was used. Both the electrical roasters were of Bharat make. Except when mentioned, the initial temperature was 140°C in all cases.

With electrical roasters, only untreated soy splits (1, 15 or 25 kg batches) were subjected to roasting with an initial temperature of 140°C, and 4 replicate samples were drawn for analytical purposes. The minimum temperature reached by soy splits and the temperature, at the time of withdrawing samples were recorded. The splits were air cooled at room temperature. The colour of the roasted grits was measured as mentioned earlier. The grits were defatted using food grade hexane, desolventized by aeration and powdered to pass through 60 mesh.

Wet heating: Dehulled soy splits were soaked in distilled water for 2 h. After draining the water, the splits (150 g batch) were spread in small trays and subjected to autoclaving for 20 min under steam pressure of 1 kg/cm^2 (temperature 121°C). The splits were cooled and dried in a current of air for 4 h (45-49°C), converted to fine grits and colour was measured as mentioned above in case of roasted grits. These fine grits were defatted, using food grade hexane and after aerating for desolventization, powdered to pass through 60 mesh. The sample is termed 'autoclaved soybean'.

All the flour samples were analyzed for protein content (Nx6.25) by micro Kjeldhal procedure (AOAC 1984). Trypsin inhibitor was measured by AACC method, as modified by Hamerstrand et al (1981). Haemaggluutinins or lectins content was measured by the serial dilution technique, using trypsinized rabbit blood erythrocytes. The highest dilution of the extract, causing visible agglutination, is identified as the titre value (Lis and Sharon 1972). Available lysine was estimated according to Carpenter (1960).

In vitro digestibility of the protein of raw and processed soybean samples was measured by the pepsin-pancreatin digestion method.

The roasted sample of 'Ankur' variety of soybean flour was used to measure the PER of the proteins by Campbell's procedure (1963). Results were statistically evaluated by the student "t" test (Snedecor 1950). Histopathology of the pancreas and liver of the rats fed with raw or roasted soy flour, as a sole source of protein in an otherwise adequate diet, was studied by microscopy by taking sections and staining according to Lillie (1965).

Results and Discussion

Tables 1 and 2 present the protein contents of roasted and defatted soy flours. Protein content of roasted soy splits did not vary to a considerable extent. Slight variations were perhaps due to residual oil content. "Kalitur" variety had the maximum protein content of about 60.1 %. However, when roasted for 15 min, it was reduced to 48.8 %.

Trypsin inhibitor was the highest (56.3 ± 1.64 mg/g of protein) in 'Ankur' variety of soybean (Table 2). This was reduced on roasting and the value showed a steep reduction on roasting for10-15 min. However, autoclaved meal had the least value, inactivation being upto 98% (Tables 2 and 3). In case of 'Bragg' variety, the different ratios of batch size to maximum capacity of roaster gave different levels of inactivation. Initial temperature of roasting, pretreatment with alkali salt solution as well as duration of roasting have a marked effect on the inactivation of trypsin inhibitor (Table 1). At high initial temperature (140°C), browning was more and whiteness values were 12.9% and 10.4%,

TABLE 1. PROTEIN CONTENT AND ANTINUTRITIONAL FACTORS BEFORE AND AFTER ROASTING OF DEHULLED SOYBEAN *(GLYCINE MAX)* ('BRAGG' VARIETY)

Batch size	Processing conditions* with maximum and minimum temp reached	Crude protein, (N x 6.25) % Mean ± SD	Trypsin inhibited, mg/g protein Mean±SD	Whiteness, % (magnesium carbonate as 100% Mean ± SD
-	Raw	48.1 ± 0.4	43.8 ± 1.5	30.8 ± 4.0
120 g	Roasted for 5 min 140°C-92°C - 120°C	46.0 ± 0.6	6.8 ± 0.0	12.9 ± 2.0
120 g	Roasted for 5 min 100°C - 90°C	46.2 ± 1.6	5.7 ± 0.8	22.5 ± 0.5
120 g	Conditioned with 10% added moisture for 90 min and roasted for 8 min 100°C - 80°C	47.6 ± 2.3	17.0 ± 4.2	27.7 ± 3.0
120 g	Conditioned with 10% added salt solutions for 90 min and roasted for 8 min, 100°C - 80°C	a) 46.3 ± 2.5 b) 47.5 ± 3.1	7.3 ± 0.6 2.6 ± 0.0	25.7 ± 3.0 22.6 ± 2.5
120 g	Soaked and pressure cooked at 1 kg/cm² steam pressure for 20 min, (121°C)	47.3 ± 2.3	5.8 ± 0.8	25.2 ± 0.8
1 kg	Roasted for 10 min 140°C-90°C-130°C	45.6 ± 0.0	4.4 ± 0.05	10.4 ± 0.9
1 kg	Roasted for 15 min 100°C-90°C-100°C	47.1 ± 1.2	4.1 ± 0.00	17.7 ± 0.1
15 kg	Roasted for 15 min 140°C - 92°C	48,9 ± 0.9	11.4 ± 1.4	27.8 ± 4.5
15 kg	Roasted for 30 min 140°C-90°C-121°C	46.8 ± 1.2	5.8 ± 0.9	20.0 ± 1.4
15 kg	Roasted for 40 min 140°C-92°C-130°C	46.8 ± 1.5	7.6 ± 0.6	17.1 ± 0.7
**25 kg	Roasted for 20 min 140°C - 90°C	47.3 ± 0.9	15.6 ± 0.5	Not determined
25 kg	Roasted for 20 min 140°C - 120°C	49.0 ± 0.9	15.9 ± 0.6	Not determined

First 6 samples were roasted manually in skillet except for the first sample

* Initial temperature of skillet and final temperature of soybean are given for first 6 samples, except for first sample

a. Sodium bicarbonate 0.5%

b. Ammonium bicarbonate 0.5%

Last 7 samples were processed in mechanical roasters. Temperature: Initial -min-final

**Haemagglutinin content of raw soybean was 11.5 ± 0.8; in the processed samples. It was not detectable except in one sample (25 kg batch roasting) 1.2 ± 0.0

Values are the mean ± S.D. of 4 replicates

as against 20% and above for other samples (Table 1). Magnesium carbonate was the standard for 100% whiteness. However, in pretreated samples, whiteness was higher, compared to raw beans though inactivation of trypsin inhibitor was maximum (3 mg/trypsin inhibitor per g proteins). It is to be noted that inactivation of trypsin Inhibitor is predominantly influenced by varying batch size and capacity of roaster (Table 1). Optimum time and initial temperature have to be decided accordingly. These effects might be due to non-uniformity of heat transfer across the soysplits. Time required to inactivate the trypsin inhibitor in 120 g batch was 5 min, whereas, for the same

extent of inactivation with 15 kg batch needed 30 min. In case of 25 kg batches, 20 min duration was not sufficient. These observations have to be kept in mind, while fixing standards of roasting time and temperature, when large scale trials are to be made.

Haemagglutinins of soybean were found to be susceptible on roasting, or pressure cooking. In case of 'Ankur' variety, 98 to 100% was destroyed in 10 and 15 min roasting time. Even roasting for 5 min was sufficient to reduce haemagglutinin activity to non-detectable levels in the 'Bragg' variety (Table 1).

Available lysine and a good percentage of *in vitro* digestibility of proteins were retained in the pressure cooked soybean flour, whereas, these values were very low for roasted soybean (Table 3). PER values of roasted soybean proteins were considerably lower (1.8 as against 2.8 for pressure cooked soybean) (Table 3), though inactivation of trypsin inhibitor (97% for 15 min roasted meal as against 98% for pressure cooked soybean) was nearly the same.

TABLE 2. PROTEIN AND ANTINUTRITIONAL FACTOR CONTENT IN RAW OR ROASTED SOYBEAN *(GLYCINE MAX.* 'ANKUR' AND 'KALITUR' VARIETIES).

Processing conditions*		Crude protein,% (N x 6.25) Mean ± SD	Trypsin inhibited, mg/g protein Mean ± SD	Haemogglutinin, mg/g protein Mean ± SD
Raw	a.	51.3 ± 2.96	56.3 ± 1.64	10.7 ± 0.62
	b.	60.1	34.5	14.5
Roasted-10 min, (140°C 83-130°C)	a.	47.9 ± 2.14	9.1 ± 0.75	0.2 ± 0.045
	b.	51.0	19.6	N.D.
Roasted-15 min, (140°C 83-14°C	a.	47.3 ± 1.75	1.6 ± 2.07	N.D.
	b.	48.8	7.7	N.D.
Roasted-20 min, (140°C 83-150°C)	a.	46.2 ± 0.35	1.4 ± 0.63	N.D.
	b.	54.0	4.6	N.D.
Roasted-25 min, (140°C 83-160°C)	a. } b. }	Completely charred		Not determined
Soaked and autoclaved under steam pressure, 20 min, at 121°C	a.	48.7 ± 0.49	0.9 ± 1.54	N.D.
	b.	56.6	3.6	N.D.

*1 kg roasted in a 4 kg roaster

N.D: Not detectable

a: 'Ankur '- Values are the mean ± SD of 4 replicates

b: 'Kalitur' - Average of two samples only

TABLE 3. GROWTH RESPONSE OF RATS FED RAW ON PROCESSED SOYBEAN ('ANKUR' VARIETY)

Processing condition	Trypsin inhibitor, % inactivated	Haemagglutinin, % inactivated	Available lysine % retained	*In vitro* degestibility, %	PER* Mean ± SD
Casein (Standard)	-	-	-	100	3.0±0.14[a]
Soybean splits soaked and autoclaved for 20 min	98	100	94	64	2.8±0.09[b]
Soybean splits roasted for 20 min	84	98.4	72	51	1.8±0.08[c]
Soybean splits roasted for 15 min	97	100	59	24.7	1.8±0.05[d]
Raw soabean splits	Nil	Nil	100	43.3	Negative growth

*9 rats per group, 21-23 day old weanling rats grouped according to randomised block design; average initial weight of each rat 37.5 g ; duration 4 weeks

Test of significance by 't' test

Difference

PER a~b Significant; b~c, b~d, a~c and a~d : Very highly significant; c~d: Not significant

Non-enzymatic browning (a reaction between lysine and reducing sugars) during roasting resulted in low retention of available lysine (59%) and low enzymatic digestibility (24.7%) of the proteins. The reaction is accelerated by dry heat. The beneficial effect of longer duration of roasting (15 min), had on reducing trypsin inhibitor activity, might have been imbalanced by reduction in available lysine and digestibility of the proteins (Table 4). Hence, the PER had not improved beyond 1.8, though trypsin inhibitor activity had been lowered much more. Histopathological examination of pancreas for hypertrophy of acinar cells was found to be normal, while mild cytoplasmic vaccuolation in liver was present in case of heat processed soybean. This might have been due to essential amino acid deficiency, as haemagglutinins were completely inactivated. Essential amino acid deficiency can cause periportal fatty change in liver (Patwardhan and Ramachandran 1960). Casein gave a normal picture both liver and pancreas.

Conclusions

Soybean trypsin inhibitor and haemagglutinins can be inactivated upto 95 ± 2% and 100%, respectively, by roasting the dehulled soy splits.

PER improved from negative to 1.8. However, available lylsine values were very much lowered. A balance between the highest inactivation of trypsin inhibitors and least destruction of available lysine had to be maintained. Roasting soybean enhanced flavour, in addition to improving the nutritive value.

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Studies on Some Functional Characteristics of Whey Protein-Polysaccharide Complex

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Functional characteristics of whey protein-carboxymethyl cellulose (WP-CMC) was studied and compared with those of ultrafiltered whey protein concentrates (UF-WPC). WP-CMC complexes were highly soluble at neutral pH, but showed very less protein solubility at pH below isoelectric point of whey protein. The temperature did not show any significant change in the solubility. Higher buffering capacity was observed below pH 3.0 and between pH 5.7 and 6.3. The viscosity of the WP-CMC complex decreased with rise in temperature above 50°C, but UF-WPC indicated an increase in viscosity above 50°C. These complexes formed weak gels even at lower pH. Emulsion and foam solubility of WP-CMC complex were very high, as compared to UF-WPC.

Keywords : Whey protein, Carboxymethyl cellulose, Functional characteristics, Ultrafiltered whey protein concentrates.

The charged polysaccharides have a special ability to interact with food proteins. Significance of these interactions in food system for protein recovery, protein stabilisation and food texture modification have been well documented (Samant et al. 1993). Generally, the properties of such protein-hydrocolloid complexes differ considerably from those of individual polymers (Bimlesh and Malik 1993). In case of protein-anionic polysaccharide complexes, the conformation and charge ratio of the molecular component dictates the properties. Many functional properties can be controlled by complexing proteins with polysaccharides (Tolstoguzov 1990). The work carrried out by Asano (1996) suggests that carboxymethyl cellulose (CMC), which is a polysaccharide, interacts with several milk proteins in acidified milk. Subsequently, Hidalgo and Hansen (1971) developed the method of recovering the whey proteins by complexing with CMC.

The main objective of this study was to examine the physico-chemical properties of the whey protein-carboxymethyl cellulose complex. Such type of work will be helpful in further utilization of this complex in various formulated foods.

Materials and Methods

Recovery of whey protein-carboxymethyl cellulose (WP-CMC) complex: WP-CMC complex was recovered by using the method given by Mathur and Srinivasan (1979) with slight modification. The pH of cheese whey was adjusted to 3.2 and mixed with an equal volume of the acidulated water (pH 3.2), containing calculated amount (0.3%) of CMC (substitution range of 0.65 to 0.85).The precipitated complex was recovered by centrifugation, followed by dialysis and freeze-drying. Along with WP-CMC complex, the ultrafiltered whey protein concentrates (UF-WPC), obtained from Experimental Dairy, National Dairy Research Institute, were also analyzed for the sake of comparison.

Chemical analysis: The samples were analyzed for proteins (Morr et al. 1985), carbohydrates (Winzler1955), fat, ash and moisture contents (ISI Methods 1981).

Functional properties: Protein solubility was determined by the method described by Morr et al (1985) and data were subjected to statistical analysis. Buffering capacity (BC) was determined by titrating 0.5% solution of WP-CMC complex with 0.1 N HCl or 0.1 N NaOH and was calculated by the equation:

$$\frac{dB}{dpH} = \frac{\text{Milli-equivalent of titrant}}{\text{Gram sample} \times \text{pH}}$$

BC curve was drawn by plotting $\frac{dB}{dPH}$ vs. pH

Relative viscosity of aqueous solution of WP-CMC complex, having concentration varying between 2 and 10% (w/v), was determined between 20°C and 80°C, using falling Ball Hoppler's viscometer. The equation used was:

$$\text{Viscosity } n = T\ (S_B - S_L)\ K$$

where,

T= falling time of the ball,

S_B= specific gravity of the ball,

S_L= specific gravity of liquid used and

K= ball constant

* Corresponding Author

Gelling behaviour of these samples was observed by the method of Zirbel and Kinsella (1988) with 20% concentration in water.

For determining emulsion stability, emulsions were prepared with ultrasonic instrument (Branson Sonifier Distruptor, Model B-12), using 45 g water, 5 g soybean oil and 120 mg protein product. Immediately after sonification, the viscosity of the emulsion was determined, using Ostwald viscometer.

Foaming properties were examined, using a household mixer by whipping 75 ml of 3% (w/v) protein solution for 5 min at maximum speed (DeWit et al. 1988).

Results and Discussion

The WP-CMC complex was white in colour as compared to UF-WPC, which was slightly brownish. The former was more fluffy. The yields of WP-CMC complex and UF-WPC were 6.2 and 7.8 g/l cheese whey.

Chemical composition: The chemical composition of WP-CMC complex, given in Table 1, indicates that the protein contents in WP-CMC complex were slightly less than those of UF-WPC. WP-CMC complex contained more carbohydrates than ash and moisture contents. The average fat content in both the WPCs was almost similar.

Solubility: It is observed from Table 2 that protein solubility of WP-CMC complex was very much dependent on pH, as compared to UF-WPC. The complex had much more solubility at pH 7.0, than at pH 3.5. The UF-CMC also had more solubility at pH 7.0, but in this case the difference was of the order of about 10% only. The WPC manufactured by complexation or precipitation method generally had more solubility dependence upon pH, than the whey protein concentrates from other processes because of residual reagents, which precipitated positively charged protein molecule at or below isoelectric point (Delaney 1976). The residual amounts of the complexing reagents, which were perhaps present as anionic species, had no effect on the solubility of WPC at pH above the isoelectric point of the whey protein, when these proteins were also carrying negative charge. This is evident from the fact that at pH 7.0, the solubility of WP-CMC complex was higher than that of UF-WPC. Statistical analysis showed that per cent solubility of WP-CMC complex at temperature 20°, 30° and 40°C did not show any significant difference ($p > 0.05$), but in case of UF-CMC, the per cent solubility at those temperatures differed significantly ($p < 0.01$) (Table 2). The solubility was lower at 40°C than at 30°C in almost all the cases. This lower solubility at 40°C may be explained on the basis of the findings of Macritchie (1979), who reported that bovine serum albumin (BSA) was highly soluble in water at 30°C, but showed severe precipitation in temperature range between 40 and 45°C. This charged solubility at about 40°C paralleled the reversible partial unfolding of BSA, observed at 42 and 50°C (Lin and Koeing 1976).

pH and buffering capacity (BC): The initial pH value of the WP-CMC complex was low (4.5) in

TABLE 1. CHEMICAL COMPOSITION (g/100 g) OF WP-CMC AND COMPLEX) AND UF-WPC

	WP-CMC complex	UF-WPC
Protein, %	57.70 - 64.27 (60.94)	61.25 - 65.79 (63.52)
Carbohydrate, %	17.13 - 18.50 (17.82)	4.06 - 6.46 (5.26)
Fat, %	13.40 - 17.85 (15.63)	12.08 - 16.06 (14.07)
Ash, %	1.11 - 2.690 (1.86)	3.88 - 5.04 (4.97)
Moisture, %	1.65 - 2.75 (2.20)	5.16 - 6.92 (6.09)

Values in parentheses indicate average of five samples

TABLE 2. SOME FUNCTIONAL PROPERTIES OF WHEY-PROTEIN-CARBOXYMEHTYL CELLULOSE COMPLEX AND ULTRAFILTERED WHEY PROTEIN CONCENTRATES

Functional properties	WP-CMC		UF-WPC	
(a) Solubility, %				
	pH		PH	
	3.5	7.0	3.5	7.0
Temperature (°C)				
20	14.15*	86.69*	56.79**	70.70**
30	16.47*	100.00*	74.18**	81.94**
40	15.69*	99.60*	67.49**	76.09**
(b) pH and buffering capacity				
Initial pH	4.85		5.63	
pH of peak in BC curve	6.30		7.0-7.8	
(c) Emulsion stability in terms of relative viscosity	2.56		1.35	
(d) Whipping properties				
Overrun, %	35.33		40.00	
Foam stablity	5.31		1.40	

* solubilities at different temperatures were not significantly different ($p > 0.05$)

** solubility differed with temperature significantly ($p < 0.01$)

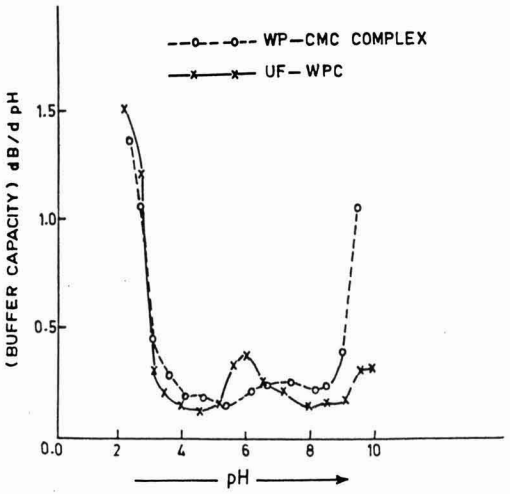

Fig. 1. Buffering capacity as a function of pH

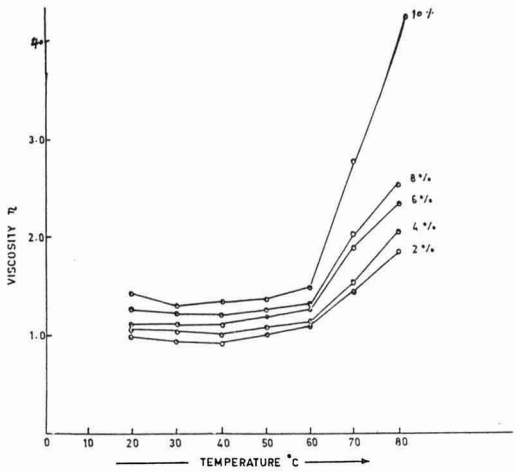

Fig 3. Viscosity of whey protein concentrates prepared by ultra-filtration as a function of temperature

comparison with UF-WPC (6.3), which is perhaps due to the method of preparation of these samples. It is shown in Fig. 1 that BC of WP-CMC complex was higher at values below pH 3.0 and above 6.0, while whey protein concentrates prepared by ultrafiltration showed higher BC below pH 4.0 and a broad peak in BC/pH curve was observed around 6.0. Buffering capacity data provided an indication of the type and concentration of the important ions that were retained in these whey protein concentrates.

Viscosity: The WP-CMC complex showed higher viscosity than WPC from other methods. This might

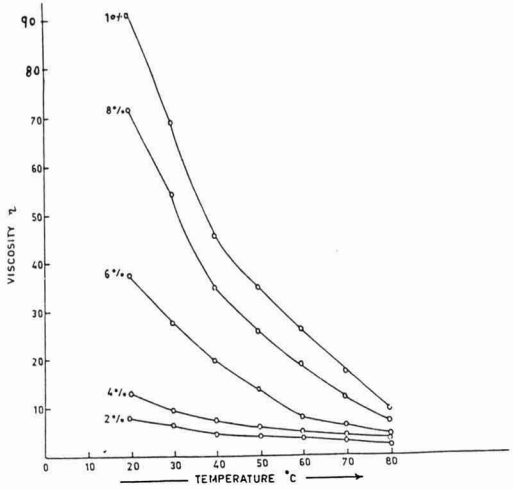

Fig. 2. Viscosity of whey protein-carboxy methyl cellulose complex as a function of temperature

be due to CMC being highly viscous. The complexes showed higher viscosity at low temperature and behaved more or less like gel at 10% concentration, as shown in Fig. 2. However, with the rise of temperature, the viscosities of these complexes decreased continuously, unlike those of the UF-WPC, when there was decrease initially and then (at around 50°C and above) increase due to denaturation of whey proteins (Fig. 3). In former case, it appeared that the effect of increase in viscosity due to denaturation of whey protein was balanced by the behaviour of CMC, because viscosity of a polysaccharide solution decreased with increase in temperature (Whitsler and Daniel 1985).

Gelation: Whey protein-CMC complex, prepared from cheese whey, did produce gels, but these gels were very weak and fragile. It was not possible to cut sections from these gels, and study their textural characteristics with the help of Instron. But, UF-WPC produced gels which were quite hard and springy in nature. The formation of protein gels was due to protein network, which resulted from a balance between protein-protein and protein-solvent (water) interactions and attractive as well as repulsive forces between the adjacent polypeptide chain (Hermanson 1979). Around pH 4.5, the whey proteins are only slightly changed and bind a small amount of water. The small charge should help in formation of the network. Due to very small amount of water, which the proteins are carrying, a precipitate is obtained instead of a gel (Hiller and

Cheeseman 1979; Bimlesh and Malik 1994). It is interesting to note that pH of WP-CMC complex was around 4.5 and at this pH, there should not be any gel formation. The weak gel formed by WP-CMC complex may be, however, due to cross linking between -OH group of CMC with NH_2 or -COOH groups of whey proteins. Protein can form gel through interaction with anionic polysaccharide gelling agents (Lin 1977).

Emulsion stability: It is well established that proteins stabilise the fat particles in emulsion by forming a membrane around the oil particles and making the oil particles to carry similar charge. These charged particles cannot come close to each other and coalesce. The charge on the oil particles also increases the viscosity of system due to electroviscous effect. Therefore, the viscosity of the emulsion also gives a qualitative idea about the stability of the emulsion. Higher the viscosity, more stable is the emulsion. The viscosity of the emulsion stabilised with whey protein-CMC complex and UF-WPC complex was almost double than that of UF-WPC. This might be due to the fact that CMC binds with water and imparts viscosity to the aqueous phase and thus stabilizes the emulsion. The emulsion stability increases on transition from a protein to its complex with polysaccharide (Tolstoguzou1986).

Whipping properies: WP-CMC complex showed lower overrun, but better foam stability than UF-WPC as shown in Table 2. The higher overrun can be produced with higher protein solubility (Liano and Mangino 1987). But, WP-CMC complex dispersion had low pH, i.e., around 4.5 and solubility at this pH was very low (Table 2). Good foam stability can be explained on the basis of higher viscosity of aqueous solution of WP-CMC complex.

Conclusions

Complexation of whey protein with carboxymethyl cellulose changes the functional properties of these proteins to a greater extent. Due to carbohydrate complexation, the functional properties of whey proteins can be controlled in a particular range of pH, depending upon the food products. The study on protein-polysaccharide interaction reveals their potential, which can be well utilized to meet new technological requirements.

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Gas Retention in Fermented Doughs Obtained from a 'Landrace' and 'Durum' Wheat Cultivars

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The gas holding power of doughs prepared from flour obtained from a 'Landrace' ('Horani-27') and ten Durum wheat cultivars ('ACSAD-65', 'Amra', 'Der Alla-2', 'Der Alla-6', 'Veery', 'Korifla', 'Lacesh', 'Rabi-S', 'Sham-1' and 'Hard red winter wheat') were assessed by a gasograph, farinograph and extensograph. Results indicated that wheat cultivars varied significantly ($P<0.05$) in carbon dioxide production. 'Sham-1' had the lowest gas holding power, 'hard red winter wheat' had the highest gas holding power and all other cultivars were intermediate. The rheological properties varied significantly. 'Horani-27' was the highest in water absorption and in the resistance to extension, but it was intermediate in mechanical tolerance index.

Keywords : Wheat cultivars, 'Landrace', Gas holding, 'Durum', Jordan.

Yeast fermentation is essential in the manufacture of several leavened baked foods, such as Balady bread, rolls and crackers. When yeast metabolizes sugar present in wheat doughs, organic acids, alcohols, carbon dioxide and other compounds are usually produced. The interdependency of sugar metabolism, total gas production and the quality of the baked products have been recognized by cereal scientists.

Gas production in wheat dough has been investigated by several workers (Baily and Johnson 1924; Heald 1932; Sherwood et al. 1940; Shogren et al. 1976; Rubenthaler et al. 1980). Durum wheat is used mainly to produce bread in Jordan. These cultivars have been evaluated by Ereifej and Shibli (1993 a,b) for their rheological properties and baking quality.

The purpose of this investigastion was to compare the gas holding capacity of doughs prepared from flours of a 'Landrace' and 'Durum' wheat cultivars grown in Jordan.

Materials and Methods

Ten 'Durum' wheat cultivars were used in this study (Table 1). All cultivars were grown at Maru Agriculture Experimental Station (North Jordan) in a randomized complete block design with three replications in 1987-1988. 'Hard red winter wheat' ('HRWW') was obtained from Al Talhuni Mill Co. (Irbid, Jordan). All wheat samples were tempered to 15.5% moisture content and milled in Buhler experimental mill (Model MLV-202) at the Western Wheat Quality Laboratory, Pullman, WA. The gas production in each replicate was measured, using a risograph according to Rubenthaler et al (1980). Flours (10g, 14% mb) were mixed for 1.5 min with 15 ml water, which contained 0.15 g NaCl, 0.60 g of sucrose and 0.20 g fresh baker's yeast. The gassing meters were zeroed and the gasograph reaction bottles were stoppered for two min, after being placed in the water bath. The amount of gas released in the reaction bottle (not the retained gas by the dough slurry) was recorded at different time intervals.

The physical properties and chemical analysis for these cultivars were reported earlier (Ere; fej and Shibli 1993 a). For the determination of water absorption and mechanical tolerance, a Brabender farinograph equipped with a 50-g bowl and the constant flour weight procedure (method 54-21, AACC 1983) were used. The farinograms were evaluated according to Shuey (1972).

The Brabender extensograph was used to test the flours for resistance to extension and extensibility

TABLE 1. FARINOGRAPH AND EXTENSOGRAPH DATA OF THE WHEAT CULTIVARS

Wheat cultivar	Farinograph absorption, %	Mechanical tolerance Index, BU	Resistance to extension, BU
'Sham-1'	59.0^{c*}	15^{d}	400^{h}
'Lacesh'	60.0^{bc}	15^{d}	400^{h}
'Amra'	59.5^{c}	20^{c}	410^{g}
'ACSAD-65'	59.0^{c}	10^{e}	400^{h}
'Rabi-S'	60.0^{bc}	15^{d}	428^{f}
'Horani-27'	68.5^{a}	10^{e}	542^{a}
'Der Alla -2'	61.2^{b}	20^{c}	500^{b}
'Veery'	59.0^{c}	10^{e}	448^{e}
'Der Alla-6'	61.0^{b}	15^{d}	436^{e}
'Korifla'	60.2^{bc}	25^{b}	442^{d}
'HRWW'	69.7^{a}	25^{a}	450^{c}

* Means within columns having different letters are significantly different ($P < 0.05$.)

(method 54-10, AACC 1982). Dough-extension curves were obtained at rest periods of 45,90 and 135 min. Only the curve obtained for final rest period was utilized for comparing the resistance to extension. Protein (N x 5.7), wet gluten and starch were determined according to AACC (1982) procedures. Particle size index (PSI %) and sodium dodecyl sulphate sedimentation (SDS-SED) were determined according to Williams et al (1988).

Statistical analysis: The collected data were statistically analyzed and the least significant difference (LSD) among treatments was determined according to Steel and Torrie (1980). Analysis of variation was performed to compare the differences in gas production as affected by cultivar and fermentation time.

Results and Discussion

Farinograph studies : Farinograph data (Table 1) showed a wide variation in water absorption values, ranging from 59 ('ACSAD-65', 'Veery' and 'Sham-1') to 69.7 % ('HRWW'). All other wheat varieties had intermediate levels. These results compare very well with rheological data presented on two major wheat varieties grown in Saudi Arabia (Khatchadourian et al. 1985) and hard red spring wheat flour grown in USA (Volpe and Zabik 1981).

The mechanical tolerance index data are shown in Table I. The values ranged from 10 BU ('ACSAD-65', 'Veery', and 'Horani-27') to 25 BU ('HRWW'). All other cultivars had intermediate values. These results are in agreement with data on Saudi Arabian wheat cultivars reported by Khatchadourian et al (1985).

As indicated in Table I, the resistance to extension of dough made from the wheat cultivars ranged from 400 BU ('ACSAD-65', 'Lacesh' and 'Sham-1') to 542 BU ('Horani-27'). All others had intermediate values. These data compare very well with those reported by Khatchadourian et al (1985), Volpe and Zabik (1981) and Singh et al (1990).

PSI was used to classify these wheats, according to their hardness, using the relative hardness scale by Williams and Sobering (1986). The PSI ranged from 10.3 ('Der Alla-2') to 20.3 ('Veery'). The Jordanian wheats were found to be very hard ('Der Alla-2'), medium hard ('Sham-1', 'Lacesh', 'Amra', 'Der Alla-6' and 'Horani-27'). and hard ('ACSAD-65', 'Rabi-S' and 'Korifla'). Seven of the cultivars showed typical PSI % values for 'Durum' wheats (18.45 ± 1.06). The local cultivar 'Der Alla-2' showed the lowest value (10.3), while 'ACSAD-65' and 'Korifla' were intermediate (13.4±0.28). Some of the chemical and milling properties of the wheat cultivars are shown in Table 2.

TABLE 2. SOME OF THE CHEMICAL AND MILLING PROPERTIES OF WHEAT CULTIVARS.

Wheat cultivar	Protein, %	Gluten wet, %	Starch, %	SDS-SED[a] ml	PSI[b] %
'Sham-1'	9.4[gh]*	24.2[e]	76.3[b]	45.0[f]	18.0[e]
'Lacesh'	9.6[f]	27.0[b]	74.1[e]	52.0[d]	19.5[b]
'Amra'	9.5[fg]	28.4[a]	75.0[c]	47.0[e]	17.1[f]
'ACSAD-65'	9.0[i]	23.3[g]	74.1[e]	45.0[f]	18.0[e]
'Rabi-S'	9.8[e]	20.2[h]	73.5[f]	59.0[a]	18.3[d]
'Horani-27'	11.2[b]	26.5[c]	73.9[g]	38.0[i]	17.3[f]
'Der Alla-2'	10.7[a]	25.6[d]	72.4[h]	39.0[h]	10.3[h]
'Veery'	10.2[d]	27.1[b]	72.6[h]	56.0[b]	20.3[a]
'Der Alla-6'	9.3[h]	25.6[d]	76.7[a]	42.0[g]	18.7[c]
'Korifla'	9.4[gh]	23.8[f]	74.6[d]	55.0[c]	13.7[g]
'HRWW'	13.5[a]	25.8[d]	70.2[i]	45.0[f]	13.7[g]

* Means within columns having different letters are significantly different at $P < 0.05$.

[a] SDS-SED: sodium dodecyl sulphate sedimentation.

[b] PSI: particle size index.

The risograph (gasograph) data are presented in Table 3. The accumulative carbon dioxide produced in the fermentation jars was recorded at 1 min interval for 180 min for each sponge, made from each replicate and recorded as gas units (GU).

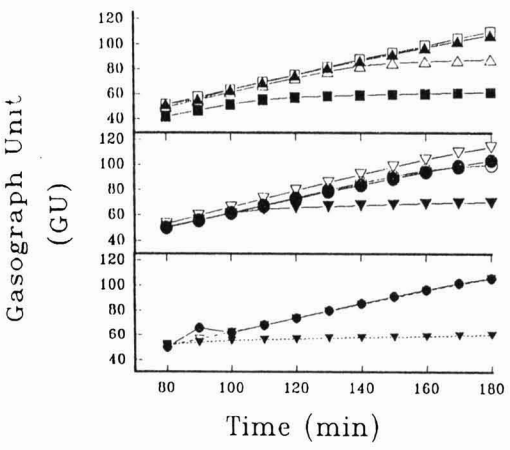

Fig. 1. Gasograph gas production of doughs prepared from 'Durum wheat' flour and 'Hard red winter wheat'. From top to bottom: 'Sham-1' (□); 'Lacesh' (▲; 'Amra' (△); 'ACSAD-65' (■); 'Rabi-S' (▽; 'Horani-27' (●); 'Der Alla-2' (○); 'Veery' (▼); 'Der Alla-6' (●); 'Korifla' (▽) and 'Hard red winter wheat' (▼);

TABLE 3. EFFECT OF CULTIVAR AND FERMENTATION TIME ON GAS PRODUCTION IN DOUGHS OBTAINED FROM A 'LANDRACE' AND 'DURUM' WHEAT CULTIVARS.

Wheat cultivar	Gas Units, GU Mean ± S.E (Cultivar effect)	Time, min	Gas Units, GU Mean ± S.E (Time effect)
'Sham-1'	80.5 ± 3.3^{bc}	80	50.1 ± 0.5^{k}
'Lacesh'	55.2 ± 1.1^{h}	90	55.3 ± 0.5^{j}
'Amra'	73.7 ± 2.3^{e}	100	60.6 ± 0.9^{i}
'ACSAD-65'	80.0 ± 3.2^{cb}	110	65.9 ± 0.9^{h}
'Rabi-S'	77.9 ± 2.9^{d}	120	69.0 ± 1.4^{g}
'Horani-27'	77.7 ± 3.0^{d}	130	75.1 ± 1.6^{f}
'Der Alla-2'	84.1 ± 3.6^{a}	140	79.3 ± 2.0^{e}
'Veery'	68.5 ± 1.0^{f}	150	83.2 ± 2.4^{d}
'Der Alla-6'	79.2 ± 3.2^{c}	160	86.9 ± 2.7^{c}
'Korifla'	79.0 ± 3.1^{c}	170	90.3 ± 3.1^{b}
'HRWW'	57.0 ± 0.4^{g}	180	93.1 ± 3.4^{a}

ANALYSIS OF VARIANCE OF CULTIVAR AND GAS PRODUCTION INTERACTION.

Source of variation	Degrees of freedom	Mean squares	F. value
Cultivar	10	3272.097	895.33**
Time	10	6924.485	1894.71**
Interaction	100	139.799	38.25**

**Highly significant ($P < 0.01$).

[c] Means within columns having different letters are significantly different ($P < 0.05$).

SE = Standard error.

The average was computed for each variety. The gas units were computed for each dough, after 80 min from the beginning of fermentation. All wheat cultivars produced equal amounts of gas during the initial fermentation period. After 80 min, variation in gas retained within the dough was noticed. Fig.1 shows the listing of the cultivars according to gas holding power, starting from the standard ('HRWW') wheat (higher gas holding power) to 'Sham-1' (lower holding power). The explanation for the variation in gas holding power might be due to the variation in the protein content and quality.

Data, depicted in Fig 1, show continuous increase in CO_2 production, which varied among cultivars due to different sugar contents or might be due to starch damage. He and Hoseney (1991) studied the gas retention in bread dough during baking and found that the amount of CO_2 released varied at the beginning of the starch gelatinization (65°C) and increased from 55 - 70°C and the CO_2 loss started at 72°C. They concluded that the ability of dough to retain gas was associated with gelatinized starch. Although temperature was not involved in the present experiment, the data showed significant variations in gas production. Table 3 shows that the mean CO_2 retention of the wheat cultivars ranged from 56.99 ('HRWW') to 80.53 GU ('Sham-1'). The variations in gas retention power of the doughs are associated with the gelatinized starch and protein coagulation (MacRitchie 1980). Table 3 shows the analysis of variance of mean square of gas retention. The effect of wheat cultivar, fermentation time and their interaction were highly significant at $P<0.01$.

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Evaluation of Blanching Quality in Groundnut (*Arachis hypogaea* L.)

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Thirty five Spanish and forty six Virginia groundnut genotypes, grown in the 1992 rainy season and the 1992/93 post-rainy season at the ICRISAT Asia Center, were evaluated for their blanching quality. The standardized conditions of preheating the seed samples at 200°C for 8 min, followed by blanching for 2 min at 15 psi air pressure, gave satisfactory results. There was a large variation in total blanchability within Spanish (10.8-90.6%) and Virginia (8.6-86.7%) genotypes. Results indicated that high total blanchability in genotypes were contributed largely by the blanched split seeds. Effects of growing seasons on various blanching quality parameters were more pronounced in the Virginia genotypes than in the Spanish genotypes.

Keywords : Blanching quality, Spanish and Virginia groundnut genotypes.

Groundnut, an oilseed crop, is also used in many popular food forms (Evans 1982). The salted groundnuts, candies, confectionery, roasted nuts, and butter are some of the important food uses of groundnut. The blanching process, which primarily involves the removal of skin, also called testa, is a major step in processing groundnuts for many edible end products. In addition to skin removal, blanching clears the seeds of dust, mould and other foreign materials (Woodroof 1966). It is a very important process in the manufacture of peanut butter, whole nuts, candies, and *chikkis* (a snack food comonly consumed in India). The quality of these products is adversely affected, if skins and germs are not properly removed from the cotyledons, as their presence imparts a bitter taste to groundnut butter (Willich et al. 1952). Laboratory devices have been designed and developed to measure the ease of skin (testa) removal from groundnuts (Barnes et al. 1971; Wright and Mozingo 1973; Hoover 1979).

Several factors, such as seed and skin moisture content, temperature of storage, hygroscopic and thermal properties of seed and adherence of skin to the cotyledons, affect the blanchability of groundnut (Farouk et al. 1977). Blanchability was shown to be a character, mainly related to genotype, seed size, and degree of maturity as well as the time and temperature of the post-harvest storage period (Shokraii et al. 1985). On the basis of electrophoresis of seed proteins, it was observed that a 36 kilo dalton protein, a major polypeptide, was associated with the poor blanchability in groundnut (Shokraii et al. 1985). These workers further suggested that this character could be used as a reliable indicator of blanchability in groundnut cultivars and breeding lines.

The blanching quality is an important consideration in the evaluation and testing of groundnut breeding lines developed for food uses. This paper presents the results on standardization of operating conditions of a locally fabricated laboratory blancher and on variation in blanching quality of newly developed Spanish and Virginia genotypes of groundnut.

Materials and Methods

Seed samples of advanced breeding lines of 35 Spanish and 46 Virginia goundnut genotypes were used in this study. These genotypes including two Spanish control cultivars "(JL 24" and "ICGS 11") and three input conditions (60 kg P_2O_5, irrigated, 400 kg ha^{-1} gypsum at flowering and protection against diseases and insect pests) in the 1992 rainy and the 1992-93 post-rainy seasons at ICRISAT Asia Center, Patancheru, Andhra Pradesh, India. After harvest, pods were cured, dried and shelled seeds were stored at room temperature (20±1°C) until blanching. Two determinations (replications) were made for blanching quality parameters on each genotype.

Blanching operation: A laboratory type blancher (Fig. 1) was fabricated at the ICRISAT Asia Center, based on the model developed and described by Wright and Mozingo (1973). It consists of an inclined-screen container that rotates inside an acrylic plastic cylinder. An air-steam is directed through the bottom of the rotating screen container, which loosens the skins from the groundnuts, as they move in a swirling fashion. A vaccum-cleaner connected to the plastic cylinder removes the loose

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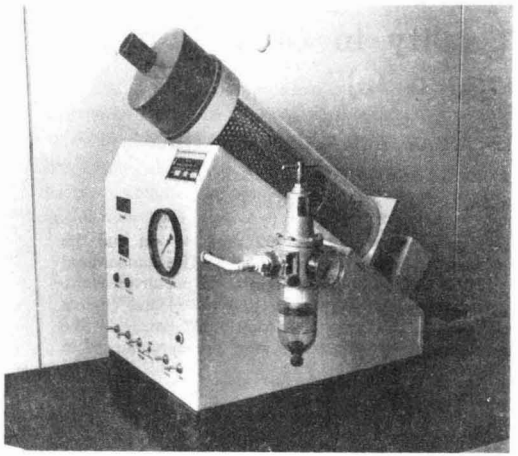

Fig. 1. A laboratory device fabricated for evaluating groundnut blanching quality at ICRISAT Asia center.

skins. Samples, weighing about 250 g, are preheated and transferred into the screen-container for blanching tests. Because of the availability of large quantity of seed material, a Virginia genotype, 'ICGV 86347' was used to standardize the blanching conditions, such as optimum time for blanching, preheating temperature, and air pressure. Samples were tested at various pressures, ranging between 10 and 20 psi. To study the optimum duration of blanching, the blanching time settings were increased by 30 sec increments from 90 to 210 sec. To measure the effect of preheating temperatures on blanchability, the blanching time and air pressure were held constant at 120 sec and 16 psi, respectively and the preheating temperature was increased from 160 to 210°C in 10°C increments. Sample weights were recorded to determine the percentage of blanched whole seed (BWS), blanched split seed (BSS) and unblanched seed (UBS). Blanching loss (BLS) was estimated on the basis at weight of skin, germ and brokens. Standard error and means for the treatment were estimated, assuming one way analysis of variance (Snedecor and Cochran 1967).

Results and Discussion

The air pressure in the blancher played an important role in determining the blanching quality of groundnuts. With an increase in the air pressure, the percentage of unblanched seed decreased and the percentage of blanched split seed increased. The percentage of blanched whole seed also increased with an increase in the air pressure up to 15 psi and then it showed a decline, as a result of higher

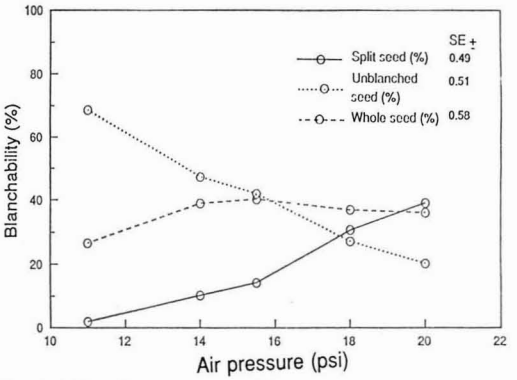

Fig. 2. Effect of air pressure on blanching quality of groundnut genotype 'ICGV 86347'

proportion of blanched split seed (Fig. 2). The duration of blanching also influenced the blanchability. As the blanching time increased from 90 to 210 sec, the percentage of unblanched seed decreased from 36 to 17%, but the percentage of blanched split seed increased rapidly from 120 sec onwards. The percentage of unblanched seed decreased with the increase in preheating temperature, the decline being sharp after 190°C.

The percentage of blanched whole seed remained fairly stable across the temperature range studied. The percentage of blanched split seed increased rapidly after 190°C. The results of the present study are similar to the findings of earlier workers, who have also reported that the satisfactory laboratory blanching tests could be made by operating the blanching device for 120 sec at 17.6 psi (Barne et al. 1971). Based on the results of present study, it is suggested that the operating conditions for the laboratory blanching device should include preheating the samples at 200°C for 8 min, followed by blanching for 2 min at 15 psi air pressure.

Results of the variablities in blanching quality parameters of 81 genotypes, comprising Spanish and Virginia types, are presented in Table 1. The range of total blanchability in Spanish (10.8-90.6) and Virginia (8.6-86.7%). genotypes was almost similar in both the seasons. The growing season environment influences the blanching quality of groundnut genotypes (Farouk et al. 1977; Mozingo 1979). This influence on total blanchability was pronounced in the present study with the post-rainy season crop giving lower mean values. The proportion of blanched whole seed was only marginally influenced, but the proportion of

TABLE 1. BLANCHING QUALITY OF SPANISH AND VIRGINIA GENOTYPES GROWN IN THE 1992 RAINY AND THE 1992/93 POST-RAINY SEASONS AT ICRISAT ASIA REGION

Season	TBS, %		BWS, %		BSS, %		UBS, %		BLS, %		100-seed mass, g	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
						Spanish						
						(n=35 genotypes)						
Rainy	68.3	29.8-90.6	39.7	9.3-62.2	28.6	3.4-81.1	27.3	0.9-66.3	4.6	2.8-8.7	54.3	34.7-73.3
Post-rainy	50.8	10.8-85.7	39.6	9.9-65.4	11.1	0.4-37.2	45.8	9.8-86.7	3.5	1.8-5.4	84.3	54.2-125.2
SE	±3.21		±2.26		±2.59		±3.35		±0.19		±2.41	
						Virginia						
						(n=46 genotypes)						
Rainy	59.5	24.7-86.7	38.7	11.5-55.3	20.8	4.2-59.8	36.3	6.6-73.2	4.2	1.5-7.0	61.8	43.9-76.4
Post-rainy	42.6	8.6-83.3	34.1	6.8-67.4	9.0	0.7-61.4	53.3	10.1-89.2	3.5	2.1-10.0	92.1	66.5-118.6
SE	±2.60		±2.04		±1.87		±2.79		±0.20		±1.81	

TBS=Total blanched seed; BWS=Blanched whole seed; BSS=Blanched split seed; UBS=Unblanched seed; BLS=Blanching loss (See text for formula).

blanched split seed declined markedly giving rise to a higher proportion of the unblanched seeds in the post- rainy season. The 100-seed mass in the post rainy season was also higher than that of the rainy season. Blanching losses in these genotypes ranged between 1.5 and 8.7% in the 1992 rainy season and between 1.8 and 10.0% in the 1992/93 post- rainy season. Parker (1987) had observed that blanching resulted in a weight loss of 3.0-3.5%, depending on the groundnut cultivars.

The genotypes having total blanchability of 70% or above are considered to be good for end use food quality (Shokraii et al. 1985). On the basis of this criterion, several Spanish and Virginia genotypes, which had total blanchability exceeding 70% in both rainy-post rainy season could be identified (Table 2). Some of these genotypes, which have high split seed blanchability could be more suitable for candies and butter preparation. A high percentage of blanched splits is preferred for these end uses, as it permits easy removal of germs and hence reduces aflatoxin contamination (Diener et al. 1982). Except for the blanching loss, the association of blanching quality parameters between rainy and post-rainy seasons in Virginia genotypes was non-significant (Table 3). In the case of

TABLE 2. 100-SEED MASS AND BLANCHING QUALITY OF SOME SPANISH AND VIRGINIA GENOTYPES GROWN IN THE 1992 RAINY SEASON AND THE 1992/93 POST-RAINY SEASON

Group	Genotype	1992 Rainy season				1992/93 Post-rainy season			
		100-seed mass g	TBS, %	BWS, %	BSS, %	100-seed mass g	TBS, %	BWS, %	BSS, %
Spanish	'ICGV 88487'	56.7	75.7	40.8	34.9	73.7	83.8	54.7	29.1
	'ICGV 88490'	55.8	79.7	43.7	36.0	69.0	75.4	41.0	34.4
	'ICGV 90320'	45.1	90.4	9.3	81.1	65.4	72.4	35.2	37.2
	'ICGV 91096'	58.2	84.7	45.3	39.4	75.5	82.8	53.2	29.6
	'JL 24'	39.7	88.5	18.5	70.0	58.0	85.7	58.8	26.9
	'ICGS 11'	37.8	80.4	37.8	42.6	60.1	65.7	50.7	15.0
	SE (n=6)	±1.47	±2.13	±1.84	±2.52	±1.93	±2.06	±2.54	±1.78
Virginia	'ICGC 90182'	56.5	76.8	27.3	49.5	82.2	67.2	33.5	33.7
	'ICGV 90281'	47.9	72.1	27.1	45.0	74.5	85.3	63.9	21.4
	'ICGV 90307'	58.7	74.6	30.4	44.2	78.6	74.9	63.4	11.5
	'ICGV 90321'	51.0	74.1	22.7	51.4	80.1	79.9	18.5	61.4
	'ICGV 91080'	76.4	71.2	55.3	15.9	100.0	74.6	67.4	7.2
	'ICGS 76'	48.9	40.9	31.2	9.7	70.6	24.7	22.3	2.4
	'Chandra'	50.3	57.4	36.8	20.6	80.3	53.1	39.4	13.7
	'Chalimbana'	67.3	45.8	33.6	12.2	94.4	18.4	15.2	3.2
	SE (n=8)	±1.45	±2.16	±1.93	±1.83	±2.65	±2.12	±1.76	±1.63

BWS=Blanched whole seed; BSS=Blanched split seed; TBS=Total blanched seed.

TABLE 3. RELATION BETWEEN BLANCHING QUALITY PARAMETERS OVER RAINY SEASON AND THE POST-RAINY SEASON AT ICRISAT ASIA REGION.

Character	Correlation (r)	
	Spanish (n=35)	Virginia (n=46)
100-seed mass, g	0.583**	0.325*
Total blanchability, %	0.679**	0.219
Blanched whole seed, %	0.261	0.226
Blanched split seed, %	0.696**	0.168
Unblanched seed. %	0.672**	0.224
Blanched loss, %	0.373*	0.362*

n = number of genotypes

* Significant at 0.05% level

** Significant at 0.01% level

Spanish genotypes, these associations, except for blanched whole seed, were significant. This indicated that the influence of growing environment on blanching quality parameters was more pronounced in Virginia types than that of Spanish genotypes. The results of this study suggest that blanching quality parameters could be consistent across seasons for Spanish types and not for Virginia types, implying that selection for blanching quality paarameters could be done irrespective of season for Spanish and probably not for Virginia types. Further, it is emphasized that blanching quality is an important characteristic and remarkable genotypic differences exist in this trait. Efforts should be made to develop genotypes with improved blanching quality, keeping in mind the end uses of groundnut.

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Studies on the Changes in Peroxidase, Acid Phosphatase, Phenols and Degree of Colouration of Eight Cultivars of Red Onion (*Allium cepa* L.) Bulbs During Development

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Developing bulbs of eight red onion varieties have been assayed for peroxidase, acid phosphatase, phenols and degree of colouration at seven growth stages, beginning at 30 days after transplanting (DAT), at 15 day intervals, till maturity. Specific activity of peroxidase was found to be maximum at 45 DAT, decreased continuously afterwards and at maturity, no peroxidase activity was detected. The specific activity of acid phosphatase increased upto 60 DAT and declined thereafter. Phenol content of bulbs remained almost static upto 60 DAT, followed by an increased upto 90 DAT and decreased thereafter till maturity. The degree of colouration exhibited the same trend. The varieties had considerable variability for the parameters determined not only at maturity, but also prior to maturity.

Keywords : Onion, Peroxidase, Acid phosphatase, Phenols, Degree of colouration, Growth.

Onion, (*Allium cepa* L). is a unique vegetable that is consumed by almost all sections of society throughout the year, not only at maturity, but also at different stages of growth. This alliaceous crop has gained importance of a cash crop, rather than a vegetable crop, because of its high export potential (Pandey 1989). Peroxidase is known to be the most heat stable enzyme in vegetables and its role in the formation of coloured products and off-flavour development is well documented. In some vegetables, complete inactivation of peroxidse is necessary in order to obtain good quality frozen onion (Muftugil 1985). Catalysis of a variety of biochemical reactions and vital role played by acid phosphatase in regulation of cell metabolism through inorganic phosphate levels is also well known (Tsubai et al. 1957; Turner and Turner 1975). Degree of colouration in foods during processing and storage is a very common phenomenon of primordial interest, which not only alters the colour and appearance, but also flavour and nutritive value (Berk 1980). Phenols, in addition to causing discolouration, are believed to be responsible for resistance to onion smudge, caused by *Celletotrichum cioreinaus* and Botrytis brown disease caused by *Botrytis cinera* (Clark and Lorbeer 1974). The red onion skin tannin extract, consisting of poly-hydroxy phenols, can be used as an antioxidant for edible oil (Odozi et al. 1984). Modified red skin tannin extract can be used for making wood varnishes and adhesives (Odozi and Agiri 1986). Presently, little information is available on changes in levels of peroxidase, acid phosphatase, phenols and degree of colouration during development of onion bulbs and also such information is required during processing of onion. Therefore, the present study was undertaken and the results are reported in this paper.

Materials and Methods

Eight varieties of red onion (' VLI', 'VL 3', 'Arka Niketan ', ' Agri-found Light Red ', ' 102-1', 'Punjab red round ', 'Pusa Red ', 'Hisar-2') were grown in rabi season of 1989-90 at the Vegetable Research Farm of CCS Haryana Agricultural University, Hisar, with three replicates in a randomised block design. The recommended doses of fertilizers and other agronomical practices were employed to raise the crop under Hisar conditions (HAU 1981). At random, five onion plants were collected from each replication, beginning one month after transplanting at an interval of 15 days, till maturity. After discarding the non-edible part, developing bulbs were reduced to cookable size (0.25 to 1.00 cm^2), dried in an oven at 60°C to a constant weight and ground to pass through 80 mesh sieve. Total phenols were determined according to Swain and Hillis (1959). Degree of colouration was determined by measuring absorbance of 0.2% aqueous extracts of dried onion bulbs at 520 nm, using Turner 350 Spectrophotometer (Bajaj et al. 1979). For peroxidase and acid phosphatase assay, samples were always collected in the plastic bag, placed in the ice bucket, and deep-frozen prior to analysis. Peroxidase was extracted by homogenising 1 g tissue in Tris HCl buffer (pH 7.6, 0.05 M) in chilled pestle mortar, using acid washed sand as an abrasive. The homogenate was centrifuged at 15000 rpm for 20 min at 4°C and supernatant obtained was used for

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for activity assay by the modified method of Shanon et al (1966). Acid phosphatase was extracted in phosphate buffer (pH 6.5, 0.05 M) and homogenate was centrifuged in a refrigerated centrifuge at 10,000 rpm, for 30 min and the supernatant was used for activity assay by the method of Malik and Singh (1980). Soluble proteins in enzyme extract were estimated by the method of Lowry et al (1951). The data were statistically analyzed and critical value differences mentioned in results pertain to CD for interaction (V x D) at 5% and 1% levels of significance.

Results and Discussion

Specific activity of peroxidase increased upto 45 DAT to reach maximum and declined thereafter with virtually no activity at final stage (Fig. 1). Hart and Fisher (1971) made a mention of sulphites, which have been found to be particularly useful in inhibition of peroxidase activity and it can be inactivated at about 160°F. Peroxidase concentration of 0.3 and 2.7 units g^{-1} of sample on wet weight and dry weight basis have also been reported earlier in onions, the value being least as compared to many vegetables (Ramanuja et al. 1988). The differences in peroxidase specific activity in presently studied onion cultivars at developmental stages can be genetic one and may be attributed to environmental factors, rapid inactivation and activation at specific physiological stage, presence of inhibitors and activators, interaction of peroxidase and auxin and also variance in mechanism of regulation of its activity. Poovaiah et al (1972) also held the above opinions on peroxidase studies in red, yellow and white onions bulbs, during short and long dormancies.

Acid phosphatase specific activity increased upto 60 DAT and declined thereafter, but maximum activity was observed at 75 DAT in varieties 'Agrifound Light Red ', '102-1' and 'Pusa red' (Fig. 2). Developing bulbs of varieties differed significantly not only among themselves, but also at each stage. The velocities of many biochemical reactions of cellular metabolism have been found to be elevated through inorganic phosphate levels (Tsubai et al. 1957; Turner and Turner 1975). Murray and Collier (1977) reported values ranging between 0.94 to 48.1 units mg $protein^{-1}$ and in the present study, the range for acid phosphatase activity was 0.05 to 2.40 units mg protein.

Total phenols of onion bulbs, on the whole remained static almost upto 60 DAT, followed by an increase upto 90 DAT and then declined till maturity (Table 1). The varieties differed in total phenol content during development. The probable reasons for the higher concentration of phenols in bulbs at 75 and 90 DAT may be due to involvement of enzymes of phenol metabolism either towards increased synthesis or decreased catabolism of phenolic compounds. Bajaj et al (1979, 1980) showed that total phenolic content in onion varieties at maturity ranged from 1.10 to 2.95%, but in the present studies, values varying between 2.21 and 3.56% are depicted at different

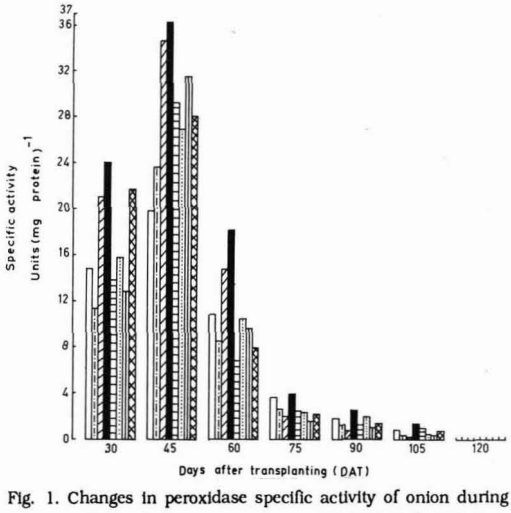

Fig. 1. Changes in peroxidase specific activity of onion during bulb development □ 'VL-1'; ▯ VL-3', ▨ 'Arka Niketan', ■ 'Agrifound Light Red', ▤ '102-1', ⁝ 'Punjab Red Round', ▯ 'Pusa Red', ▩ 'Hisar-2', C.D. at 5% 0.1611, C.D. at 1% 0.2121.

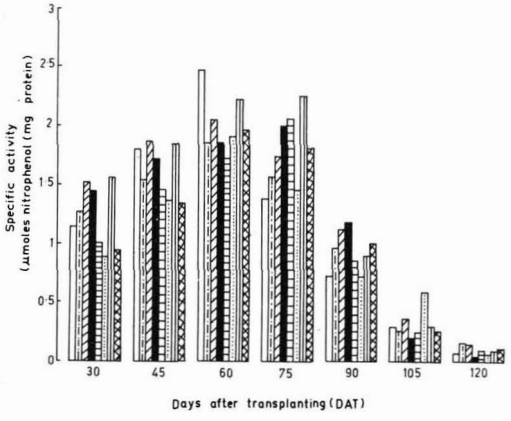

Fig. 2. Changes in acid phosphatase specific activity of onion during development □ 'VL-1'; ▯ 'VL-3', ▨ 'Arka Niketan', ■ 'Agrifound Light Red', ▤ '102-1', ⁝ 'Punjab Red Round', ▯ 'Pusa Red', ▩ 'Hisar-2', C.D. at 5% 0.040, C.D. at 1% 0.053.

TABLE 1. DEGREE OF COLOURATION DURING DEVELOPMENT OF ONION BULBS

Varieties	Days after transplanting (DAT)						
	30	45	60	75	90	105	120
'VL-1'	0.194±0.005	0.181±0.003	0.208±0.006	0.237±0.007	0.367±0.011	0.319±0.009	0.294±0.009
'VL-3'	0.137±0.003	0.157±0.002	0.176±0.005	0.252±0.009	0.347±0.012	0.310±0.011	0.254±0.005
'Arka Niketan	0.149±0.004	0.137±0.004	0.181±0.009	0.201±0.008	0.284±0.009	0.268±0.009	0.236±0.004
'Agri-found 'Light Red'	0.114±0.005	0.143±0.006	0.161±0.004	0.229±0.006	0.310±0.009	0.276±0.010	0.259±0.008
'102-1'	0.125±0.006	0.114±0.007	0.155±0.004	0.215±0.005	0.337±0.012	0.301±0.008	0.244±0.006
'Punjab Red Round'	0.149±0.005	0.155±0.003	0.187±0.006	0.197±0.006	0.301±0.010	0.284±0.008	0.229±0.008
'Pusa Red'	0.161±0.004	0.174±0.006	0.201±0.008	0.194±0.003	0.377±0.011	0.367±0.10	0.310±0.010
'Hidsar-2'	0.194±0.007	0.187±0.005	0.208±0.007	0.208±0.004	0.268±0.007	0.222±0.007	0.251±0.007
Mean	0.153	0.155	0.185	0.216	0.324	0.293	0.259
CD at 5%=	0.0094						
C.D. at 1%=	0.0124						

Each value represents O.D. at 520 nm of dried onion bulb extracts and average of four determinations.

stages, which do not show resemblance. The possible reasons for such variance could be due to differences in varieties, method of assay, agro-climatic and soil conditions of the region. Hahn and Rooney (1986) were also of the opinion that environmental conditions also affect the metabolism of phenols. In addition to causing discolouration, phenols are believed to be responsible for resistance to onion smudge and Botrytis brown disease (Clark and Lorbeer 1974). Red onion varieties possess high phenolic content and thus, are less susceptible to fungal diseases (Bajaj et al. 1979).

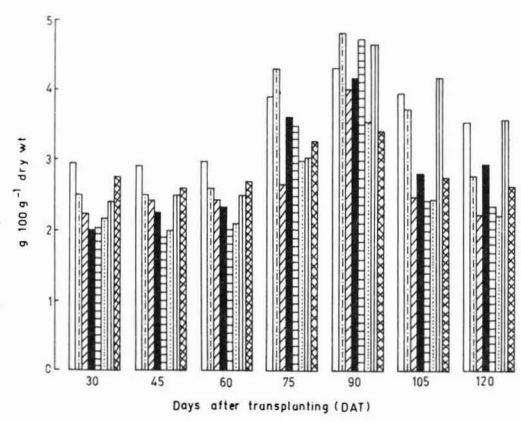

Fig. 3. Changes in phenol content of onion during bulb development □ 'VL-1'; ▯ 'VL-3', ▨ 'Arka Niketan', ■ 'Agrifound Light Red', ▤ '102-1', ⁝ 'Punjab Red Round', 'Pusa Red', ▯ 'Hisar-2', ⊠ C.D. at 5% 0.092, C.D. at 1% 0.121.

The degree of colouration in dehydrated onions increased continuously upto 90 DAT, declined thereafter and correlated well with levels of phenols (Table 1 and Fig. 3). The possible factors attributing to these changes at different stages could be due to changes in the levels of reducing sugars and free amino groups, contributed by free amino acids and proteins and/or variations in the enzymatic and non-enzyamatic oxidation of orthodihydroxy phenolic compounds, such as quercetin and protocatechuic acid. Similar views were also shared by Herman (1958), Bajaj et al (1979) and Berk (1980). The degrees of colouration of onion varieties taken for the present study differed to those of Yamaguchi et al (1957) and Bajaj et al (1980).

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Optimisation of Process Parameters in the Manufacture of *Churpi*

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The manufacturing conditions of *churpi*, a traditional milk product of Eastern India, Bhutan and Nepal, were optimized. Sensory scores of *churpi* made from cow milk, having 1% fat and 8.7% solids-not-fat, was highest. The instrumental values, except springiness, decreased with the increase in fat level of milk. A heat treatment of milk at 70°C without holding, followed by immediate straining of the coagulum were optimum. Coagulation of milk below or above the optimum temperature resulted in the decrease of all the Instron parameters, except springiness. Use of 2% citric acid solution as a coagulant resulted in the best quality *churpi*.

Keywords : *Churpi*, Traditional milk product, Process optimization, Chemical composition, Sensory profiles, Instron parameters.

Churpi is a hard variety of cheese, traditionally consumed by the people of Darjeeling hills and Sikkim in India, Nepal and Bhutan (Karki 1986; Tamang et al. 1988; Pal et al. 1993). The product, used as a nutritious masticatory, is a light amber to dark brown coloured cubical or cylindrical block, faintly sweet, but distinctly smooky, with a hard and compact body. The interesting characteristics of *churpi* are its pronounced gumminess and chewiness. It is prepared from partially skimmed milk of cow in Darjeeling, *dzno* (a crossbreed of male yak and indigenous cow) in Sikkim and yak in Bhutan. Traditionally, milk is coagulated with previous batch of whey and the green curd is cooked in an open pan. The coooked coagulum is heavily pressed overnight and dried for 40-60 days by hanging them in kitchen, having a wood-fired oven. However, in Darjeeling, the green curd is not cooked, but wrapped in a hessian cloth, stitched and dried in kitchen (Pal et al. 1993). Consequently, the quality of *churpi* varies from place to place (Pal 1940). It keeps well for about six months.

The production of *churpi* has remained a traditional family art, practised in homes in a crude manner. Optimization of the traditional process conditions in *churpi*-making is necesary to shorten production time, guarantee improved and consistent texture, flavour and colour, increase shelf-life, and this in turn, will increase its general acceptability. No attempt has yet been made to control these variable factors. The objective of the present work was to optimize the variable factors in the processing of milk for the production of *churpi*..

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Materials and Methods

Preparation of materials: cow milk was collected from the Himalayan Co-operative Milk Producers' Union Limited (HIMUL), Matigara and standardized for fat to solids-not-fat (SNF) content of 1:8.7. The milk was brought to a desired temperature and coagulated with citric acid solution of a desired strength. The coagulum was filtered and cooked in an open pan over boiling water bath for 20 min. The hot cooked coagulum was wrapped in a muslin cloth and pressed in a wooden press at 9 kg cm^2 pressure for 6 h. The mass was cut into pieces and were dried at 35±5°C by hanging over wooden fire for about 50 days (Pal et al. 1993). The samples of *churpi* were preserved in stainless steel containers with tightly closing lids. Sensory and chemical analyses of the samples were carried out within 3 days and the Instron studies were done within 15 days of their production.

Chemical analysis: The contents of fat and total solids in milk and whey were determined by the standard methods (SP 1981). The samples of *churpi* were cut into smaller pieces and ground to homogenous mass, using an electric grinder. The ground mass was analyzed for moisture (AOAC 1990), protein (ISI 1967), fat (SP 1981), lactose and glucose-galactose (Nickerson et al. 1976), ash (ISI 1980) and titratable acidity (AOAC 1990). For the determination of pH, a 10 g-ground sample was mixed with 90 ml carbon dioxide-free distilled water in a Waring blender for 1 min. The temperature of the mixture prepared was equilibrated at 25°C (AOAC 1990) and the pH was measured, using a Systronics type 335 pH meter.

Sensory analysis: Representative samples (1 cm^3) of *churpi* were served to seven trained

judges for sensory evaluation, using partially modified 100-point score card of Patil and Gupta (1986). Each panelist was habituated in consuming *churpi* for more than 2 years at the time of these studies. Since *churpi* is consumed as a masticatory, the gumminess and chewiness attributes were evaluated separately from the body and texture parameter. A group of 30 persons were screened on the basis of their interest, performance, motivation, willingness and availability, prior to selection of the panel. After the candidates were tested and interviewed by physiological and psychological screening methods, a group of 15 individuals were selected to allow for alternates and attrition. The set of training procedures included the basic concepts of flavour and texture, the principles of the texture profile method, the use of reference scales to quantify the intensity of each sensory attribute with different *churpi* samples, the evaluation of practice samples and the expansion of the basic texture profile method for *churpi* (Civille and Szczesniak 1973).

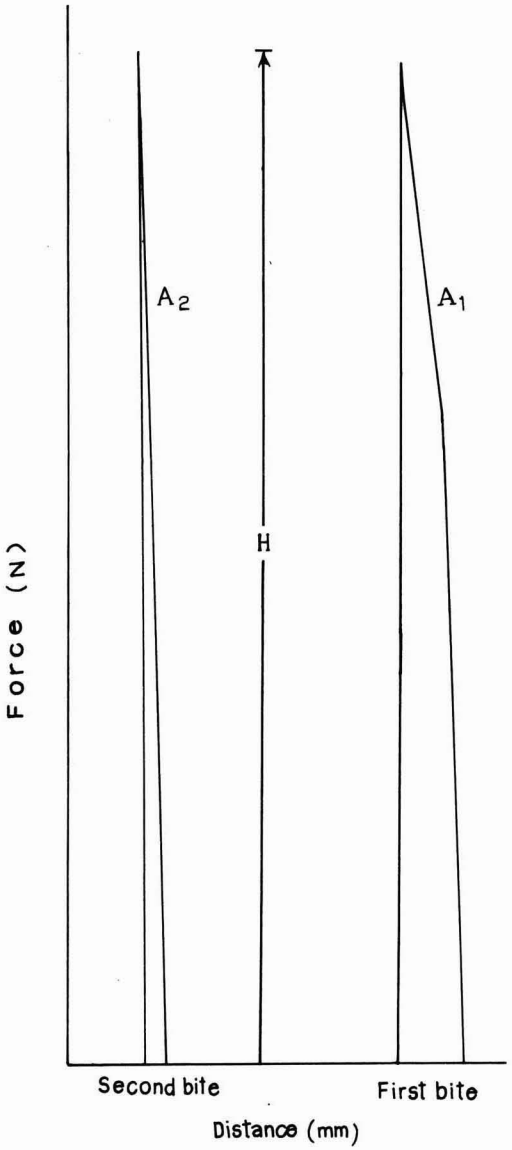

Fig. 1. A two-bite deformation curve of *churpi*

Texture profile: Cubical (5 mm x 5 mm x 5 mm) samples of *churpi* were subjected to uniaxial compression to 40% of the initial sample dimension, using an instron universal testing machine, (model 4301, Instron Ltd, UK), fitted with a 1000 N load cell. The force-distance curve (Fig. 1), obtained for a two-bite deformation cycle, employing a cross-head speed of 50 mm/min and a chart speed of 250 mm/min, was used to determine the various texture profile parameters of *churpi* at 15°C. The parameters measured were hardness (H: height of the first peak, AT^1, i.e., the maximum force recorded during the first compression cycle; N), cohesiveness (C: area under curve A^2/area under curve A^1), springiness (Spr: width of the downstroke in curve A^2; mm), gumminess (G: hardness x cohesiveness; N) and chewiness (Ch: gumminess x springiness; N. mm) (Brady et al. 1985).

Statistical analysis: Standard error of mean (SEM) and analysis of variance (ANOVA) were done, following the methods of Snedecor and Cochran (1989).

Results and Discussion

Fat level in milk : Standard *churpi* prepared from milk, having 1.0% fat and 8.7% SNF, contained 13.0% moisture, 68.5% protein, 7.7% fat, 3.1% lactose, 0.8% glucose-galactose, 7.0% ash, 0.3% titratable acidity and pH of 5.3. With the increase in fat level of milk, the fat content of *churpi* increased significantly ($p<0.01$), but the protein, sugar and ash contents decreased significantly ($p<0.01$). Fat level in milk had no significant ($p<0.01$) effect on the titratable acidity and pH of the product.

The mean scores of almost every sensory attribute of the samples made from milk, having 1.0% fat, were significantly ($p<0.01$) higher, compared to the samples made from milk of other fat levels (Table 1). However, the samples of *churpi* prepared from milk, having 0.1% fat showed

TABLE 1. SENSORY AND INSTRON TEXTURE PROFILES OF *CHURPI* AS INFLUENCED BY FAT CONTENT OF MILK

	Fat content of milk, %			
	0.1	1.0	1.5	2.0
Sensory attributes				
Flavour, 35	27.24^{b} (0.32)	33.35^{a} (0.38)	22.18^{c} (0.30)	16.36^{d} (0.41)
Body and texture, 30	27.78^{b} (0.28)	28.25^{a} (0.30)	19.28^{c} (0.38)	19.25^{c} (0.43)
Colour and appearance, 10	7.00^{c} (0.11)	8.61^{a} (0.21)	7.60^{c} (0.20)	7.60^{c} (0.20)
Gumminess and chewiness, 25	24.25^{a} (0.36)	23.28^{b} (0.31)	14.86^{d} (0.23)	15.14^{c} (0.34)
Total score, 100	86.77^{b} (1.98)	93.49^{a} (0.50)	63.92^{c} (0.59)	58.34^{d} (0.29)
Instron parameters				
Hardness, N	1118.95^{a} (10.66)	999.80^{b} (3.02)	961.58^{bc} (1.48)	875.40^{c} (39.14)
Cohesiveness	0.92^{a} (0.01)	0.76^{b} (0.02)	0.40^{c} (0.01)	0.16^{d} (0.01)
Springiness, mm	0.75^{a} (0.02)	0.66^{b} (0.04)	0.75^{a} (0.02)	0.93^{c} (0.04)
Gumminess, N	1032.24^{a} (15.89)	760.12^{b} (25.47)	383.58^{c} (4.30)	141.03^{d} (10.90)
Chewiness, N, mm	775.23^{a} (29.60)	502.92^{b} (32.00)	286.09^{c} (10.09)	128.94^{d} (6.15)

Data represent the means of four replicates, with SEM in parentheses. Values bearing different superscripts in each row differ significantly (P<0.01).

significantly (p<0.01) higher values with respect to all the Instron parameters (Table 1). The flat flavour in skim milk *churpi* was probably due to negligible amount of fat content, because the agreeable flavour of rich milk and of other dairy products is largely due to milk fat (Eckles et al. 1973). An increased aggregation of protein molecules could be the cause of higher instrumental values in the samples of skim milk *churpi*..

Churpi prepared from milk, having 1.0% fat, showed greater potential with respect to all the sensory attributes and chemical parameters. The chemical, sensory and instrumental data of *churpi*, prepared from milk of 1.0% fat, closely resembled those of the best available samples of the market *churpi* of Bhutan (Pal 1994).

Coagulation temperature of milk: Standardized milk was heated to different temperatures, ranging from 40-80°C and coagulated immediately at that temperature with 2.0% citric acid. Instrumental texture profile of *churpi* prepared from milk, coagulated at different temperatures, is presented in Table 2. *Churpi* prepared by coagulating milk at 70°C had significantly (p<0.05) higher cohesiveness, gumminess and chewiness, compared to the samples prepared by coagulating milk at other temperatures. Maximum hardness was attained at 60 as well as 70°C. Hardness and cohesiveness decreased, when coagulation temperature was above 70°C. When interaction between molecules includes few cross-links, especially if this interaction stretches the molecules themselves, the aggregations result in more flexible and elongated structures. But, when interlocking

TABLE 2. TEXTURAL PROFILE, YIELD AND SOLIDS RECOVERY OF *CHURPI* AS INFLUENCED BY COAGULATION TEMPERATURE OF MILK

	Coagulation temperature, °C				
	40	50	60	70	80
Attributes					
Hardness, N	458.90^{d} (4.03)	557.23^{c} (2.70)	976.75^{a} (14.97)	999.80^{a} (3.02)	886.50^{b} (1.20)
Cohesiveness	0.26^{bc} (0.01)	0.19^{c} (0.01)	0.23^{bc} (0.01)	0.76^{a} (0.02)	0.30^{b} (0.01)
Springiness, mm	1.25^{b} (0.08)	1.60^{a} (0.07)	1.08^{b} (0.04)	0.66^{c} (0.04)	1.20^{b} (0.00)
Gumminess, N	120.60^{c} (60.73)	105.88^{c} (5.22)	222.02^{b} (9.00)	760.12^{a} (25.47)	261.52^{b} (4.97)
Chewiness, N, mm	152.66^{c} (17.50)	168.72^{c} (8.27)	238.60^{bc}(12.55)	502.92^{a} (32.00)	313.82^{b} (5.96)
Moisture, %	13.80^{a} (0.01)	13.72^{a} (0.01)	13.45^{b} (0.01)	13.02^{c} (0.03)	12.95^{c} (0.01)
Yield, %	3.40^{c} (0.03)	3.52^{c} (0.03)	3.88^{b} (0.03)	4.13^{a} (0.02)	4.27^{a} (0.02)
Total solids recovery, %	30.20^{d} (0.27)	31.30^{d} (0.27)	34.65^{c} (0.27)	37.00^{b} (0.18)	38.34^{a} (0.17)
Total solids in whey, %	7.78^{a} (0.04)	7.65^{a} (0.02)	7.60^{a} (0.02)	7.54^{ab} (0.02)	7.30^{b} (0.08)

Data represent the means of four replicates, with SEM in parentheses. Values bearing different superscripts in each row differ significantly (P<0.01).

TABLE 3. TEXTURE PROFILE, YIELD AND SOLIDS RECOVERY OF *CHURPI* AS INFLUENCED BY METHOD OF STRAINING

	Holding time in whey, min			
Attributes	0	5	10	15
Hardness, N	999.80^{a} (3.02)	991.74^{b} (0.40)	900.88^{b} (0.19)	892.44^{c} (0.75)
Cohesiveness	0.76^{a} (0.02)	0.37^{b} (0.01)	0.32^{b} (0.01)	0.34^{b} (0.01)
Springiness, mm	0.66^{c} (0.04)	0.90^{b} (0.04)	0.93^{ab} (0.03)	1.00^{a} (0.00))
Gumminess, N	760.12^{a} (25.47)	362.00^{b} (11.44)	288.28^{c} (8.41)	301.22^{c} (6.81)
Chewiness, N, mm	502.92^{a} (32.00)	326.28^{b} (18.86)	266.66^{b} (11.28)	301.22^{b} (6.81)
Moisture, %	13.02^{c} (0.30)	13.02^{c} (0.02)	13.43^{b} (0.02)	13.66^{a} (0.01)
Yield, %	4.13^{c} (0.02)	4.13^{c} (0.02)	4.27^{b} (0.02)	4.47^{a} (0.03)
Total solids recovery, %	37.00^{c} (0.18)	37.00^{c} (0.21)	38.12^{b} (0.16)	39.81^{a} (0.28)
Total solids in whey	7.54^{a} (0.02)	7.52^{a} (0.02)	7.33^{b} (0.02)	7.19^{c} 90.02)

Data represent the means of four replicates, with SEM in parentheses. Values bearing different superscripts in each row differ significantly (P<0.05).

of molecules weakens, cohesiveness, which is basically due to interlocking of particles, also weakens with consequent decrease in hardness (Lee and Rha 1979). *Churpi* prepared by coagulating milk at 60 and 70°C also had significantly (P<0.05) higher sensory scores than the samples prepared at other coagulation temperatures.

Although the selected temperature range does not satisfy the pasteurization requirement, destruction of pathogens during extensive cooking of green curd is inevitable.

All the sensory and instrumental values of *churpi*, prepard by coagulating milk at 70°C, were found even better than the best quality market samples of Bhutan (Pal 1994).

Moisture content of *churpi* and total solids in whey decreased consistently with the increase in coagulation temperature of milk (Table 2). A consistent rise in moisture content of *paneer* above the coagulation temperature of 80°C and with 7.9% total solids in whey at the coagulation temperature of 72°C, were reported by Sachdeva and Singh (1988). Yield and total solids recovery increased with the increase in coagulation temperature. Iyer (1978) suggested that good quality *chhana* could be obtained by coagulating milk at 70°C (pH 5.1), using 2% citric acid.

Holding period: Milk, standardized to 1.0% fat and 8.7% SNF, was heated to 70°C and coagulated with hot (70°C) 2.0% citric acid solution. The coagulum was left in whey for different periods before straining. The Instron texture profile, yield, total solids recovery and loss in *churpi*, thus prepared, are presented in Table 3. *Churpi* prepared by straining immediately after coagulation had significantly (P<0.05) higher hardness, cohesiveness, gumminess and chewiness, but significantly (p<0.05) less springiness than the samples prepared by the other three methods. *Churpi* prepared by strainng immediatey after coagulation also had a significantly (P<0.05) higher score with respect to flavour, body, texture, gumminess and chewiness. However, holding period had no significant (P<0.05) effect on colour and appearance of the product.

Delayed straining caused the coagulum to retain more moisture than immediate straining, and this is in conformity with the finding of De (1980). Due to significantly higher (P<0.05) moisture content and less total solids in whey, the yield of *churpi* prepared from the coagulum, held in whey for 15 min, was significantly (P<0.05) higher, than the samples of other three holding periods.

Strength of citric acid: Churpi samples prepared by citric and lactic acids were equally acceptable with respect to sensory scores as well as instrumental data, which were significantly (P<0.05) higher than the products of other coagulants tested (Pal et al. 1995). Since citric acid is less expensive than lactic acid, the strength of citric acid was optimized in the present study.

Although hardness did not differ significantly (P<0.05) , cohesiveness, gumminess and chewiness of *churpi* prepared by using 2.0% citric acid solution were significantly (P<0.05) higher, than the samples prepared by using 0.1 and 3.0% citric acid solutions (Table 4).

The flavour score of *churpi*, prepared from 2.0% citric acid solution, was maximum and least, when prepared using 3.0% citric acid solution. Body, texture, gumminess and chewiness scores of *churpi*, made with 2.0% citric acid solution, were significantly (P<0.05) higher than the samples of 1.0 and 3.0%.

TABLE 4. TEXTURE PROFILE, YIELD AND SOLIDS RECOVERY OF *CHURPI* AS INLFUENCED BY STRENGTH OF CITRIC ACID.

	Citric acid, % w/v		
Attributes	1.0	2.0	3.0
Hardness, N	984.43^{a} (4.19)	999.80^{a} (3.02)	1006.25^{a} (3.98)
Cohesiveness	0.39^{c} (0.02)	0.76^{a} (0.02)	0.57^{b} (0.01)
Springiness, mm	0.93^{a} (0.04)	0.66^{b} (0.04)	0.64^{b} (0.02)
Gumminess, N	381.29^{c}(21.27)	760.12^{a} (25.47)	571.01^{b} (7.10)
Chewiness, N, mm	349.18^{a} (3.07)	502.92^{b} (32.00)	363.59^{a} (8.91)
Moisture, %	13.61^{a} (0.02)	13.04^{b} (0.04)	12.80^{c} (0.04)
Yield, %	4.25^{a} (0.02)	4.13^{b} (0.02)	3.93^{c} (0.03)
Total solids recovery, %	37.83^{a} (0.12)	37.00^{b} (0.18)	35.35^{c} (0.23)
Total solids in whey, %	7.34^{c} (0.02)	7.54^{b} (0.02)	7.64^{a} (0.03)

Data represent the means of four replicates, with SEM in parentheses. Values bearing different superscripts in each row differ significantly ($P<0.05$).

The moisture content, yield and total solids recovery of *churpi* varied inversely with the concentration of the solution (Table 4).

The present study suggests that, to obtain a good quality *churpi*., it is necessary to standardize milk at fat : SNF ratio of 1:8.7, heat it to 70°C, coagulate at 70°C with 2.0% citric acid solution and straining immediately after coagulation. Optimization of process parameters will help in mechanization and automation needed for large scale production.

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Pasting and *Papad* Quality Of Rice, Wheat and *Mung* Flour Blends

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Effects of the addition of *mung* flour and sodium bicarbonate to wheat and rice flour on pasting properties and quality of *papads* were investigated. Blending of *mung* flour and addition of sodium bicarbonate significantly increased the gelatinization temperature, but reduced the viscosity. Blending of *mung* flour in wheat or rice flour and addition of sodium bicarbonate reduced the expansion ratio of *papad*. The texture of *papads* significantly increased, due to the addition of sodium bicarbonate. Blending of *mung* flour in wheat or rice flour, resulted in darker coloured *papads*, which was further enhanced by the addition of sodium bicarbonate. Scores awarded for various quality attributes decreased with the increase in level of *mung* flour. All the quality attributes showed further deterioration on the addition of sodium bicarbonate. Overall acceptability was not affected significantly up to 10% level of blending *mung* flour with rice and up to 20% with wheat. The study revealed that addition of sodium bicarbonate at 0.5% level had a negative effect on the quality of *papads*.

Keywords : Cereal, Legume, Texture, *Papad*, Pasting, *Mung dhal*, Sensory quality.

Snack foods have long been a part of diets both in developing and developed countries (Ekvall and Vallo 1983; Siegel and Lineback 1976). Properly designed snack foods can make a significant contribution to nutrition in societies, where social changes are altering traditional patterns of food preparation. *Papad* is a popular snack food of India, which is consumed as roasted/fried product or as an adjunct with vegetable soups and curries. A variety of *papads* are available in India, which are produced from a great diversity of ingredients. Usually, they are made either using only cereal flour or combination of pulse flour with salt, spices and some additives (Shurpalekar and Venkatesh 1975; Govindarajan et al. 1971; Saxena et al. 1989; Arya 1990; Deepa et al. 1992). Supplementation of legume flours with cereal flours has been reported to improve the nutritional value of mixture and products thereof (Juneja et al. 1980; Del Angel and Sotelo 1982; Valencia et al. 1988; Almeida-Dominguez et al. 1990). However, supplementation with legume flours at levels of 30% and above adversely affect the taste and acceptability of products (Hallab and Khatchadourian 1974; Singh et al. 1992).

Inclusion of sodium bicarbonate in the preparation of *papad* is a routine practice at homes and has also been adopted in some research studies (Saxena et al. 1989; Shurpalekar et al. 1972). However, none of the studies reveal the beneficial effect, if any, of the addition of sodium bicarbonate on the quality of *papad*. The quality attributes of such snack products are judged from their texture and expanded volume. Expanded volumes of cereal and starch products have been reported to depend on raw materials and processing conditions, which affect gelatinization behaviour, and ultimately the expanded volume (Chinnaswamy and Bhattacharya 1983, 1984). There are no reports on the pasting behaviour of cereal and pulse flour blends during the process of manufacture of *papads*. The present study was, therefore, planned to see the effect of supplementation of *mung* flour with wheat and rice flours at different levels on the pasting properties and quality of *papads*.

Materials and Methods

Chemical analysis: The determinations of protein, ash, fat and moisture of flours used in the study were done by the methods of AACC (1976).

Preparation of samples: Representative samples of wheat (variety "WL-1562") and that of rice (variety "Jaya") were ground to whole meal in the Quadrumat Junior Mill. A *mung* (dehulled) sample was obtained from the local market and was ground to the same fineness (20 mesh) as for the two cereals. The *mung* flour was used for blending the rice and wheat flours in the proportions of 10, 20 and 30%.

Pasting properties: Pasting properties of wheat and rice flours blended with *mung* flour were studied with the help of viscoamylograph, equipped with 700 cm-g sensitivity cartridge and cooling coil. To study the effect of sodium bicarbonate, a weighed

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amount (0.5%, flour basis) was dissolved in water, which was used for making slurry. Rice flour (45 g) and 50 g wheat flour were mixed with 450 ml water. The slurry was heated from 35 to 95°C (1.5°C rise/min), held at 95°C for 10 min and cooled to 50°C with a similar rate of drop in temperature.

Preparation of papad : Flour 100 g 0.5 g black pepper (ground), 4.5 g salt and 200 ml water were mixed and rested for a period of half an hour. To test the effect of sodium bicarbonate, 0.5 g was dissolved in small portions of water and then used to make the slurry. A definite volume (one teaspoon) was poured in greased aluminium dishes, having a dia of 60 mm, spread evenly and steamed for 2 min at normal atmospheric pressure. The partially pregelatinized materials *(papad)* were taken out from the dishes, sun-dried and packed in polythene bags for further use.

Frying: Dried *papads* were deep-fat-fried in an automatic temperature controlled frier at 190°C for 20-30 sec (optimum frying), using refined cottonseed oil as frying medium.

Textural strength : Texture of fried *papads* was determined, using an Instron universal testing machine (Model-1111), 2 h after frying, using the following settings: drive speed, 50 mm/min; chart speed, 200 mm/min; force range-2000 g; dye size 3.5 mm. The force required to puncture the *papads* placed on hollow cells was measured in g.

Organoleptic evaluation : Fried *papads* were evaluated by 10 semi-trained panelists for appearance, colour, taste, and overall acceptability, using a 9 point Hedonic scale. Scoring of colour was also done using an Agtron colour index chart.

Statistical analysis: The results were statistically analyzed using two factors in randomized block design as described by Steel and Torrie (1960). The least significant differences (LSD) were calculated and reported.

Results and Discussion

Composition of flours: Wheat, rice and *mung* flours had 8.7 7.4 and 23.4% protein, respectively. Ash content was highest in *mung* flour i.e., 1.7%, whereas wheat and rice flours had 0.5 and 0.6%, respectively. The fat contents were 1.5 , 1.0 and 1.3% in wheat, rice and *mung* flours, respectively.

Pasting properties : Blending of *mung* in both wheat and rice flours significantly increased the gelatinization temperature, but reduced the peak viscosity at 95°C and 50°C (Table 1). The reduction in peak height reflected the reduced ability of *mung* flour granules to swell before physical breakdown. Similar observations with respect to wheat-chickpea flour bread crumbs were made earlier (Singh et al. 1991). The gelatinization temperature, which is taken as the point of initial increase in viscosity, increased with the blending of *mung* flour, because of restricted swelling of starch. Deshpande et al (1983) also found that the peak heights of wheat-bean composite flours were lower than that of wheat flour, indicating an inhibited hydration and

TABLE 1. EFFECT OF BLENDING *MUNG* FLOUR WITH RICE AND WHEAT FLOURS ON THE PASTING PROPERTIES

Characteristics	% *Mung* flour Without sodium bicarbonate				% *Mung* flour With sodium bicarbonate				LSD (0.05)
	0	10	20	30	0	10	20	30	
				Rice					
Gelatinization Temp. 0°C	80.0	84.0	85.0	86.0	83.0	83.0	84	84.0	0.4
Peak viscosity BU	600	335	270	210	660	440	320	260	14.8
Viscosity at 95°C BU	600	315	265	200	630	430	325	260	10.0
Viscosity* at 95°C BU	600	330	280	220	590	385	310	245	9.8
Viscosity at 50°C BU	1130	635	540	440	1440	830	600	510	21.0
Set Back	530	300	270	230	780	390	280	250	13.4
	Wheat								
Gelatinization temp. °C	65.0	68.0	69.0	71.7	66.8	68.0	71.0	73.5	0.4
Peak viscosity BU	540	405	340	300	620	550	440	370	11.3
Viscosity at 95°C BU	435	260	215	200	470	400	335	270	10.0
Viscosity* at 95°C BU	445	260	225	295	420	355	280	235	12.5
Viscosity at 50°C BU	760	540	425	370	940	850	685	570	12.7
Set Back	220	135	85	70	320	300	245	200	8.3

Values are means of three replications

LSD: Differences between two means exceeding this value are significant

*After 10 min of maintaining this temperature

TABLE 2. EFFECT OF BLENDING *MUNG* FLOUR WITH RICE AND WHEAT FLOURS ON FRYING CHARACTERISTICS OF *PAPADS*

Characteristics	% *Mung* flour Without sodium bicarbonate				% *Mung* flour With sodium bicarbonate			
	0	10	20	30	0	10	20	30
				Rice				
Colour	Creamy yellow	Golden yellow	Golden yellow with brown tinge	Brown yellow	Straw yellow	Straw yellow with brown tinge	Brown yellow	Deep brown yellow
Agtron index reading	>65	65	55	50	45	40	37	33
				Wheat				
Colour	Creamy yellow	Straw yellow	Golden yellow	Golden yellow with brown tinge	Straw yellow	Straw yellow with brown tinge	Golden yellow with brown tinge	Brown yellow
Agtron index reading	>65	65	60	55	48	45	42	37

delayed swelling. Addition of sodium bicarbonate increased the gelatinization temperature in rice, but only marginal effect was observed in the case of rice-*mung* blends. Addition of sodium bicarbonate increased the gelatinization temperature both in unblended and blended wheat: *mung* samples. The presence of sodium bicarbonate in wheat significantly increased the peak viscosity, viscosity at 95°C and 50°C. The increase in cold and hot paste viscoity with the addition of sodium bicarbonate indicated that starch in the presence of sodium bicarbonate swelled more (Ghiasi et al. 1982; Lai et al. 1989). Set back viscosity, which is regarded as a measure of gelling ability of "retrogradation tendency" (Mazurs et al. 1975), decreased with the increase in *mung* flour in wheat or rice flour. Higher set back values obtained by the addition of sodium bicarbonate showed that the sodium bicarbonate addition enhanced retrogradation starch.

Raw papad *characteristics:* The appearance and colour of raw *papads* improved with the increase in the level of *mung* up to 20% and the *papads* having 30% *mung* flour were equally good, as those prepared from unblended wheat or rice flour. The colour of *papads* made from wheat or rice, whether blended or not with *mung*, deteriorated with the addition of sodium bicarbonate. The average pH of *papads* made from wheat was 5.7 and those made from wheat, having sodium bicarbonate, was 8.5. The *papads* made from rice had a pH of 6.2, which increased to 9.0 with the addition of sodium bicarbonate.

TABLE 3. EFFECT OF BLENDING *MUNG* FLOUR WITH RICE AND WHEAT FLOURS ON THE SENSORY PROPERTIES OF *PAPADS*

Characteristics	% *Mung* flour Without sodium bicarbonate				% *Mung* flour With sodium bicarbonate				LSD (0.05)
	0	10	20	30	0	10	20	30	
					Rice				
Appearance	8.8	8.4	7.8	7.0	8.0	7.4	6.4	5.8	0.4
Colour	8.9	8.0	7.0	5.8	7.8	7.0	5.4	3.7	0.5
Taste	8.8	8.6	8.0	7.0	8.5	8.0	7.6	6.6	0.4
Texture	8.2	8.2	8.3	8.5	5.7	6.6	7.1	7.2	0.3
Overall acceptability	8.7	8.4	7.8	7.0	7.5	7.2	6.6	5.6	0.45
					Wheat				
Appearance	9.0	8.8	8.5	7.8	8.5	8.0	7.2	6.4	0.4
Colour	9.0	8.4	8.0	7.0	8.3	7.6	7.0	5.4	0.5
Taste	8.8	8.7	8.5	7.6	8.6	8.3	8.0	7.2	0.3
Texture	8.6	8.6	8.7	8.8	6.3	6.9	7.2	7.4	0.4
Overall acceptability	8.8	8.6	8.4	7.8	7.9	7.7	7.2	6.5	0.4

Values are means of three replications

LSD: Differences between two means exceeding this value are significant

Frying characteristics : Blending of *mung* in wheat or rice flour significantly reduced the expansion, which was further significantly reduced by the addition of sodium bicarbonate (data not reported). The expansion of *papads* from wheat flour was more as compared to those made from rice. The extent of reduction in expansion with the addition of sodium bicarbonate was more in rice, as compared to wheat Lai et al (1988) reported that addition of 0.2% sodium bicarbonate improved expansion and decreased the textural strength of extrudate. The reduction in expansion and increase in textural strength of *papads* in the present study may be due to use of higher level of sodium bicarbonate, i.e., 0.5%. The textural strength significantly decreased by the addition of *mung* flour. The textural strength of *papads* made from rice was more, as compared to wheat *papads*. This may be due to the characteristic differences in the starch-protein components of the two cereals. The texture significantly increased with the addition of sodium bicarbonate. This shows that the addition of sodium bicarbonate increased the binding of starch molecules in *papads*. The fat absorption after frying was more in wheat *papads*, as compared to those made from rice, which was marginally reduced by the addition of sodium bicarbonate. Blending of *mung* flour in both wheat and rice flours reduced the fat absorption in *papads*. The higher oil absorption in wheat flour *papads* may be attributed to its predominantly hydrophobic proteins. While 70-90% protein in dry bean is reported to be water soluble (Sathe et al. 1983), approximately 80-90% of protein in wheat and 90-95% of proteins in rice are reported to be water insoluble (Kent 1983).

With the blending of *mung* with wheat or rice, the colour of *papads* became darker, the intensity of development of dark colour was more in rice than wheat (Table 2). The darkening was further increased by the addition of sodium bicarbonate. The addition of sodium bicarbonate caused the caramelization, as indicated by the development of brown colour in the fried *papads*. Presence of bicarbonate might have induced starch oxidation, which led to caramelization (Lai et al. 1989). Darkening of extrudates at high pH due to caramelization of carbohydrates has also been reported by Faubion et al (1982).

Sensory evaluation of fried papads: The scores awarded for appearance, colour, taste and overall acceptability decreased progressively with the increase in level of *mung* flour (Table 3). The magnitude of reduction of scores was more with respect to colour. All the quality attributes showed further deterioration on the addition of sodium bicarbonate. The reduction of scores of these attributes was spectacular in rice and was only marginal in the case of wheat. The darkening in colour of *papads* by addition of *mung* flour is due to Maillard reaction. The sodium bicarbonate induced additional darkening due to caramelization.

Overall acceptability was not affected significantly up to 10% level of blending *mung* flour with rice and up to 20% with wheat. The study showed that addition of sodium bicarbonate at 0.5% level adversely affected the quality attributes of *papads*. Therefore, use of sodium bicarbonate in *papad* making is not suggested.

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Comparative Study of Meat Quality of 'Giriraja' and Broiler Birds

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A comparative study was conducted on meat quality characteristics of 'Giriraja' and commercial broiler birds slaughtered at the age of 7-8 weeks. Live and carcass weights as well as weights of organs such as giblet and neck of broilers were significantly (P<0.01) higher. However, there was no significant (P<0.05) difference between the moisture, protein, fat and ash contents in the meats from both the groups. Organoleptically, meat product from both the groups scored almost the same values.

Keywords : 'Giriraja', Commercial broilers, Meat quality, Proximate composition Organoleptic characteristics.

'Giriraja' birds are evolved by reciprocal crossing of commonly used broiler parent breeds with different plummage colours. These birds resemble our 'Desi' birds and are well suited for rearing them under range management. 'Giriraja' birds seem to possess desired genetic potentiality for rapid growth and egg production. As there is no information on meat quality of 'Giriraja' birds, it was desired to study the meat quality characteristics such as live carcass and organ weights, proximate composition and sensory characteristics in comparison to commercial broiler birds.

Male 'Giriraja' birds (7-8 weeks old) from UAS-poultry farm, Bangalore and the commercial broiler birds of same age and sex from the local poultry fare were procured, weighed, examined and rested for about 6 h before slaughter. Ten birds from each group were slaughtered by *halal* method, dressed and weighed. The organs, such as liver, gizzard, heart and giblet and neck were also separated and weighed. Meat samples from breast regions were taken for the estimation of moisture, protein, fat and ash contents, as per the standard methods described in AOAC (1990). *Tandoori kababs* were prepared from the remaining meat from both the groups, as per the method described by Surjit Malhan (1963) and the products from both the groups were evaluated by 20 trained panelists on a 10-point Hedonic scale. The data were subjected to analysis of variance (Snedecor and Cochran 1967).

It was observed that the growth of commercial broiler birds was faster, when compared to 'Giriraja' birds, as evidenced by an higher live weight, carcass and weights of different organs. The differences in weights between the two groups of birds were statistically significant (P<0.01), except for the heart (Table 1). The data on proximate composition of meat from both broiler and 'Giriraja' birds showed no significant (P <0.05) difference (Table 1). The *kababs* prepared from both broiler and 'Giriraja' birds, when evaluated by a trained panel, scored values, which were not significantly different with regard to sensory parameters (Table 1). This study indicates that there is no significant difference between the commercial broiler and 'Giriraja' birds with regard to chemical composition of meat and sensory characteristics of meat products (viz., *kababs*). However, the growth pattern of

TABLE 1. PHYSICAL, CHEMICAL AND SENSORY QUALITIES OF 'GIRIRAJA' AND COMMERCIAL BROILER BIRDS

Attributes	Type of birds	
	'Girigaja' birds	Commercial broilers
Physical		
Live weight, kg	1.39 ±0.05	1.54 ±0.04**
Carcass weight, kg	0.93 ±0.03	1.03 ±0.02**
Giblet, g	70 ±4.9	96.60 ±4.9**
Neck, g	62.83 ±5.12	71.17 ±4.9**
Chemical		
(g/100 g muscle)		
Moisture	75.9 ±2.9	76.4 ±1.75^{NS}
Proteins	22.1 ±0.07	21.7 ±0.06^{NS}
Fat	0.6 ±0.04	0.6 ±0.03^{NS}
Carbohydrates	1.2 ±0.02	1.1 ±0.04^{NS}
Ash	0.2 ±0.09	0.2 ±0.04^{NS}
Sensory score of *kababs*		
Colour	6.5 ±1.9	6.2 ±1.7^{NS}
Flavour	6.6 ±1.5	7.1 ±1.3^{NS}
Juiciness	9.5 ±1.7	7.3 ±1.6^{NS}
Texture	7.0 ±1.6	6.8 ±1.7^{NS}
Overall acceptability	7.2 ±1.6	7.7 ±1.3^{NS}

**Significant P <0.01. Values reported are mean ± SD
NS-Not significant P>0.05

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commercial broilers was faster than the 'Giriraja' birds.

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Antibacterial Activity of Lactic Acid Bacterial Isolates Obtained from Natural Habitats

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A total of 171 isolates of lactic acid bacteria, belonging to the genera *Lactobacillus* (106), *Lactococcus* (53), *Leuconostoc* (6) and *Pediococcus* (6), were obtained from different sources. Among these isolates, 24 were inhibitory against 19 strains of lactic acid bacteria, as evaluated by the agar spot test and well diffusion assay. Under conditions eliminating the effect of organic acids, hydrogen peroxide and bacteriophages, 7 isolates of *Lactobacillus* showed antibacterial activity, due to the production of bacteriocin-like substances.

Keywords : Lactic acid bacteria, Antibiosis, *Lactobacillus*, Bacteriocins.

Lactic acid bacteria (LAB) are known to occur in milk products, meat products, fruits and vegetables. They are used for biological processing of many raw materials to produce acceptable foods with improved flavour and consumed for their prophylactic and therapeutic properties (Fernandes and Shahani 1989). Besides, LAB are known to possess antibacterial properties, attributed to the major end products of their metabolism, such as lactic acid, acetic acid, hydrogen peroxide and peptide compounds, termed bacteriocins (Klaenhammer 1982). Bacteriocins from food grade lactic acid bacteria are bactericidal to many Gram positive bacteria associated with food spoilage (Bhunia et al. 1987). Several unique properties, such as activity over a wide range of pH and high or low temperature treatment, make them suitable as biological preservatives to extend shelf-life of refrigerated, semi-preserved and canned foods. Their use in foods has an added advantage, because they are degraded by the proteolytic enzymes of the gastrointestinal tract and are non-toxic and non-antigenic to animals (Biswas et al. 1991).

Considering the potential use of LAB, the prime objective of this investigation was set to isolate LAB from natural habitats and screen for their antibacterial activity, against closely related genera and species.

Samples of curd, cheese, *chhana* (acid-and-heat coagulated milk product), whey, spoiled milk, rotten vegetables, and putrid fish as well as meat were aseptically collected from local markets, brought to the laboratory within 3 h of collection and immediately subjected to analysis. For ensilage enrichment, the method of Whittenbury (1965) was followed. Appropriate dilutions of samples were pour plated with MRS agar (Hi-Media, India) and incubated in a candle jar for 48 h at 32°C. Colonies appearing on incubated plates were isolated at random and maintained at 4°C in MRS broth (Hi-Media), with sub-culturing at an interval of 15 days. Isolates were characterized by morphological, cultural and biochemical tests, following the methods described by Sharpe et al (1966). Characterized isolates were identified to their generic level, according to Bergey's Manual of Systematic Bacteriology (Sneath et al. 1986).

The antibacterial activity of the isolated cultures of LAB was detected, following the 'agar spot' test (Schillinger and Lücke 1989) and the 'spot on the lawn' method (Lewus and Montville 1991). Plates of MRS-0.2 agar (MRS broth containing 0.2% w/v glucose and supplemented with 1.5% w/v agar) were dried overnight, spotted with producing cultures (5 spots per plate) and incubated in a candle jar for 18-24 h at 30°C. Brain Heart Infusion (BHI) broth (Hi-Media), supplemented with 1.0% w/v agar, termed BHI soft agar, was tempered to 45°C and seeded with 18 h old 10^5-10^6 sensitive organisms per ml. The number of cells was determined, using a Neubauer's counting chamber and a phase contrast microscope. The spotted plates were overlaid with 8 ml of the seeded BHI soft agar, incubated for 18-24 h at 30°C and observed for inhibition zones. Inhibition was scored positive, if the width of the clear zone around the colonies of the producing strain was 0.5 mm or larger. The indicator bacteria used in this study included 19 cultures of LAB (belonged to 9 species and 4 genera), which were obtained from the culture collection of the Microbiology Laboratory, Department of Botany, University of North Bengal.

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Isolates of LAB, which were positive in the agar spot test against the respective indicator bacteria, were tested for the antibacterial activity in neutralized cell-free supernatant by well diffusion assay. Cell-free supernatant of the 24 h old positive LAB cultures, obtained by centrifugation, was neutralized to pH 6.5 with 1 N sodium hydroxide, followed by 10-fold concentration in a rotary evaporator at 65°C and membrane sterilized by passing through a 0.45-µm filter (Lewus and Montville 1991). Pour plates were prepared from BHI soft agar, seeded with 18 h old 10^5-10^6 indicator organisms per ml. Wells of 4-mm dia cut into the pour plates with sterile cork borer were filled with 50 µl of the concentrated supernatant. The plates were incubated at 32°C and the antimicrobial activity of the supernatant was detected and quantitated after 24 h, by measuring the width of the clear zones around the wells (Lewus and Montville 1991).

The presence of the lytic bacteriophages was ruled out by a modified version of the reverse-side technique (Parrot et al. 1990). Wells of a 7-mm dia were punched out of 7-mm thick MRS agar discs in plates, by using a sterile cork borer. The base of each well was sealed with 2 drops (0.1 ml) of molten agar, and then culture supernatants (0.1 ml) were added to the wells. The inoculated plates were incubated at 25°C for 6 h to allow diffusion of the liquid into the medium. The agar disc was then loosened from the edge of the petri dish, with a sterile spatula, to fall into the upper lid, exposing the bottom surface of the disc. After drying at 37°C for 2 h, the freshly exposed surface was overlaid with 8 ml of molten (45°C) BHI soft agar, seeded with 18 h old 10^5-10^6 indicator organisms per ml.

Aliquots of culture supernatants (10-fold concentrated) of positive LAB isolates were treated with 5 µg/ml catalase (Hi-Media), 60 U/ml pepsin (Hi-Media) and 40 U/ml trypsin (E. Merck, Germany), following the procedures described by Schillinger and Lücke (1989) and Rammelsberg and Radler (1990), respectively. The residual antibacterial activity in the treated samples was assayed by well diffusion method.

The identified genera of LAB among the natural isolates, obtained from different sources, are presented in Table 1. A total of 171 isolates of LAB were obtained from 74 different samples. Lactobacilli constituted 62% of the total isolates and predominated in whey and curd, followed by 31% of lactococcal isolates, which occurred frequently in rotten vegetables, putrid meat and silage. Besides, isolates of leuconostocs were found in chhana and rotten vegetables and those of pediococci in silage which together constituted 7% of the total isolates.

TABLE 1. LACTIC ACID BACTERIAL ISOLATES FROM DIFFERENT SOURCES

Source*	Genera of LAB			
	Lacto-bacillus	*Lacto-coccus*	*Leuco-nostoc*	*Pedio-coccus*
	(No. of isolates)			
Curd (13)	29	3	0	0
Chhana (16)	17	6	4	0
Whey (11)	35	0	0	0
Cheese (7)	5	7	0	0
Silage (5)	1	10	0	6
Rotten vegetables (16)	8	14	2	0
Putrid fish (2)	10	2	0	0
Putrid meat (4)	1	11	0	0
Total (74)	106	53	6	6

* Figures in parentheses indicate number of samples analysed.

TABLE 2. ANTIBACTERIAL ACTIVITY OF THE LACTIC ACID BACTERIAL ISOLATES DETERMINED BY AGAR SPOT TEST

Genera	No. of isolates (A)	Positive isolates (B)	Percent frequency ($\frac{B}{A} \times 100$)
Lactobacillus	106	17	16
Lactococcus	53	4	8
Leuconostoc	6	2	33
Pediococcus	6	1	17

TABLE 3. ANTAGONISTIC ACTIVITY OF THE NEUTRALIZED CULTURE SUPERNATANTS OF SELECTED LACTIC ACID BACTERIAL ISOLATES AGAINST STRAINS OF *LACTOBACILLUS PLANTARUM*

Natural *Lactobacillus* isolates	*Lb. plantarum* strains*		
	ATCC 10241	GMRI	LMRI
	(Degree of inhibition)		
W-25B	-	(+)	-
W-25C	-	+	-
W-26B	-	+	+
W-28	-	+	+
W-30A	-	(+)	(+)
W-30B	(+)	-	-
C-34	-	(+)	-

* Symbols for well diffusion assay: +, large inhibition zone (width, ≥3.0 mm); (+), small inhibition zone (width, <3.0 mm); -, no inhibition zone.

TABLE 4. DETERMINING THE NATURE OF ACTIVE PRINCIPLES IN CONCENTRATED CULTURE SUPERNATANTS (CS)

	No. of strains positive in well diffusion assay				
Genera	CS unadjusted (pH <3.0)	CS neutralized	Treated with catalase	Treated with proteases	Subjected to reverse-side technique
Lactobacillus	17	7	7	0	7
Lactococcus	4	0	0	0	0
Leuconostoc	2	0	0	0	0
Pediococcus	1	0	0	0	0

Among the isolates of LAB screened for antibacterial activity, 14% showed antagonistic activity in the agar spot test (Table 2). The concentrated culture supernatants of the positive 24 isolates also produced inhibition zones in well diffusion assay, against the respective indicator strains. Of them, only 7 isolates of *Lactobacillus* were positive in the well diffusion test, when their concentrated supernatants were neutralized (Table 3).

The antibacterial activity produced by 7 isolates of *Lactobacillus* under neutral pH conditions was due to the production of bacteriocins, as evidenced by the treatment with proteolytic enzymes and catalase (Table 4). Further, the action was not the result of action of lytic bacteriophages. According to preliminary studies included in this work, the antibacterial compound produced by these 7 isolates is of proteinaceous nature, a typical characteristic of bacteriocins (Tagg et al. 1976). Hence, about 4% of the total LAB isolates were producers of bacteriocin-like substances, active against the indicator strains used. A similar observation was recorded in the study of Gies et al (1983), wherein 5% of the total lactococcal strains possessed antibacterial activity.

From the findings, it is evident that there occurred a good number of isolates, belonging to the predominant genera of LAB in natural habitats. Besides, use of suitable isolation and screening procedures can benefit in obtaining potential isolates with antibacterial properties, which can find use in food preservation.

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Effect of Dehulling and Genotypes of Sorghum *(Sorghum vulgare)* on *Roti* Quality

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Varietal differences and the effect of dehulling on physical characteristics of sorghum grain as well as flour and their association with *roti* quality were evaluated. The 100 grain weight, grain hardness, corneousness and swelling quality of flour showed considerable genetic variations. Differences in physical characteristics between whole grain, dehulled grain and flour were observed. Dehulling improved the sensory qualities of *rotis* made with 'NTJ-1' and NTJ-2 sorghum flours. Dehulling minimised varietal differences with respect to grain hardness and KOH gel spread, without affecting the rolling and kneading qualities of *rotis*.

Keywords : Sorghum, *Roti* quality, Physical characteristics, Cultivars, Sensory quality, Dehulling.

Sorghum is a staple food for a large section of population living in dryland regions of India. Traditional users of sorghum are usually found in parts of Telangana and Rayalaseema region of Andhra Pradesh, India. In these areas, sorghum is used in the form of *roti*, along with rice or fermented gruel *(ambali)*. Usually, dehulling of sorghum is done only when rice is prepared, whereas *roti* and fermented gruel are prepared with whole grain flour.

Work on *roti* evaluation revealed that physico-chemical characteristics influence its quality (Subramanian and Jambunathan 1980, 1982). It was also shown that judicious refining of these grains can upgrade the appearance and eating quality of products, due to the removal of part of the bran (Pushpamma 1982; Murthy 1984). Dehulling may alter the physical characteristics, which might affect the dough quality as well as sensory properties of finished products. Hence, it was planned to study the effect of dehulling on the grain characteristics and product quality in 11 cultivars of sorghum.

Eleven sorghum cultivars, grown at Agricultural Research station, Nandyal, Andhra Pradesh and ICRISAT, Hyderabad, were selected for the study. Five kg lots of dried grain (moisture 10%) were dehulled in a agro-huller (developed by APAU). Both whole and dehulled grain were ground to flour in cyclotec sample mill (model 1093-001) to pass through a 60 mesh sieve and used for further analysis.

Grain hardness, corneousness, swelling capacity of flour, dough quality (Subramanian and Jambunathan 1982), water uptake of flour in dough making (Desikachar and Chandrasekar 1982), gel spread and KOH gel spread (Murthy et al. 1982) were assessed in both whole and dehulled grains and flour. The organoleptic properties of plain *rotis*, without accompaniment (Subramanian and Jambunathan 1981), were evaluated by a trained panel of 12 judges.

Physical characteristics: Varietal differences influenced the milling yields (Table 1), because of differences in physical characteristics. The dehulling technique was not suitable for sorghum varieties with soft endosperm, due to excessive breakage observed during dehulling process. The grain hardness showed a wide variation of 5-10 kg per cm^2 in whole grain and 1.5-7.0 kg per cm^2 in dehulled grain (Table 1). Varietal differences were observed in 100 seed weight of whole and dehulled grain. Variation (1.0-4.0) was also seen in the corneousness of different varieties of sorghum. Dehulled grains had better swelling ratio, in comparison with whole grain. Contrary to this, dehulling reduced the swelling capacity of flour in the national varieties. Similar trend was seen in other international varieties, except in 'M-35-1', 'IS 24885' and 'IS 24761'.

Gel spread: The flow of gels was sensitive to slight changes in either the concentration of flour or the normality of the alkali. Average gel spread in whole and dehulled flour was 10.24 and 10.22 cm, respectively (Table 1). Both coarse and fine flour samples of grain had closer gel spread values. There was a marked difference in the flow of KOH gels of sorghum cultivars. Corneousness of grain was positively correlated with KOH gel spread (r=0.7136) and water uptake (r=0.7604).

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TABLE 1. PHYSICAL CHARACTERISTICS AND MILLING YIELD OF 11 SORGHUM CULTIVARS (WHOLE AND DEHULLED)

	Milling yield, %	Hardness		Corneousness [a]	100 seed weight		Swelling capacity of grain, v/w		Swelling capacity of flour, v/w		Gel spread, cm		KOH gel spread, cm	
		W	D		W	D	W	D	W	D	W	D	W	D
National varieties														
LOCAL	89.2	5.49	2.62	2.5	3.20	2.89	1.75	3.36	7.42	6.49	10.10	10.3	10.50	8.50
'N-14'	91.0	5.28	2.60	1.0	2.82	2.62	1.78	2.90	10.21	7.48	10.50	10.6	7.10	11.10
'NTJ-1'	94.3	5.34	1.68	2.5	2.28	2.14	1.95	2.73	8.14	6.18	9.95	10.2	8.20	12.80
'NTJ-2'	92.7	7.56	5.84	3.0	2.96	2.84	1.66	2.46	6.55	5.82	10.10	9.9	12.10	12.00
International varieties														
'M-35-1'	89.8	5.84	3.16	2.5	3.67	3.57	2.03	2.78	7.31	7.80	9.85	10.3	11.85	16.90
'IS-24729'	86.2	6.16	4.28	2.1	3.88	3.63	1.75	2.39	11.17	9.72	10.00	10.7	9.70	11.15
'IS-22472'	91.5	6.64	4.64	3.0	3.40	3.26	1.81	2.62	7.59	6.87	10.13	6.9	10.90	10.20
'IS-24885'	36.5	10.52	7.00	2.4	3.92	3.82	1.78	2.55	8.92	9.40	10.30	10.7	5.40	8.75
'IS-24761'	91.5	10.84	5.20	4.0	4.11	3.65	1.70	2.51	4.50	6.37	10.50	9.9	12.35	15.25
'IS-15255'	65.0	5.64	2.30	1.3	3.81	3.77	1.97	2.73	10.75	7.53	10.30	11.1	12.00	16.75
'IS-25359'	81.3	5.52	2.68	1.5	2.67	2.34	1.59	3.07	10.82	6.49	10.90	11.8	9.75	13.10

W = Whole; D= Dehulled

a= Corneousness was measured on a scale of 1-5, where 5 is more corneous and 1 is more floury

Dough quality: Quality of dough was assessed, based on ease of kneading and spreading and water uptake by dough. Maximum water uptake was seen in 'IS 24761' and minimum in 'IS 25359'. Dehulled flour required comparatively less amount of water for making dough in all the varieties of sorghum, except in 'IS 22472' (Table 2). Positive correlation was observed between grain hardness and kneading quality (r=0.6167), corneousness of grains with kneading quality (r=0.6840), rolling quality (r=6309) and sensory score (r=6582). Negative association was observed between swelling capacity of flour, kneading quality (r= -0.6553), and sensory score (r= -0.6484). KOH gel spread showed a significant positive correlation with water uptake (r=0.7604), kneading quality (r-0.7824) and sensory score (r=0.6785). A similar trend was observed in dehulled sorghum flour in spite of reduced water uptake. It indicates that the improvement in the quality of flour, after dehulling, contributes to the quality of *roti* more than water uptake.

Sensory scores: The mean scores for all the organoleptic characteristics, except texture among the national hybrid varieties, were significantly higher for *roti*, prepared from flour of 'NTJ 1' and 'NTJ 2' sorghum varieties. Among the international varieties, maximum scores were for 'IS 24761' and 'M-35-1' and least scores for *rotis* prepared from

TABLE 2. DOUGH CHARACTERISTICS OF 11 SORGHUM CULTIVARS (WHOLE AND DEHULLED)

Varieties	Water uptake, ml		Kneading quality score		Rolling quality, cm		Baking time, min		% moisture loss	
	W	D	W	D	W	D	W	D	W	D
National varieties										
Local	63.0	69.0	2.0	3.0	21.3	33.7	6.0	5.0	22.9	24.7
'N-14'	58.7	57.3	2.0	2.3	20.9	21.8	6.0	5.0	22.3	24.5
'NTJ-1'	55.7	55.3	2.3	2.7	22.4	23.0	7.0	6.0	25.2	30.0
'NTJ-2'	63.0	54.7	2.3	2.0	22.8	22.0	6.0	5.0	25.2	25.1
International varieties										
'm-35-1'	57.3	53.3	3.0	3.0	24.1	23.1	5.0	7.0	21.7	35.0
'IS-24729'	56.0	51.7	2.3	2.3	21.6	21.9	6.0	7.0	22.0	35.6
'IS-22472'	59.3	60.7	2.3	3.0	23.2	25.5	5.0	6.0	21.9	27.4
'IS-24885'	52.0	50.7	1.0	1.0	17.3	17.3	7.0	7.0	33.3	27.9
'IS-24761'	62.0	51.3	3.0	3.0	24.5	23.8	4.0	7.0	21.6	30.6
'IS-15255'	70.7	58.0	3.0	3.0	22.6	23.9	6.0	6.0	27.5	23.5
'IS-25359	53.7	49.0	1.0	2.0	17.5	27.5	8.0	8.0	28.5	29.1

W = Whole; D = Dehulled

TABLE 3. MEAN SENSORY SCORES FOR *ROTIS* PREPARED WITH DIFFERENT GENOTYPES, WHOLE AND DEHULLED SORGHUM

	Appearance	Colour	Texture	Flavour	Taste	After taste	Overall acceptability
			National varieties				
Local	2.81^{b}	3.13^{b}	4.00^{a}	3.25^{ab}	2.94^{ab}	2.94^{ab}	2.81^{bc}
'N-14'	3.59	3.72^{cd}	3.66^{de}	3.59^{cd}	3.22^{bc}	2.97^{bcd}	3.28^{cd}
'NTJ-1'	4.16^{d}	4.34^{a}	3.31^{abcd}	3.78^{de}	3.72^{cde}	3.53^{defg}	3.81^{efg}
'NTJ-2'	3.97^{cd}	4.91^{de}	3.34^{bcd}	3.84^{de}	3.72^{cde}	3.28^{def}	3.59^{def}
			International varieties				
'M-35-1'	3.63^{c}	3.47^{bc}	3.91^{a}	3.72^{de}	3.19^{bc}	3.19^{de}	3.44^{def}
'IS-24729'	1.75^{a}	1.81^{a}	3.03^{ab}	2.63^{a}	2.56^{a}	2.25^{a}	2.16^{a}
'IS-22472'	3.91^{cd}	3.99^{cdde}	4.03^{a}	4.00^{e}	4.03^{de}	3.75^{efg}	3.97^{gh}
'IS-24885'	3.00^{b}	3.09^{b}	3.38^{cd}	3.50^{cd}	3.50^{cd}	3.03^{cd}	3.38^{de}
'IS-24761'	3.03^{cd}	4.13^{de}	3.31^{bcd}	3.81^{de}	4.00^{de}	3.84^{fg}	3.94^{fgh}
'IS-15255'	1.84^{a}	1.81^{a}	2.88^{a}	2.88^{ab}	2.53^{a}	2.50^{abc}	2.50^{ab}
'IS-25359'	4.24^{d}	4.38^{a}	3.09^{bc}	3.84^{de}	4.13^{e}	3.88^{g}	4.13^{h}
Whole flour	3.43^{a}	3.28^{a}	3.49a	3.49a	3.35^{a}	3.02^{a}	3.20^{a}
Dehulled flour	3.58^{a}	3.63^{a}	3.40^{a}	3.58^{a}	3.52^{a}	3.28^{b}	3.52^{b}

Means carrying different superscripts are significantly different.

'IS-15255' and 'IS-25359' sorghum flour (Table 3).

Since corneousness has significant positive association with grain hardness, KOH gel spread, kneading quality, rolling quality and sensory score, varieties with higher corneousness are more suitable for *roti* preparation. KOH gel spread of flour is an important indicator in identifying varieties suitable for *roti*. Thus, it is possible to identify sorghum varieties suitable for making *roti*, based on certain physical characteristics. Dehulling helps to minimise varietal differences with respect to grain hardness and KOH gel spread, without affecting the rolling, kneading or sensory qualities of *rotis*.

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Studies on Rice and Turkey Meat Blend *Papads*

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Papad, an Indian savoury, was prepared using mixed turkey raw meat and heat treated (50°C/20 min.) turkey meat by blending with rice flour (50:50). The traditional rice *papads* were used as control. There were significant ($P<0.05$) increases in protein and fat contents and decrease in ash content in turkey raw meat and heat-treated turkey meat *papads*, compared to control *papads*. The % yield and % expansion on frying were higher ($P<0.05$) for control *papads*. The acceptability scores were highest for control, followed by heat-treated turkey meat and turkey raw meat *papads*. Histological studies revealed that heat-treated turkey meat made better blend with rice flour in *papad* making, as compared to turkey raw meat.

Keywords : *Papad*, Turkey meat, Rice, Blending pattern, Sensory quality, Proximate composition.

Papad, a low moisture traditional Indian savoury food item (Fig. 1), is consumed either after frying or roasting (Pruthi et al. 1984). It is popular with almost all sections of society. *Papads* are mostly prepared at cottage scale or domestic level and generally made from blackgram (*Phaseolus mungo* L.), greengram (*Phaseolus aureus* Roxb), rice and wheat, either alone or in blends (Shurpalekar and Venkatesh 1975). The shelf-life of these *papads* has been reported to depend upon their moisture content and relative humidity of the storage environment (Balasubrahmanyam et al. 1974). Physico-chemical characteristics of various types of *papads* have been studied by several workers (Shurpalekar et al. 1970; Pruthi et al. 1984; Deepa et al. 1992). Saxena et al (1989) conducted studies on blends of different pulses in preparation of *papads*. Very few or no such preparation exists, in which pulses or some starch have been blended with meat.

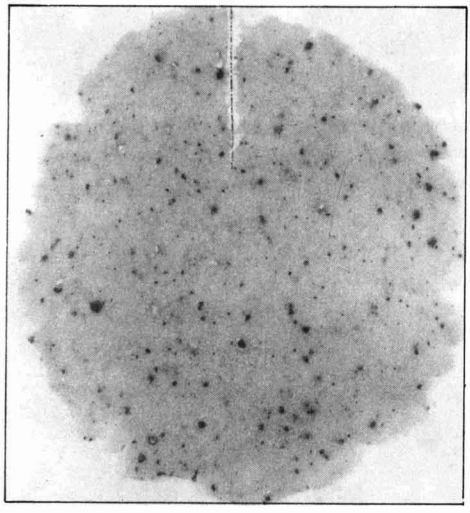

Fig. 1. *Papad*, an Indian savoury

The purpose of the present study was to develop *papads* made from rice and meat blend, to improve the nutritional quality of traditional rice *papads*, which contain lower protein. The protein content of rice is 7.96% (Goyal and Mathews 1985).

Preparation of dough: The dough consisted of 200 g rice flour, 15 g common salt, 2 g sodium bicarbonate and 3.5 g black pepper. This mixture was kneaded using water to prepare dough. Slightly flattened balls with a hole in the centre were made and kept in boiling water for 15-20 min. On removal, the gelatinized dough was blended with turkey minced meat. Two blends were prepared, one from 200 g turkey raw meat and the other with the same amount of heat-treated (50°C/20 min.) turkey meat by adding to the gelatinized dough balls. *Papads* used as control were made from rice dough and spices only.

Rolling papads: Dough (25 g) was hand-rolled into thin film with an approximate thickness of 0.80 mm and a dia of 5.5 cm. Based on the findings of Pruthi et al (1984), they were sun-dried, till the moisture of *papads* dropped below 18%, which indicated the completion of drying. *Papads* were packaged in polythene bags, till fried and evaluated for various quality parameters.

Physico-chemical analysis: All *papad* samples were analyzed for moisture, proteins (N x 6.25), crude fat and ash by the standard AOAC (1984) procedure. Per cent yield and per cent expansion of *papads*, after frying, were calculated, using the formula given by Deepa et al (1992).

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Sensory evaluation: Papads fried in the refined groundnut oil were evaluated for appearance, flavour, crispiness, texture and overall acceptability, using a 9-point Hedonic scale, by a group of 5 semi-trained panelists, drawn from employees of the University.

Histological examination: Papad samples (control, turkey raw meat and heat-treated turkey meat) were processed by routine paraffin embedding. Sections of 4-6 μ thickness were cut and stained with haematoxylin eosine stain (Lune 1968). The stained sections were examined microscopically for the presence of starch, fat and proteins.

Statistical analysis: Data were analyzed, using analysis of variance (ANOVA) technique according to Snedecor and Cochran (1980).

TABLE 1. YIELD, PUFFING CHARACTERISTICS AND PROXIMATE COMPOSITION OF *PAPADS*

n = 17, X ±S.D.

Attribute	Rice:meat blends			
	100:0	50:50*	50:50**	LSD
Unit weight, g	12.78[a]	11.18[a]	11.21[a]	
	±0.02	±0.11	±0.09	2.61
Diameter, cm	5.92[a]	5.33[b]	5.42[b]	
	±0.07	±0.09	±0.18	0.41
Thickness, mm	0.74[a]	0.83[b]	0.79[c]	
	±0.01	±0.01	±0.01	0.04
Yield, %	51.13[a]	44.73[b]	44.52[b]	
	±0.10	±0.41	±0.12	0.84
Expansion, %	19.28[a]	11.11[b]	13.88[b]	
	±0.93	±1.60	±1.59	4.66
Moisture, %	16.28[a]	12.99[b]	12.77[b]	
	±0.31	±0.26	±0.11	0.81
Protein, %	8.99[a]	20.38[b]	20.28[b]	
	±0.35	±0.49	±1.06	2.34
Fat, %	2.30[a]	5.43[b]	5.71[b]	
	±0.20	±0.16	±0.12	0.54
Ash, %	13.86[a]	11.01[b]	11.48[b]	
	±0.16	±0.32	±0.44	1.08
Appearance	8.35[a]	6.20[b]	6.90[b]	
	±0.14	±0.48	±0.33	1.02
Flavour	7.80[a]	6.90[a]	7.70[a]	
	±0.12	±0.26	±0.28	0.69
Crispiness	8.60[a]	6.70[b]	8.20[a]	
	±0.13	±0.37	±0.19	0.75
Texture	8.00[a]	6.80[b]	7.50[a]	
	±0.20	±0.30	±0.14	0.67
Overall	8.50[a]	6.30[b]	7.70[a]	
acceptability	±0.40	±0.56	±0.24	1.06

Means in each row followed by different superscripts are significantly different (P<0.05).

* Turkey raw meat, ** Heat treated turkey meat.

Physical characteristics of papads: *Papads* prepared from rice alone and with meat blends were almost round/circular discs with a dia, ranging from 5.33 to 5.92 cm and thickness from 0.74 to 0.83 mm, well within the specified Indian standards (IS 1972). The average unit weights of these *papads* ranged from 11.21 to 12.78 g. The control *papads* had significantly (P<0.05) higher yield after drying, as compared to meat blend *papads* (Table 1). This was due to higher moisture content of dried control *papads*.

Proximate composition: The moisture content of *papads* ranged from 12.77 to 16.28%, as compared to 15.0% (maximum), recommended by Indian Standards Institution (IS 1972). There were significant (P<0.05) increases in protein and fat contents of turkey raw meat and heat-treated turkey meat *papads* compared to control. The per cent ash content of control *papads* (13.86) was significantly higher, compared to turkey raw meat

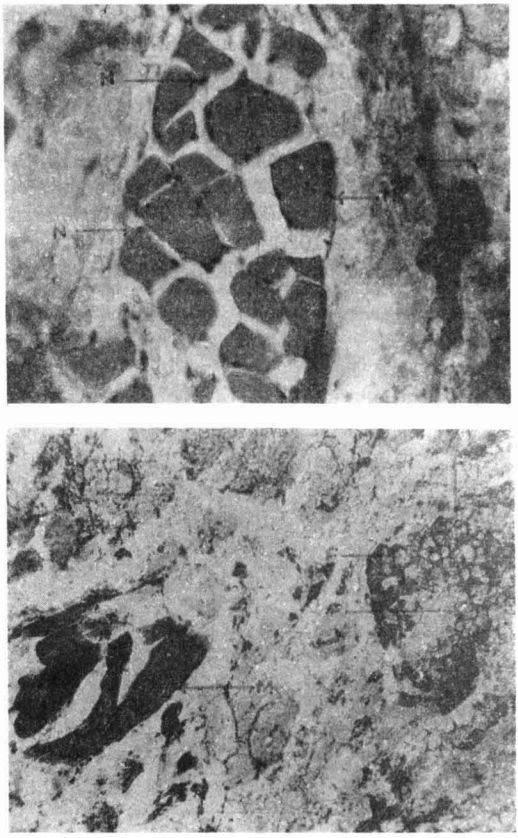

Fig. 2 & 3. Cross section of turkey raw meat *papad* showing starch, protein and fat x 400. N-Nuclei, M-Muscle fibre, S-Starch granules and F-Fat vacoules.

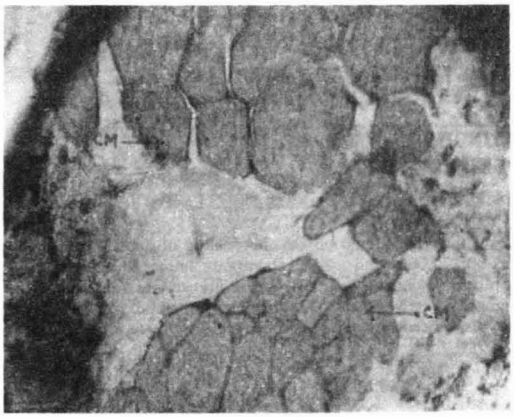

Fig. 4. Cross section of heat treated turkey meat *papad* showing coagulated muscle protein-CM; x 400.

Fig. 5. Cross section of rice *papad* (control) showing starch granules - S; x 200.

(11.01) and heat-treated turkey meat *papads* (11.48), due to blending of meat with rice flour. However, the meat blend *papads* did not differ significantly in proximate composition (Table 1).

Quality assessment: The *papads* showed better expansion (19.28%) after frying, compared to turkey raw meat (11.11%) and heat-treated turkey meat (13.88%) *papads* (Table 1). The control *papads* had significantly ($P<0.05$) better appearance, compared to meat blend *papads*. For other organoleptic parameters, heat-treated turkey meat blended *papads* scored in the desirable range and were similar to control. However, turkey raw meat blended *papads* had significantly ($P<0.05$) lower acceptability, in comparison to heat-treated turkey meat and control (Table 1).

Blending pattern: Blending pattern and distribution of recipe components of *papads* were evaluated histologically. The presence of starch, protein and fat was established. Multiple nuclei (N) at periphery of muscle fibres (M) and fat vacuoles (F), indicating the presence of skeletal muscle and few pinhead granules (s), indicating the presence of starch were observed in turkey raw meat *papads* (Fig. 2 and 3). In heat-treated turkey meat *papads* (Fig. 4), coagulated muscle (CM) protein, absence of peripheral nuclei and fat vacoules clearly indicated the effect of heat treatment. Control *papads* (Fig. 5) exhibited only starch granules.

In conclusion, rice flour can be blended successfully with turkey meat (50:50) in making *papads*. Although papads, blended with turkey raw meat and heat-treated turkey meat did not differ significantly in proximate composition, heat-treated turkey meat blended *papads* had significantly higher sensory scores and better acceptability. Heat-treated turkey meat gave a better blend with rice flour, compared to turkey raw meat.

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Studies on Caustic Peeling of Apples

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Effects of temperature, concentration of NaOH solutions and immersion time on caustic peeling of apples were studied. NaOH solutions of 6, 9, 12 and 15% were heated to 60, 70, 80, and 90°C at various immersion times were used, until more than 98% peeling was achieved. Temperature of caustic solution versus immersion time plot showed a linear trend. Concentration of the caustic solution changed linearly with respect to immersion time. Increase in both temperature and concentration reduced the immersion time needed for efficient peeling.

Keywords : Apple, Mathematical analysis, Caustic peeling.

In apple processing, peeling is an essential step. Various techniques are used for this purpose, such as mechanical, lye, high pressure steam and dry peeling (Setty et al. 1993). Apples are not well adapted to mechanical peeling, due to their irregular shape and cavities. Therefore, either lye peeling or steam peeling procedures are applied. Success of peeling depends on the rapid transfer of heat to the tissues to be peeled for a minimum duration, followed by cessation of heating and rapid cooling (Powers et al. 1977).

Major advantages of lye peeling are lower cost, rapid handling, reduction of loss of fruit and suitability to all shapes, sizes and varieties (Setty et al. 1993).

There are various studies on lye peeling of different fruits and vegetables (Athanasopoulos and Vagias 1987; Rayindirli 1994; Neumann et al. 1978; Powers et al. 1977; Schlimme et al. 1984; Smith et al. 1981; Walter and Schadel 1982). Dipping apples in lye solutions dissolves the peels of fruits and vegetables. The peeling yield depends on temperature and concentration of lye solution as well as immersion time (Setty et al. 1993).

The main objective of this study was to analyze the optimum time-temperature-concentration relations mathematically for caustic peeling of apples.

Apples of 'Amasya' variety were purchased from a local market. The fruits were of medium size and the average weights were in the range of 80-110 g. The apples were pre-washed vigorously to remove any possible waxy coating, dirt and impurities.

NaOH solutions were prepared in four different concentrations; 6%, 9%, 12% and 15%. Experiments were carried out at four different temperatures; 60°C, 70°C, 80°C and 90°C. Solutions were heated to the specified temperature and apples were dipped into them initially for different times. Apples removed from the solutions, were immediately washed in tap water for a minute to determine the extent of peeling. Apples were weighed before and after peeling. For each treatment, two apples were used. The increment in time for each consecutive treatment was studied to determine optimum peeling conditions.

The peeled apples were scored by using the weight loss data. (Bayindili 1994). The limits used were:

(*) : No peeling, <25%
(**) : Bad peeling, 25-50%
(***) : Slight peeling, 50-75%
(****) : Good peeling, 75-98%
(*****) : Excellent peeling, >98%

In the study, to determine the effects of temperature, time and concentration on peeling efficiency, apples, after having been peeled, were scored, depending on their weight loss (Table 1).

The immersion time was found to be inversely proportional with temperature and concentration of NaOH solutions.

Immersion time was determined to be too long at 60°C, compared to other temperatures, which is not desirable. During the experiments, immersion time interval was, therefore, studied at narrow levels to find out the optimum time necessary for efficient peeling. Temperature versus time plot showed a linear trend in the form of equation (1):

$$T = a - bt \qquad (1)$$

where T is the temperature of NaOH solution (°C) and t is immersion time (min).

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TABLE 1. RELATIONSHIP BETWEEN TIME, TEMPERATURE, CONCENTRATION AND PEELING SCORES FOR CAUSTIC PEELING OF APPLES

	Degree of peeling at 60°C			
	NaOH, %			
t (min)	6	9	12	15
2	•	•	•	•
4	•	•	•	•
7	••	••	•••	•••
9	•••	•••	••••	•••••
10	•••	••••	•••••	•••••
12	••••	•••••	•••••	•••••
14	•••••	•••••	•••••	•••••
16	•••••	•••••	•••••	•••••

	Degree of peeling at 70°C			
	NaOH, %			
t (min)	6	9	12	15
1	•	•	•	•
2	•	•	•	•
4	•	•••	•	•••
5	••	•••	•••	••••
6	•••	•••	••••	•••••
7	•••	••••	•••••	•••••
8	••••	•••••	•••••	••••••
9.5	•••••	•••••	•••••	••••••

	Degree of peeling at 80°C			
	NaOH, %			
t (min)	6	9	12	15
1	•	•	•	•
2	•	•	••	••
3	••	••	•••	••••
4	•••	•••	••••	•••••
5	•••	••••	•••••	•••••
6	••••	•••••	•••••	•••••
7	••••	•••••	•••••	•••••

	Degree of peeling a 90°C			
	NaOH, %			
t(min)	6	9	12	15
1	•	•	•	•
2	•	•	••	•••
3	••	•••	••••	•••••
3.5	•••	••••	•••••	•••••
4	••••	•••••	•••••	•••••
4.5	••••	•••••	•••••	•••••
5	•••••	•••••	•••••	•••••

The constants a, b and correlation coefficient are tabulated in Table 2. Data and model equations are shown on the same graph as points and lines, respectively (Fig. 1).

As can be seen in Fig.1, the increase in temperature reduces the time necessary for peeling. To determine the optimum conditions of caustic peeling, first the optimum temperature and then by using this temperature, the optimum concentration was studied. The optimum temperature may be selected as 90°C, since that temperature reduced the peeling time to 4 min for the minimum caustic concentration. However, at this temperature, softening of the tissue occurred, which is unacceptable. Because of this destructive effect, 80°C was selected. After fixing the

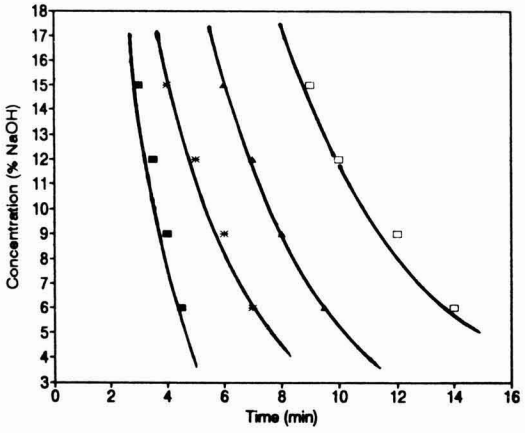

Fig.1. The effect of temperature on immersion time for different concentrations of NaOH solutions (■) : 15%, (▲) : 12%, (✳) : 9% (□) : 6%. Symbols represent the experimental points and the solid lines are based on proposed model.

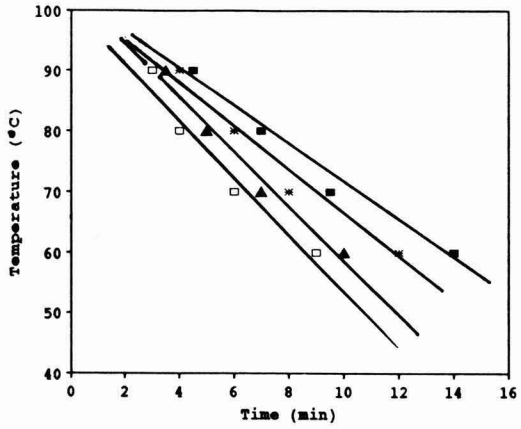

Fig.2. The effect of NaOH concentrations on immersion time for different temperatures (■) : 60°C, (▲) : 70°C, (✳) : 80°C (□) : 90°C. Symbols represent the experimental points and the solid lines are based on proposed model.

TABLE 2. CONSTANTS FOR MODEL EQUATION OF TIME-NAOH CONCENTRATION AND TEMPERATURE

Constants	NaOH concentration, %				Constants	Temperature °C			
	6	9	12	15		60	70	80	90
a	102.54	102.86	103.93	101.19	d	29.95	30.17	27.00	33.00
b	3.15	3.71	4.54	4.76	e	1.73	2.58	3.00	6.00
r^2	0.98	0.97	0.98	0.95	r^2	0.98	0.99	0.99	0.99

temperature to 80°C, optimum concentration can easily be determined. As concentration increases, the immersion time needed for peeling reduces. Since there is a small difference in peeling times and high concentration of NaOH is not desired, 12% NaOH concentration was chosen.

Concentration versus time plot (Fig. 2) showed linear trend in the form of equation (2):

$$c = d - et \quad (2)$$

where c is the concentration of NaOH solution (%) and t is the immersion time (min.).

The constants d and e values evaluated by regression analysis, are shown in Table 2. Correlation coefficient was determined to be quite high.

The peeling yield was evaluated by measuring the weights of apples before and after peeling. It was found that yield was about 86.5%.

In this study, optimum time, concentration and temperature of lye solution were determined for peeling of apples. Both the lye concentration, time and temperature-time relation showed the linear trend. As a result, it was found that for efficient peeling of 'Amasya' apples, 12% concentration and 80°C temperature were optimum.

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Sensory Characteristics of Some Fast Foods Prepared with Cow Milk *Paneer* and Soy *Paneer (Tofu)*

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Four fast foods, i.e., bread rolls, cutlets, burgers and sandwiches, prepared by incorporating milk *paneer* and soy *paneer*, were compared for their protein contents and sensory properties. On dry weight basis, soy *paneer*-incorporated foods contained higher amounts of proteins, than those incorporated with milk *paneer*. Comparative sensory evaluation showed that incorporation of soy *paneer* did not affect sensory characteristics of all the products, except for flavour in bread rolls, after-taste in cutlets and sandwiches. The mean scores for all the sensory attributes ranged between 6.6 and 7.7 on a 9-point Hedonic scale. Addition of mixed spices improved the sensory attributes of *tofu* incorporated foods.

Keywords : *Paneer*, Bread roll, Cutlet, Burger, Sandwich, Sensory quality, Soy *paneer*, Cow milk *paneer*.

Incorporation of soy *paneer* in the formulation of different food products has been investigated by few workers (Vijayalakshmi and Vaidehi 1982; Vaidehi et al. 1985 a, b; Chakrabarti and Gangopadhyay 1990). Commonly, these foods are otherwise incorporated with milk *paneer*/cheese (Jain 1985), which are not only costly, but also in short supply during lean periods of milk production (Meenakshi Rani and Verma 1994). During these periods, soy *paneer*, which is not only cheap, but nutritious also (Johnson 1989), can serve as *paneer* analogue in the preparation of some breakfast foods. Therefore, the present investigation was undertaken to compare the sensory characteristics of some fast foods, i.e., bread rolls, cutlets, burgers and sandwiches, formulated by incorporating soy *paneer* and milk *paneer*.

Soybean seeds of variety 'PK-942' and cow milk, were procured from the Department of Plant Breeding and Livestock Research Centre of the University, respectively. Remaining ingredients, such as refined vegetable oil, potatoes, buns, spices, etc., were purchased from the local market. Soy *paneer* and milk *paneer* were prepared according to the method described by Pant et al (1993).

Four fast foods, i.e., breads rolls, cutlets, burgers and sandwiches, were prepared by incorporating soy *paneer* and milk *paneer*, both with and without the addition of spices and condiments, except for burgers, which consisted of deep-fat-fried *masala* slice of soy *paneer*/milk *paneer* and tomato slices stuffed between two bun halves. The preliminary trials were conducted to optimize the level of soy *paneer*. The criterion for selecting optimum level of soy *paneer* was that the incorporated product should not differ perceptibly from the commonly prepared product. The different food products were prepared according to the recipes presented in Table 1, following the existing processes. All the food products were also analyzed for their moisture and protein contents by using standards methods of AOAC (1984).

Soy *paneer* and milk *paneer*-incorporated products were compared for their sensory attributes by using a trained sensory panel, consisting of 8 members from the faculty of Department of Food Science and Technology, Foods and Nutrition and Plant Breeding. The products were evaluated either during 11.00 to 11.30 AM or 3.0 to 3.30 PM. The panelists were presented with the samples and requested to record their ratings for appearance, colour, body and texture, flavour, after-taste and overall acceptability for all the products, except for burger, on a 9-point Hedonic scale, where 1 represented disliked extremely and 9 represented liked extremely. Burger was not evaluated for three sensory attributes i.e., appearance, colour and body and texture, since it would had been impossible to differentiate between *tofu* and milk *paneer* burgers for these attributes.

The data of the sensory evaluation were analyzed statistically on a CRD, using ANOVA technique (Snedecor and Cochran 1968) for significant differences.

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TABLE 1. INGREDIENTS USED FOR THE PREPARATON OF BREAD ROLLS, CUTLETS, BURGER AND SANDWICHES

Product	Bun/ Bread, No.	Tomato slice, g	Bread crumb pow-dered slices	*Paneer* mashed, g	*Tofu* mash-ed, g	Boiled pot-ato, g	Salt, tea-spoon	Mixture: Onion, g	Ginger, g	Garlic No. of buds	Green chillies, No.	*Garam Masala*, tea-spoon	Oil for frying, tea-spoon
Bread rolls													
Paneer plain	-	-	3	150	-	150	1	-	-	-	-	-	1.0
Tofu plain	-	-	3	-	150	150	1	-	-	-	-	-	1.0
Paneer masala	-	-	3	150	-	150	1	35	8	2	3	1	1.0
Tofu masala	-	-	3	-	150	150	1	35	8	2	3	1	1.0
Cutlet													
Paneer plain	-	-	-	250	-	250	1.5	-	-	-	-	-	1.75
Tofu plain	-	-	-	-	250	250	1.5	-	-	-	-	-	1.75
Paneer masala	-	-	-	250	-	250	1.5	50	10	5	5	-	1.75
Tofu masala	-	-	-	-	250	250	1.5	50	10	5	5	-	1.75
Burger[1]													
Paneer	10	240	-	500	-	500	3	100	20	10	10	-	3.5
Tofu	10	240	-	-	500	500	3	100	20	10	10	-	3.5
Sandwich													
Paneer	20	240	-	600	-	-	1.5	-	-	-	-	-	-
Tofu	20	240	-	-	600	-	1.5	-	-	-	-	-	-

[1]Stuffing mixture was deep -fat- fried.

TABLE 2. MOISTURE, PROTEIN AND MEAN SENSORY SCORE FOR *PANEER* AND *TOFU* INCORPORATED BREAD ROLLS, CUTLETS, BURGERS AND SANDWICHES

Product	Moisture, %	Protein, %		Appearance	Colour	Body and texture	Flavour	After-taste	Overall sensory score
		Wet wt.	Dry wt.						
Bread rolls									
Paneer plain	43.2	11.7	20.6	7.3	7.0	7.3	7.6	7.6	7.6
Tofu plain	49.0	11.4	22.4	7.7	6.9	7.6	6.6	6.9	6.9
Paneer masala	48.0	10.7	20.6	7.1	7.3	7.0	7.3	7.6	7.6
Tofu masala	54.0	10.2	22.2	7.6	7.3	7.7	7.6	7.1	7.6
C.D. at 5%	ND	ND	ND	0.69	0.95	0.92	0.96	0.75	0.73
Cutlets									
Paneer plain	43.1	12.0	21.1	7.1	7.6	7.0	7.7	7.7	7.4
Tofu plain	50.2	11.3	23.1	7.6	7.4	7.2	6.9	6.6	6.7
Paneer masala	49.2	10.6	20.9	6.7	6.6	6.9	7.7	7.6	7.4
Tofu masala	55.2	10.2	22.7	7.2	7.0	7.2	7.5	7.2	7.4
C.D. at 5%	ND	ND	ND	1.06	1.28	1.02	1.02	1.04	1.11
Burgers									
Paneer	53.6	7.5	16.2	ND	ND	ND	7.4	7.2	7.2
Tofu	57.7	7.4	17.4	ND	ND	ND	7.6	7.5	7.6
C.D. at 5%	ND	ND	ND	-	-	-	0.55	0.67	0.66
Sandwiches									
Paneer	49.5	18.8	31.4	ND	ND	ND	7.7	7.4	7.4
Tofu	58.0	13.9	33.1	ND	ND	ND	6.8	6.7	6.8
C.D. at 5%	ND	ND	ND	-	-	-	0.77	0.87	0.78

All values are average of 8 panelists

ND - Not determined

From the results presented in Table 2, it can be seen that, on dry weight basis, all *tofu*-incorporated products contained higher amounts of proteins, than those incorporated with milk.

The results of preliminary trials indicated that *tofu* could replace potatoes by 50% in the preparation of products, without affecting their acceptability. Therefore, 50% level of *tofu* incorporation was considered for all the products.

From the results presented in Table 2, it can be seen that incorporation of *tofu*, as substitute for *paneer* in most of the food products included in this study, did not affect their sensory attributes significantly ($P>0.05$), except for flavour in bread rolls and sandwiches and after-taste in cutlets. It was interesting to observe that some of the sensory attributes scored higher for *tofu*-incorporated products, as compared to milk *paneer*- incorporated

ones. For example, appearance and body and texture of *tofu*- incorporated bread rolls and cutlets scored higher. In case of burger, incorporation of *tofu* resulted in higher scores for all the sensory attributes, i.e., flavour, after-taste and overall acceptability, as compared to milk *paneer* incorporation. Addition of spices to *tofu*-incorporated bread rolls improved all the attributes, except for appearance, non-significantly, whereas in case of cutlets, the appearance and colour were affected adversely. On the other hand, addition to *paneer*-incorporated products exerted an adverse effect on most of the sensory attributes, which were non-significant ($P>0.05$).

From this investigation, it may be concluded that soy *paneer (tofu)* can serve as milk *paneer* analogue in the preparation of some selected foods, without affecting their sensory quality significantly.

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Sand-drying of Paddy Parboiled Under Different Conditions

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Paddy parboiled under different conditions was dried, using sand (30-50 mesh BSS) heated to 100° through 250°C for 0.5 to 4.5 min. Moisture removal was rapid (10-19% wb), causing heavy milling breakage. Though all the grains were fully translucent initially, opaque-spots appeared in some grains after drying. Slow sand drying for avoiding the quality changes may not be viable.

Keywords : Sand-drying, Parboiled rice, Induced opaqueness, Drying parboiled paddy, Different types of parboiled paddy

Although parboiling has been known to heal pre-existing defects, including cracks in paddy, improper drying may bring about undue damage in milling quality (Bhattacharya 1969). Hence, sun-drying (Bhattacharya and Ali 1970) and mechanical drying in LSU dryer (Bhattacharya et al. 1971), RPEC recirculatory dryer (Bal et al. 1976) and cup and cone dryer (Pillaiyar et al. 1981) under commercial practices have been standardized for parboiled paddy. The severity of drying alters the cooking and eating characteristics of parboiled rice to a great extent (Mohandoss and Pillaiyar 1982). High temperature short time (HTST) treatment of moist paddy with sand concurrently parboils and dries the grain quickly. The rapid moisture removal prevents starch retrogradation, causing reduced cooking time of rice (Ali and Bhattacharya 1980). It has been shown that, by altering the temperature of sand, parboiled rices, having distinct quality characteristics, can be produced (Pillaiyar et al. 1994). Since sand medium caused a rapid moisture removal even in a short residence time in the above cases, it was felt as to why drying of conventional parboiled paddy also could not be done, using sand as medium. Hence, a study was undertaken and the quality changes that accompanied are reported in this communication.

Three month-old "Adt 36" (slender) paddy was used for the following parboiling treatments: (a) Normal parboiling - Npb: soaking in 1.5 times hot water (90°C) in a vessel, keeping covered overnight and steaming for 10 min at atmospheric pressure (0 kg/cm²); (b) Short soaking tempering - SST pb: soaking at 70°C for 1 h, draining water, tempering for 8 h and steaming as above (Pillaiyar et al. 1993); (c) Pressure parboiling - Ppb: pre-steaming for 10 min at 0 kg/cm², adding water at room temperature, soaking for 45 min (70-45°C), draining and steaming at 0 kg/cm² for 20 min + 0.352 kg/cm² for 10 min + 0.703 kg/cm² for 20 min + 1.055 kg/cm² for 25 min.

Soon after parboiling, paddy was mixed with hot (100° through 250°C) sand (30-50 mesh BSS) at 1:4 ratio in a laboratory metal pan, heated with ring-gas burner for different durations Table 1). Paddy was separated from sand through 10 mesh (BSS) sieve and finish- dried in shade to millable condition (about 14% wb). In certain cases, after separating the sand, the paddy was transferred to a tightly closed 'iglo' (thermocool) container, held for 2 h and finish- dried in shade. All samples were shelled in a Satake rice machine (type THU, 35A, Satake Engineering Co. Ltd., Japan) and milled in a McGill miller (No. 2, McGill Inc., Houston, Texas, USA) to constant bran removal of 6 ± 0.1% and the brokens segregated, using an indented inclined reciprocating shaker. The moisture content was determined by drying the samples at 105°C in hot air oven, till constant weight and expressed on wet basis (wb). The visual change in brown and milled rice, as a result of drying was noted. The equilibrium moisture content at saturation (EMC-S) of whole milled rice in distilled water for 23 h was determined and expressed on dry basis (db) (Indudhara Swamy et al. 1971). The optimal cooking time (o.t.) of milled rice was determined by double pot excess water method (Bhattacharya and Sowbhagya 1971).

Mixing SSTpb and Ppb samples, having 28.8 and 30.9% moisture, with hot sand, caused an appreciable removal of moisture even in a short residence time (12.7% in 5 min at 100°C; 19.2% in 5 min at 125°C; 20.6% in 2 min at 200°C and 18.8% in 1 min at 250°C in SSTpb; and the moisture removal in Ppb was still higher (Table 1). Such a rapid removal of moisture caused heavy milling breakage. The milling breakage was, however, less at 100°C - drying with a shorter residence time.

All the grains were fully translucent after parboiling. But, opaque spots (similar to insipid

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TABLE 1. EFFECT OF SAND ROASTING OF PARBOILED PADDY ON MOISTURE REDUCTION AND QUALITY CHARACTERISTICS

Type of paddy	Temperature of sand, °C,	Duration of drying, min	Moisture reduction, %	Milling breakage, %	Grains with induced opaqueness, %	EMC-S, % db		Cooking time, min	
						Fully translucent grains	Grains with induced opaqueness	Fully translucent grains	Grains with induced opaqueness
'SST'	-	-	28.8*	0.2	0	71.4	-	33	-
'Pbp'	-	-	30.9*	0.8	0	96.2	-	47	-
'SST'	100	0.5	0.2	0.4	0	71.5	-	40	-
'SST'		1	0.7	2.0	1	72.9	-	40	-
'SST'		2	3.7	5.6	2	82.5	-	40	-
'SST'		3	6.1	6.0	2	86.3	-	38	-
'SST'		5	12.7	24.0	2	131.9	-	36	-
'Ppb'		3	12.1	10.0	4	129.1	-	47	-
'Ppb'		3.5	15.5	32.2	8	140.0	-	45	-
'Ppb'		4.5	16.6	58.5	16	144.3	-	45	-
'SST'	125	3	10.4	38.0	34	160.1	-	41	-
'SST'		5	19.2	46.8	36	171.4	194.9	39	32
'Ppb'		1.5	18.0	29.6	95	-	195.6	-	36
'Ppb'		2	19.3	46.0	95	-	196.8	-	36
'SST'	150	3.0	13.0	46.0	13	170.7	-	38	30
'Ppb'		1	10.0	28.0	24	141.2	-	44	-
'Ppb'		1.5	12.8	48.0	83	-	153.3	-	38
'SST'	200	1	10.6	12.0	38	201.5	-	34	29
'SST'		2	20.6	14.8	44	224.3	278.8	32	28
'Ppb'		1	19.2	24.0	96	-	217.7	-	35
'SST'	250	0.5	13.7	40.0	22	247.4	-	32	26
'SST'		0.75	14.6	41.0	98	-	240.1	-	23
'Ppb'		1	18.8						

* Initial moisture

popping) appeared in many grains after sand drying. This type of visual change in grain might have happened due to rapid moisture expulsion, followed by expansion of cells and hence this change is termed as "induced opaqueness" to differentiate from the normal opaqueness in parboiled grains, due to insufficient parboiling. Though moisture removal was rapid in HTST-parboiling also, induced opaqueness did not generally appear in grains. However, high temperature application did cause induced opaqueness in HTST-parboiled grains (Pillaiyar et al. 1994). Ali and Bhattacharya (1980) noted an increase in EMC-S value with severity of sand-roasting. In this study also, a similar observation was made. The cooking time, which was 47 min for fully translucent kernels, reduced to 23 min for induced-opaque rices (Table 1). While studying the cooking time of rices, Sowbhagya and Ali (1991) observed an appreciable reduction in cooking time for sand-parboiled rices processed at severe conditions.

The milling breakage in the sample, dried at a sand temperature of 100°C for 3 min, was less. The grains having induced opaqueness also were less in this case. Drying at this temperature and duration did not result in substantial moisture reduction (Table 1). A similar result was obtained in drying wet raw paddy in a commercial sand roaster, applying temperatures that did not cause gelatinization of grains (Pillaiyar et al. 1995). In the same study, frequent passes through the roaster were necessitated to reduce the moisture to 14% (wb). Because of this, drying operation using sand roaster tended to be non-viable. The results of the present study also suggest a similar situation.

The beneficial effect of hot tempering the dried parboiled paddy, as noticed by Bhattacharya and Indudhara Swamy (1967), was not felt to the

desired extent in this case, as tempering in thermocool containers resulted in only a marginal reduction in milling breakage (from 48.5 to 35.0%, from 55.0 to 40.0% in cases of 150°-1.5 min and 150°C-2 min sand drying, respectively). However, the EMC-S value was low for the above tempered lots (135.4 and 119.7%, respectively), when compared to the identical lots without tempering (154.7 and 185.8%).

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Incidence and Characteristics of *Bacillus cereus* Isolated from Indian Foods

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A higher incidence of *Bacillus cereus* was recorded in about 300 samples of a variety of food products. The distribution pattern of *B. cereus* was 46% in uncooked rice, 30% in pasteurized milk. 28% in cooked rice, 24% in cooked vegetables, 20% in spices and 12% in raw pulses. A major population of the isolates tested was haemolytic. The antibiogram pattern indicated a higher resistance of isolates against ampicillin, trimethoprim, colistin, rifampicin and nitrofurantoin.

Keywords : *Bacillus cereus*, Indian foods, Incidence, Characteristics, Antibiogram, Cooked foods, Raw foods.

From the many reported food poisoning outbreaks of known bacterial origin from all over the world, *Bacillus cereus* is well established as a significant cause of foodborne illnesses in humans (Goepfert et al. 1972). Strains of *B. cereus* have been reported to cause 2 types of food poisoning, diarrhoeal and emetic, involving a variety of foods, including rice, spices, meat, dried potato, egg, milk, flour and other food products. (Kim and Goepfert 1971; Mortimer and McCann 1974; Raevori et al. 1976; Schiemann 1978; Ahmed et al. 1983; Chung and Sun 1986; Wong et al. 1988). There have been very few reports on the occurrence of *B. cereus* and other *Bacillus* spp in Indian snack and lunch foods (Rakh et al. 1988; Varadaraj et al. 1992). The data from these above reports point out that rice and milk products are the significant vehicles of *B. cereus* foodborne illness. Considering the popularity and wide consumption of rice and milk-based foods in India, the present study was undertaken to survey the incidence of *B. cereus* in a variety of foods from Indian market and their antibiogram pattern.

Samples of cooked and uncooked rice (50 each), spices (75), vegetables (25) and pulses (25) were obtained from local markets and different household communities. Pasteurized milk samples (50) were purchased from local milk scheme. Samples were collected in sterile containers, brought to the laboratory in an ice-box and immediately subjected to analysis.

Ten g each of the samples were blended in sterile 90 ml aliquots of 0.1% peptone water and mixed thoroughly for 30 min at ambient temperature. Appropriate serial dilutions of the samples were surface-inoculated in triplicate on pre-poured plates of mannitol - egg yolk - polymixin B (MYP) agar of Mossel et al (1967). Inoculated plates were incubated at 32°C for 24-48 h. Suspected colonies of *B. cereus*, which appear as dry, rough with irregular margin, pink to purple colour, surrounded with a clear zone of egg yolk precipitate, were isolated at random and maintained at 6°C on nutrient agar slants for further studies.

Isolates were identified by morphological, cultural and biochemical characteristics (Kramer et al. 1982). The morphological tests included appearance of cells, Gram's reaction, motility and presence/position of spores. Isolates were tested for their growth in anaerobic agar, 7% NaCl, at 45, 55 and 65°C and for Voges - Proskauer reaction. The biochemical characteristics included production of catalase and lecithinase; nitrate reduction; citrate utilization; hydrolysis of starch, gelatin and casein; and acid from glucose, mannitol, sucrose, salicin, lactose, xylose, and arabinose, under anaerobic conditions. Haemolysis of sheep erythrocytes was performed, using plates of blood agar containing 5% sheep blood and incubating the plates for 24-72 h. Antibiogram of the isolates was carried out, following the method described by Bauer et al (1966). The antibiotics included were ampicillin, chloramphenicol, streptomycin, trimethoprim, ciprofloxacin, vancomycin, colistin, nitrofurantoin and rifampicin.

In almost all the samples of foods analyzed, there was the occurrence of *B. cereus* (Table 1). The incidence of *B. cereus* contamination was nearly same in all types of food products, highest incidence of contamination being found in rice, pasteurized milk and *dhal* (traditionally cooked pulses). The ranges of the counts of *B. cereus* are also shown in Table 1. The present study revealed that rice, in particular the uncooked type, was frequently

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TABLE I. INCIDENCE OF *B. CEREUS* IN VARIOUS FOOD PRODUCTS

Food sample	Isolates positive for *B. cereus*,		Viable count, cfu/ml or g
	No.	%	
Cooked rice (50)	14	28	$1x10^3$ - $4x10^3$
Uncooked rice (50)	23	46	$2x10^3$ - $3x10^3$
Pasteurized milk (50)	15	30	$6x10^3$ - $2x10^4$
Spices (75)	15	20	$7x10^3$ - $1x10^4$
Raw pulses (25)	3	12	$2x10^3$ - $6x10^3$
Cooked vegetables (25)	6	24	$4x10^3$ - $1x10^4$
Dhal (25)	8	32	$1x10^3$ - $1x10^4$

Figures in parentheses indicate number of samples analyzed.

TABLE 2. ANTIBIOTIC SENSITIVITY OF *B. CEREUS* ISOLATES

Antibiotic	Conc, mcg/disc	Resistant	Sensitive
Ampicillin	10	50	ND
Chloramphenicol	30	ND	50
Streptomycin	10	6	44
Trimethoprim	5	46	4
Cirpofloxacin	5	ND	50
Vancomycin	30	6	44
Colistin	10	43	7
Nitrofurantoin	300	28	22
Rifampicin	05	46	04

ND - Not detected. Total isolates tested were 50 in each case.

contaminated by *B. cereus*. However, isolates of *B. cereus* were not detected in freshly cooked rice. The isolation of these cultures in 6-8 h. stored cooked rice indicates the survival of the spores during cooking and subsequent germination during storage at ambient temperature. Besides, a higher incidence of *B. cereus* was also recorded in samples of pasteurized milk. The level of *B. cereus* incidence, recorded in the food products analyzed, were almost the same, as recorded in several of the earlier studies (Mortimer and McCann 1974; Raevori et al. 1976; Ahmed et al. 1983; Chung and Sun 1986). The higher rates of incidence in *dhal* and cooked vegetable samples clearly point out the heat resistance and survival of *B. cereus* spores, since these food preparations involve higher cooking time- temperature combination, as compared to rice.

The isolates, presumed to be *B. cereus* on primary isolation, were confirmed by morphological, cultural and biochemical characteristics. Sucrose utilization under anaerobic condition by *B. cereus*, which was not reported earlier, was found to be positive among 99% of the isolates. Of the 51 randomly isolates of *B. cereus*, 45 produced β-haemolysis on sheep blood agar. The antibiogram pattern of *B. cereus* isolates is shown in Table 2. Among the isolates, a higher resistance to ampicillin, trimethoprim, colistin, rifampicin and nitrofurantoin was recorded. An antibiogram pattern indicates the effectiveness of antibiotics, if required to be used in any kind of treatment.

The higher incidence of *B. cereus* in a majority of food products has to be viewed with serious concern, as these isolates are known to cause health hazards in human population.

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Prevalence of Enteropathogens of Zoonotic Significance in Meat, Milk and Their Products

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From a total of 205 market samples of meat, milk and their products and 50 milk samples from a cow herd at Bareilly, 19 faecal *Escherichia coli* isolates were obtained, of which 6 belonged to serotypes 0:3, 0:81, 0:82, 0:84, 0:147 and 0:157. Only 3 isolates of *E. coli* were found to be enterotoxigenic, one was of serotype 0:3 and other two were from untyped category. Enterotoxigenic and multiple drug resistant *Morganella morganii* and *Klebsiella pneumoniae* sub-species *aerogenes* strains were isolated from cow milk and *khoa* sweet samples, respectively. Non-enterotoxigenic *K. oxytoca, K. ornitholytica, K. planticola* and *Edwardsiella hoshinae* were isolated from cow milk, *kababs*, sausages and buffalo meat samples, respectively. Samples were devoid of *Salmonella* and *Shigella* strains.

Keywords : Enterotoxigenic *Escherichia coli, Morganella morganii, Klebsiella pneumoniae, Edwadsiella hoshinae*, Meat, Milk, *Escherichia coli* 0:157.

Enteropathogens are the commonest cause of food poisoning outbreaks all over the world (WHO 1975). Among these, *E. coli, Salmonella* and *Shigella* are more important, due to serious epidemic caused by these organisms (Holmes and Gross 1990; Agarwal et al. 1984). *Klebsiella*, an important emerging foodborne as well as nosocomial pathogen with an epidemic potential, has been reported to produce heat labile (LT) and heat stabile (ST) enterotoxins, similar to that by *E. coli* and *Vibrio cholerae* strains (Klipstein and Engert 1977; Singh and Kulshreshtha 1992). *Edwardsiella*, a rare cause of foodborne infection, has been reported to be associated with diarrhoeal illness in human beings (Ewing et al. 1965). Since milk and meat are important sources of animal proteins, the present investigation was undertaken to determine the prevalence of foodborne pathogenic enterobacteria in milk, meat and their products and also to test enterotoxigenicity of bacterial isolates.

Forty each of goat meat, *kababs* and sausages, 45 buffalo meat, 5 salamies and 3 *khoa* sweet samples were collected, from retail outlets in Bareilly, under aseptic conditions in sterile polythene bags and brought to the laboratory immediately in an ice box. A total of 50 cow milk samples from individual animals from an organized dairy and 32 samples (17 buffalo, 15 cow) from pooled milk supplied by milk vendors were also collected and included in the study. All samples were processed for isolation of *E. coli, Salmonella* spp and *Shigella* spp (ICMSF 1978). For isolation of *Edwardsiella* spp, method described by Farmer and McWhorter (1984) was used. To isolate *Klebsiella* spp, aliquots were enriched in *Klebsiella* broth (KB) for 24 h at 37°C. The composition of KB was as follows: Yeast extract 1 g, bile salt 5 g, inositol 10 g, sodium chloride 5 g, phenol red 0.08 g, distilled water 11. (pH 6.8±0.2). It was sterilized by autoclaving at 121°C for 15 min. A loopful of enriched KB broth culture was streaked on to pre-test plates of *Klebsiella* agar (KB with 2% agar). After 24 h incubation at 37°C, specific large, yellow, mucoid colonies were picked up on to triple sugar iron agar slants and identified on the basis of morphological, cultural and biochemical characteristics (Holmes and Gross 1990). For serotyping of *E. coli* (Sojka 1965), isolates were sent to Central Research Institute, Kasauli. Antibiotic sensitivity of all the isolates was tested by using commercially available discs of 10 mcg each of streptomycin, ampicillin, gentamicin, norfloxacin, ciprofloxacin and polymyxin B; 30 mcg each of neomycin, nalidixic acid, chloramphanicol, oxytetracycline, cephalexin, ofloxacin, kanamycin, and doxycycline; 10 IU of penicillin G; 300 mcg of nitrofurantoin and 25 mcg of cotrimoxazole, by disc diffusion method (WHO 1961).

Enterotoxigenicity of all bacterial isolates was tested, using cell free culture filtrate (CFCF), prepared according to the method described by Evans et al (1973). CFCFs were divided into two equal parts. One portion was subjected to heating of 65°C for 30 min, to destroy heat-labile enterotoxigenic factors and stored at 4°C, till further testing by rabbit ileal loop (RIL) test (De and

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TABLE 1. CHARACTERIZATION OF ENTEROTOXIGENIC ENTROBACTERIA ISOLATES FROM MILK AND MEAT PRODUCTS

Bacterial species	isolates, n	Source	Types of enterotoxic factors produced	Enterotoxicity of CFCF in				Antibiotic resistance
				RITL	VPFT	MFPT	SMT	
E. coli 0:3	1	*Kababs*	LT	+	+	+	-	AM, NO, CF, FD, DO,P, T,
E. coli UT	2	Cow milk	LT	+	+	+	-	P, DO, T
Morganella morganii	1	Cow milk	LT	+	+	+	-	AM, FD,PB, P, T, CF
K. pneumoniae Subsp *aerogenes*	1	*Khoa* sweet	ST, LT	+	+	+	+	AM, CO, FD, GM, CH, NO, K, CF

AM : Ampicillin, NO : Norfloxacin, FD : Nitrofurantoin, P : Penicillin GM : Gentamicin, PB : Polymyxin-B, CO : Cotrimoxazole, K :Kanamycin, CH : Chloramphenicol, DO : Doxycycline, T : Tetracycline, CF : Cephalexin, LT : Heat-labile toxin, ST : Heat-stable toxin, CFCF : Cell free culture filtrate, RILT : Rabbit ileal looptest, VPFT : Vasapermeability factor test, MFPT : Mouse foot pad test, SMT : Suckling mouse test.

Chatterjee 1953), vasopermeability factor (VPF) test (Evans et al. 1973), mouse foot pad (MFP) test (Singh and Kulshreshtha 1992) and suckling mouse (SM) test (Dean et al. 1972).

A total of 19 faecal *E. coli* were isolated from buffalo meat (7), *kababs* (1), sausages (3), buffalo milk (2), cow milk (5) and *khoa* sweet (1) samples, of which 6 were found to belong to serotypes 0:3, 0:81, 0:82, 0:84, 0:147 and 0:157. Interestingly, out of 3 enterotoxigenic strains, two belonged to untyped group of *E. coli* isolates and the 3rd one was of 0:3 serotype. Isolation of faecal *E. coli* from 15.5% buffalo meat, 7.5% sausages, 11.7% buffalo milk and 7.7% cow milk samples reflects high prevalence of this potential pathogen. It might be due to contamination of these products either during procurement, processing or adulteration with poor quality contents.

Isolation of *E. coli* 0:3 from *kababs*, a ready-to-eat product, is of public health significance, because this serotype has been reported to be associated with urinary tract infection in human beings (Kapoor 1989). It has also been isolated from fresh water fish in India (Singh and Kulshreshtha 1994). *E. coli* 0:82 and 0:84 were isolated from buffalo milk samples, and the latter has also been reported earlier to be prevalent in milk (Murdia and Gupta 1980). But *E. coli* 0:82 has been isolated for the first time in India and its public health significance is not known yet. Another isolate of concern is *E. coli* 0:147 serotype, isolated from a cow milk sample. This serotype has caused important zoonotic infections in human beings (Dupont 1982) and has commonly been isolated in India from human cases of diarrhoea, fish and pet dogs (Kapoor 1989; Singh et al. 1994). Microbiological examination of sausages yielded *E. coli* 0:157, which has been reported frequently to cause haemorrhagic colitis, enteritis and haemolytic uraemic syndrome in human patients (Rayon et al. 1986). Zoonotic spread of *E. coli* 0:157, through meat of infected animals, is well documented (Holmes and Gross 1990), but in India, it was isolated for the first time during this study.

Of the 11 *K. pneumoniae* sub-species *aerogenes*, isolated from buffalo meat (1), buffalo milk (1), cow milk (8) and *khoa* sweet (1) samples, one produced heat stable as well as heat labile enterotoxin (Table 1). It was interesting to observe that all the milk samples, which yielded *K. pnumoniae* sub-species, were from milk procured from vendors. This could probably be attributed to the practice of adulteration of milk with water of poor quality, as no *Klebsiella* organism could be isolated from milk samples collected directly from udder, under aseptic conditions. Contaminated water has been identified as the chief source of *Klebsiella* earlier (Holmes and Gross 1990). The enterotoxigenic *Klebsiella* strain, isolated from *khoa* sweet samples, was probably associated with the diarrhoeal syndrome among 3 persons, who consumed the same sweet in a departmental tea party. The faecal samples of patients were not available for bacterial isolation and association of *Klebsiella* with diarrhoeal syndrome was established on the basis of retrospective epidemiological investigations (Palmer 1990).

Another significant finding of the study is the demonstration of heat labile enterotoxic effect with RIL, MFP and VPF tests in CFCF of multiple drug resistant *M. morganii*. It has rarely been reported to cause diarrhoea in human beings (Senior 1990). One strain each of non-enterotoxigenic *E. hoshinae*, *K. planticola*, *K. ornitholytica* and *K. oxytoca* were

TABLE 2 . ANTIBIOGRAM (SENSITIVITY) OF ENTEROPATHOGENIC BACTRIAL SPECIES.

Bacterial species	No.of isolates tested	AM	NO	ST	FD	P	N	GM	PB	NA	CO	K	CH	O	DO	Ce	T	CF
		Isolates sensitives, Nos.																
E. coli	19	2	7	9	15	0	19	19	19	19	12	11	9	19	1	19	0	11
K. pneumoniae Subsp *aerogenes*	11	0	6	11	0	0	10	10	11	11	0	11	6	11	5	11	6	4
K. planticola	1	0	1	1	0	0	1	1	1	1	0	1	1	1	1	1	0	1
K. ornitholytica	1	0	0	1	0	0	1	1	1	1	0	1	1	1	0	1	0	1
K. oxytoca	1	0	1	1	0	0	1	1	1	1	0	1	1	1	0	1	0	1
E. hoshinae	1	0	0	0	1	0	1	0	0	1	1	1	1	1	1	1	1	0
M. morganii	1	0	1	1	0	0	1	1	0	1	1	1	0	1	0	1	0	0

AM : Ampicillin, NO : Norfloxacin, FD : Nitrofurantoin, P : Penicillin, GM : Gentamicin, PB : Polymyxin-B, CO : Cotrimoxazole, K : Kanamycin, CH : Chloramphenicol, DO : Doxycycline, T : Tetracycline, CF : Ciphalexin, N : Neomycin, O : Ofloxacin, Ce : Ciprofloxacin, ST : Streptomycin, NA : Nalidixic acid.

isolated from buffalo meat, sausage, *kabab* and cow milk samples, respectively.

Antibiotic sensitivity pattern of all 35 isolates of enterobacteria, isolated in this study (Table 2), revealed multiple drug resistance in most of the isolates, including enterotoxigenic *Klebsiella, K. morganii* and *E. coli* strains, which is of public health significance.

It may be concluded that goat meat, ready-to-eat meats (except sausages) and unadulterated milk were comparatively safer in terms of enteric pathogen carriage than buffalo meat and vendors' milk. The study revealed the need for control over contamination through unhygienic practices, specially in case of milk.

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Effect of Organic Acids and Spices on Quality and Shelf-life of Meats at Ambient Temperature

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Meat cuts (beef, mutton) and chicken carcasses, when sprayed with acetic and lactic acids and the extracts of ginger, garlic and onion, singly or in combination with sodium chloride, extended the shelf-life of meats at ambient temperature (28±2°C). The shelf-life of beef cuts was higher than that of mutton cuts and chicken carcasses. Colour, odour and other sensory parameters of treated meats were acceptable to taste panelists. Beef-*masala*, mutton-*masala* and chicken-*masala* prepared from the meats, treated with lactic acid and ginger extract, were superior with regard to sensory qualities.

Keywords : Organic acids, Spices, Shelf-life, Quality, Different meats.

Organic acid decontamination of meat carcasses has been evaluated with increasing frequency (Dickson and Anderson 1992). Acetic and lactic acids have been shown to control meat borne spoilage and pathogenic organisms (Gordon and Bryan 1992; Syed Ziauddin et al. 1993). Spices are generally used in foods as flavouring and tenderising agents (Ayres et al. 1980) and also they act as preservatives of foods, due to volatile oils and oleoresins (Pruthi 1980). The antimicrobial properties of various spices on foods have been reviewed by Davidson et al (1983). Ginger rhizome has been shown to possess an antioxidant agent prevent lipid oxidation in foods (Lee et al. 1986) and also contain a powerful enzyme, which can be used for tenderizing meat (Thompson et al. 1973; Syed Ziauddin et al. 1992a; Meena and Vijay Sethi 1994). Garlic and onion extracts are also known to have antimicrobial properties, which help in preservation of foods (Krishnamurthy and Sreenivasa Murthy 1956). In the present investigation, an attempt has been made to find out the efficacy of some spices like ginger, garlic and onion and organic acids such as, lactic and acetic acids, in extending the shelf-life and improving the quality of meats of different species at ambient temperature.

Larger cuts of beef and mutton carcasses (4-5 kg of beef and 2-3 kg of mutton) and the dressed chicken carcasses (1-1.5 kg each) were procured soon after slaughter from the local market. Solutions containing 2% acetic (glacial) acid, 2% lactic acid (90%, Merck), 1% acetic acid + 1% lactic acid, 2% acetic acid + 0.25% citric acid + 0.1% acetic acid, 2% lactic acid + 0.25 citric acid + 0.1% ascorbic acid, 1% acetic acid + 1% lactic acid + 0.25% citric acid + 0.1% ascorbic acid, (v/v) were prepared in distilled water. The meat cuts were weighed and sprayed with solutions at the rate of 20 ml per kg of meat. The extracts of local variety ginger, garlic and onions were prepared by blending in a Waring blender for 1-2 min in distilled water (100 g in 100 ml distilled water). The pulpy material, after blending, was squeezed in a muslin cloth to obtain 100% extract. The meats cuts were weighed and sprayed with 100% ginger extract, 100% ginger + 20% sodium chloride (v/v), 100% garlic extract, 100% garlic + 20% sodium chloride, 100% onion extract, 100% onion extract + 20% sodium chloride, a mixture containing equal quantities of 100% ginger + 100% garlic + 100% onion + 20% sodium chloride solution (v/v) and 20% sodium chloride (v/v) solution at the rate of 20 ml per kg meat. The treated meat cuts and chicken carcasses, along with the untreated (control) samples, were hung at ambient temperature (28 ± 2°C) and at a relative humidity of 35-45%. Six replicates were used for each treatment. The shelflife and quality of raw meat were assessed by determining off-odour development as well as change in colour and odour of meat by panelists, as per the method followed by Gill and Penney (1985).The shelf-life period was determined one hour before the onset of off-odours and microbial count of log 7.0 and above/g wt. Microorganisms were enumerated by standard plate count technique (Buchanan and Gibbons 1974) and were expressed as log of colony forming units (cfu) per g sample. Meat products namely beef-*masala*, mutton *masala*, and chicken *masala* were prepared at the end of shelf-life of treated meats, as per the method described by Surjit Malhan (1963). The products were used for sensory evaluation by the taste panelists. The results were analyzed by analysis of variance technique (Steel and Torrie 1980) and Duncan's multiple range test (Duncan 1960).

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TABLE 1. COLOUR, ODOUR AND SHELF-LIFE OF MEATS TREATED WITH DIFFERENT ORGANIC ACIDS AND SPICES

Treatments	Beef			Mutton			Chicken		
	Colour	Odour	Shelflife	Colour	Odour	Shelflife	Colour	Odour	Shelf-life
Organic acids									
2% acetic acid	1.8	1.8	37	1.7	1.8	25	2.5	2.9	22
2% lactic acid	1.7	1.8	36	1.7	1.8	24	2.5	2.5	18
1% acetic acid + 1% lactic acid	1.7	1.5	37	1.7	1.4	25	2.5	2.5	22
2% acetic acid + 0.25% citric acid + 0.1% ascorbic acid	1.2	1.7	40	1.5	1.6	28	2.6	2.2	22
2% lactic acid + 0.25% citric acid + 0.1% ascorbic acid	1.2	1.6	38	1.6	1.7	26	2.5	2.2	20
1% acetic acid + 1% lactic acid + 0.25% citric acid + 0.1% ascorbic acid	1.6	1.8	34	1.6	1.8	22	2.5	2.1	17
Spices									
20% sodium chloride	3.0	3.1	35	3.0	3.2	25	3.2	3.2	18
100% ginger extract	2.9	2.5	32	3.1	3.2	22	3.2	3.1	17
100% ginger extract + 20% sodium chloride	3.0	3.6	36	3.0	3.0	26	3.1	3.0	22
100% garlic extract	2.8	2.9	36	3.2	3.3	26	2.9	3.0	24
100% garlic extract + 20% sodium chloride	2.9	2.7	40	3.2	3.2	30	3.0	3.1	26
100% onion extract	3.0	3.0	33	3.1	3.3	22	3.1	3.1	17
100% onion extract + 20% sodium chloride	2.9	3.0	34	3.0	3.2	23	3.1	3.2	18
Mixture of garlic, ginger, onion and sodium chloride	3.2	3.2	34	3.2	3.3	24	3.2	3.2	19
Untreated (control)	3.1	3.2	30	3.1	3.3	20	3.3	3.3	12

Colour and odour score : 1 : excellent; 2 : very good; 3: good; 4 : acceptable; 5 : unacceptable.

Values are means of six replications,($P<0.05$).

The results presented in Table 1 indicate that the shelf-life for beef was 30 h, mutton 20 h and chicken 12 h at room temperature. Since, beef cuts were larger in size, compared to mutton cuts and chicken carcasses, the shelf-life was more for both control and treated beef cuts. Larger the size of cut, longer was the shelf-life (Syed Ziauddin et al. 1992b). It was observed that meat treated with solution, containing 2% acetic acid + 0.25% citric acid + 0.1% ascorbic acid, had maximum shelf-life for beef (40 h), mutton (28 h) and chicken (22 h), thus extending the shelflife by 10 h for beef, 8 h for mutton and 10 h for chicken carcasses. There was highly significant difference ($P<0.01$) in shelf-life period of different meats with different treatments (Table 1), which is in agreement with the findings of Gill and Penney (1985) and Anderson et al (1992). It was also observed that the colour of meat cuts treated with solutions, containing citric and ascorbic acids, was more acceptable, as compared, to control. This might be due to the action of ascorbic acid, which retained the natural colour of meat for a longer duration. But, acetic acid -treated chicken carcasses showed slight brownish colouration and the carcasses presented cooked appearance. However, no significant ($P<0.05$) change was observed with regard to odour (Table 1). There was a reduction in microbial growth due to antimicrobial effect of organic acids used. In all the cases, the microbial counts enumerated at the start of spoilage, the point at which the meat exhibited off-odours, varied between 7.0 and 8.0 log cfu/g meat (Table 2).

With regard to spices, the shelflife extended at ambient temperature in meats treated with garlic, ginger and onion extracts (Table 1). Garlic

TABLE 2. MICROBIAL COUNT (LOG cfu/g) IN MEAT TREATED WITH ORGANIC ACIDS AND SPICES AND STORED AT 28±2°C (RH 35-45%)

	Beef			Mutton			Chicken		
Organic acids									
2% acetic acid	0	12	38	0	12	26	0	12	23
	(4.4)	(3.5)	(7.8)	1.7	1.8	25	2.5	2.9	22
2% lactic acid	0	12	37	0	12	25	0	12	19
	(4.6)	(3.5)	(7.6)	(4.2)	(3.1)	(7.8)	(3.6)	(3.2)	(7.3)
1% acetic acid	0	12	38	0	12	26	0	12	23
+ 1% lactic acid	(4.1)	(3.6)	(7.8)	(4.5)	(3.5)	(7.9)	(3.5)	(3.0)	(7.6)
2% acetic acid	0	12	41	0	12	29	0	12	23
+ 0.25%	(4.4)	(3.2)	(7.6)	(4.5)	(3.5)	(7.8)	(3.1)	(2.8)	(7.4)
citric acid +									
0.1% ascorbic acid									
2% lactic acid	0	12	39	0	12	27	0	12	21
+ 0.25% citric acid	(4.6)	(3.2)	(7.4)	(5.0)	(4.1)	(7.9)	(3.0)	(2.7)	(7.2)
+ 0.1% ascorbic acid									
1% acetic acid	0	12	35	0	12	23	0	12	18
+ 1% lactic acid	(5.1)	(4.2)	(7.8)	(4.8)	(3.6)	(8.0)	(3.0)	(2.5)	(7.4)
+ 0.25% citric acid									
+ 0.1% ascorbic acid									
Spices									
	0	8	36	0	8	26	0	8	19
20% sodium chloride	(4.8)	(4.3)	(7.8)	(4.2)	(4.0)	(7.8)	(3.2)	(3.0)	(7.7)
100% ginger	0	8	33	0	8	23	0	8	18
extract	(4.1)	(4.0)	(7.6)	(4.0)	(3.8)	(8.2)	(3.1)	(3.0)	(7.9)
100% ginger	0	8	37	0	8	27	0	8	23
extract	(4.3)	(3.9)	(7.5)	(4.1)	(3.8)	(8.1)	(3.2)	(3.0)	(7.0)
+ 20% sodium chloride									
100% ginger	0	8	37	0	8	27	0	8	25
extract	(4.5)	(4.4)	(7.5)	(4.4)	(3.9)	(7.9)	(3.3)	(3.1)	(8.5)
100% garlic extract	0	8	31	0	8	31	0	8	37
+ 20% sodium chloride	(4.6)	(4.0)	(7.6)	(4.5)	(4.0)	(7.8)	(3.5)	(3.1)	(7.6)
100% onion extract	0	8	34	0	8	23	0	8	18
	(4.6)	(4.3)	(7.9)	(4.0)	(4.0)	(7.8)	(3.1)	(3.0)	(7.8)
100% onion extract +	0	8	35	0	8	24	0	8	19
20% sodium chloride	(4.2)	(4.0)	(8.2)	(3.8)	(3.5)	(7.9)	(2.8)	(2.6)	(7.8)
Mixture of ginger + garlic +	0	8	35	0	8	25	0	8	20
onion + sodium chloride	(4.4)	(4.1)	(7.9)	(4.1)	(3.8)	(8.0)	(3.0)	(3.0)	(8.3)
Untreated (control)	0	8	31	0	8	21	0	8	13
	(4.5)	(6.1)	(8.0)	(4.1)	(5.2)	(7.9)	(3.6)	(3.4)	(8.2)

Values are mean of six replications, ($P<0.05$).

appears to possess higher antimicrobial activity, compared to ginger and onion, as evidenced by longer shelf-life in meats (Beef 40 h, mutton 30 h, chicken 26 h). Larger the size of meat cuts, longer was the shelf-life in both control and treated meat. Gill and Penney (1985) also made similar observation It was observed that all the treated meat samples were acceptable. However, meats treated with ginger extract were more acceptable, compared to garlic and onion-treated meats, with regard to odour of uncooked meats. The microbial growth in the meats, treated with different spices was slightly reduced at 8 h storage and the microbial count at the start of spoilage, the point at which the meat exhibited off-odours varied between 7.5 and 8.5 log cfu/g meat (Table 1).

Sensory scores of beef-*masala*, mutton-*masala* and chicken-*masala*, prepared from the treated meats, are presented in Table 3. Chicken-*masala* was more acceptable to taste panelists, compared to beef and mutton-*masalas*, with regard to flavour, juiciness, texture and overall acceptability of the products. Among the different treatments, the meats treated with lactic acid and ginger extract

TABLE 3. SENSORY SCORES OF MEAT PRODUCTS TREATED WITH DIFFERENT ORGANIC ACIDS AND SPICES

Type of product	Colour		Flavour		Juiciness		Texture		Overall quality	
	A	B	A	B	A	B	A	B	A	B
					Organic acids					
Beaf-*masala*	6.6	6.1	6.8	6.6	6.9	6.2	7.2	6.1	7.6	6.0
Mutton-*masala*	6.8	5.4	6.6	6.3	7.2	5.4	7.3	5.1	7.5	5.8
Chicken-*masala*	7.0	6.7	7.2	7.0	8.9	8.0	8.4	7.3	8.6	8.2
					Spices					
	C	D	C	D	C	D	C	D	C	D
Beef-*masala*	6.2	6.9	6.8	7.2	5.9	6.3	6.1	7.1	6.5	7.2
Mutton-*masala*	5.4	6.8	6.2	6.6	5.4	7.2	5.1	7.2	5.9	7.5
Chicken-*masala*	6.7	7.0	7.0	7.2	8.0	8.1	7.3	8.4	8.2	8.6

Score: 10 point Hedonic scale, A : treated with 2% lactic acid + 0.25% citric acid + 0.1% ascorbic acid; B : treated with 2% acetic acid + 0.25% citric acid + 0.1% ascorbic acid; C ; meat treated with 100% garlic extract + 20% sodium chloride; D : treated with 100% ginger extract + 20% sodium chloride. Values are mean of 6 replications ($P<0.05$).

were superior, compared to meats treated with acetic acid and garlic and onion extracts, as lactic acid rendered the meat more tender and juicy, besides extending the shelf-life of meat (Smulders et al. 1986) Similarly, ginger extract caused tenderization of meat, which was attributed to the proteolytic enzyme present in ginger, as observed by Lee et al (1986). This study has indicated that organic acids, such as lactic and acetic acids and spices, like ginger, garlic and onion, possess antimicrobial properties, control the microbial spoilage of meat and can be used for preservation of meat at ambient temperature (28±2°C).

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Effect of Sprouting, Cooking and Dehulling on Polyphenols of Redgram (*Cajanus cajan.* L.)

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Polypheonolic content of redgram was determined after subjecting it to sprouting, cooking and dehulling. All these methods of processing helped in reducing the levels of polyphenols.

Keywords : Redgram, Polyphenols, Processing, Sprouting, Cooking, Dehulling.

Redgram has occupied an important place in human nutrition as a rich source of proteins in the diets of a majority of population in India. It is a valuable source of minerals and vitamins and occupies a very important place in human nutrition in many developing countries. However, it is known to contain many antinutritional factors including polyphenols, which are generally located in the seedcoat of pigmented cultivars of redgram (Singh 1988). The polyphenols decrease the digestibility of proteins and carbohydrates, as a result of formation of insoluble enzyme-resistant complexes. Other antinutritional effects, which have been attributed to these polyphenols, include damage to the intestinal tract, lowered feed efficiency and growth depression in animals (Reddy et al. 1985). Redgram is consumed by a large number of people in Gulbarga district, Karnataka State, India without any harmful effects. This indicated that deleterious and antinutritional effects were partly or wholly removed by processing. The present study was aimed at devising simple and inexpensive methods, which can be adapted at the home level to reduce the levels of polyphenols in redgram.

Redgram seeds of three local cultivars viz., 'DMPT-GC7-133-1', 'DMPT-GC-94' and 'GC7-133-1' were procurred from Pulse Research Station, Gulbarga. All chemicals used were of analytical grade.

Sprouting of seeds : The seeds were surface-sterilized by treating with 0.1% mercuric chloride for 30 min. The sterilized seeds were washed and soaked in water overnight at 4°C. The soaked seeds were placed on moist filter paper in petri plates and incubated at 37°C in the dark. The seeds were moistened with distilled water at regular intervals. The sprouted seeds were harvested at 24 h intervals.

Cooking of seeds : The raw and soaked seeds were cooked in open pan for various time intervals.

Dehulling of seeds: The seeds were washed and soaked overnight at 4°C and the seed coats were removed physically. Raw,sprouted, cooked and dehulled seeds were assayed for polyphenol content by Folin-Denis method (1915).

Table 1 presents results on the effect of sprouting on polyphenols of redgram. A decrease was observed in all the three varieties tested. There was a complete loss of polyphenols in varieties 'DMPT-GCT-133-1,-GC7-133-1', 'DMPT-GC-94' and 'GC-133-1', when they were sprouted for 96, 48 and 72 h, respectively. This observation is in comformity with results obtained by Rao and Deosthale (1982), who have reported loss of polyphenols both in redgram and *Bengal*gram as a result of sprouting. Similarly, Baber et al (1988) have observed 37% loss in polyphenols, when jackbean *(Psophocarpus tetragonolobus)* was sprouted. This loss of polyphenols during sprouting may be attributed to the presence of polyphenol oxidase and enzymatic hydrolysis. Some of the losses may also be expected from leaching of these polyphenols into the water (Rao and Deosthale 1982).

Table 2 presents data on the effect of cooking on polyphenols of redgram. A gradual loss was observed, when the time of cooking was increased from 10 to 120 min. However, the loss was more if the seeds were soaked prior to cooking. Rao and Deosthale (1982) have reported that cooking without prior soaking brought about 70% loss in polyphenols of redgram and *Bengal*gram. Baber et al (1988) have reported that when the dry seeds of jackbean were cooked for 60 min, there was 60% loss in polyphenols. However, there was nearly a complete loss in the polyphenols, when the seeds were soaked prior to cooking. Several authors have suggested that the apparent decrease in polyphenols

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TABLE 1. EFFECT OF SPROUTING ON POLYPHENOLS OF REDGRAM *(CAJANUS CAJAN,L)*

Sprouting time, hrs	Polyphenols mg/g		
	DMPT-GC7-133-1'	DMPT-GC-94'	GC7-133-1'
Raw seeds	2.72 ± 1.9	1.55 ± 2.6	1.80 ± 0.5
24	0.87 ± 1.0	0.55 ± 1.0	0.70 ± 0.25
48	0.65 ± 2.5	ND	ND
72	0.35 ± 0.5	ND	ND

Each value is an average of triplicate determiation

ND - Not detected

during cooking is most likely not due to an actual decrease in polyphenols, but to a change in their solubility or chemical reactivity (Expenyong 1985; Ayyagari et al. 1989). Thus, the observed decrease may be due to binding of polyphenols with other organic substances and proteins, or from alterations in the chemical structure of polyphenols, that cannot be determined by available chemical methods (Reddy et al. 1985).

Results on the effect of dehulling on polyphenols of redgram are presented in Table 3. A decrease in polyphenols was observed in all the varieties tested, as a result of dehulling. This suggests the presence of polyphenols in seed coat, and the same is supported by Deshpande et al (1982,1983).

In conclusion, it may be stated that sprouting, cooking, and dehulling, which are the most simple and inexpensive methods can be practised at home level to reduce the polyphenolic content of redgram.

TABLE 2. EFFECT OF COOKING ON POLYPHENOLS OF REDGRAM *(CAJANUS CAJAN,L)*

Cooking time, min	'DMPT-GC7-133-1'		'DMPT-GC-94'	
	Cooking	Soaking and cooking	Cooking	Soaking and cooking
Untreated	2.72 ± 1.9	2.72 ± 1.9	1.55 ± 2.6	1.50 ± 2.6
10	2.50 ± 0.3	0.87 ± 0.4	1.02 ± 0.2	0.70 ± 0.5
20	2.20 ± 0.7	0.77 ± 2.0	0.87 ± 2.0	0.35 ± 0.4
30	1.85 ± 2.4	0.72 ± 2.0	0.72 ± 2.5	0.20 ± 0.1
40	1.25 ± 1.0	0.40 ± 4.5	0.42 ± 0.2	ND
50	1.10 ± 0.6	0.25 ± 2.5	0.27 ± 0.1	ND
60	0.57 ± 0.5	ND	0.22 ± 0.3	ND
90	0.35 ± 1.2	ND	ND	ND
120	ND	ND	ND	ND

Each value is an average of triplicate determination

ND - Not detected

TABLE 3. EFFECT OF DEHULLING ON POLYPHENOLS OF REDGRAM *(CAJANUS CAJAN, L)*

Name of the variety	Polyphenols mg/g	
	Before removing seed coat	After removing seed coat
DMPT-GC-94	1.55 ± 2.6	0.97 ± 0.2
'GPC-133'	1.20 ± 0.1	0.72 ± 0.1
'F2-Perrinial ICPL-63'	1.02 ± 0.5	0.67 ± 0.4
'GPC-ICPL-87067'	1.22 ± 2.0	0.47 ± 0.6
'DMPT-GC-11-54-2'	2.60 ± 0.6	1.10 ± 0.6
'DMPT-GC7-133-1'	2.72 ± 0.2	0.82 ± 0.7
'GPC-PDIX-BDM-1'	1.65 ± 0.6	0.70 ± 0.8
'GC7-133-1'	1.80 ± 1.0	0.62 ± 0.8

Each value is an average of triplicate determinations

Acknowledgment

S. Paramjyothi is thankful to Gulbarga University for the financial support for carrying out this work.

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FOOD SCIENCE: Edited by Norman N. Potter, and Joseph H. Hotchkiss: 5th Edition; Published by Chapman & Hall, 115, Fifth Avenue, New York, NY 10003, 1995, pp. 608, Price: £ 39,00

This book under review is the 5th edition of food science and written by the same authors, who edited the 4th edition as well. The first edition was published nearly thirty years ago. Subsequently, three editions have been published and they have accepted worldwide as an introductory text for curriculum in food science and technology. This has inspired the authors to update with latest information and also to provide more advanced and specialised knowledge in the subject, keeping the base format and objectives of the previous editions. This book highlights the broad and complex inter-relationships on food ingredients, processing, packaging, distribution and exploring, how these factors influence food quality and safety. The important aspects like biotechnology, food safety, environmental issues, and supercritical fluid extraction have been given prominence with latest information. In addition, government regulations, globalisation of foods and new processing technologies have been incorporated.

There are 25 chapters in this book. The first four chapters deal with introduction to food science, characteristics of the food industry, constituents of foods, their properties and significance and the nutritive aspects of food constituents. Chapters 5 to 11 deal with the salient features of unit operations in food processing, quality factors in foods, food deterioration and its control including principles of food preservation like processing by heat, cold, dehydration, concentration, irradiation, microwave and ohmic principles. Chapter 12 deals with fermentation and other uses of microorganisms including genetic engineering. From chapters 13 to 20, preparation and processing of individual products like milk and milk products, meat, poultry and eggs, seafoods, fats, oils and related products, cereals, grains, and legumes, fruits and vegetables, alcoholic and non-alcoholic beverages, confectionery and chocolate products have been discussed in detail with updated information. Chapter 21 deals with the principles of food packaging, highlighting types of containers, food packaging materials and forms, package testing, packages with special features, safety of food packaging and environmental considerations.

Chapter 22 deals with food processing and the environment like properties and requirements of processing water, properties of waste water and solids and their treatment. Chapter 23 covers food safety, risks and food related hazards. This also includes microbiological considerations in food safety, effects of processing and storage, on microbiological safety, microbiological methodology, HACCP as a method to prevent food borne illness and chemical hazards associated with foods. Chapter 24 deals with a very important aspect on governmental regulation of food and nutritional labelling. This includes food, drug and cosmetic act, additional food laws, legal categories of food substances and testing for safety. International food standards and codex alimentarius, which serves as a reference guide have also been incorporated. In the last chapter, the general problem related to nature of nutrition, approaches to combat world hunger and the role of technology in this direction are discussed.

The book provides an introductory foundation on food science and technology, which helps to build advanced and specialized knowledge. The book will be very useful to even those who do not have much knowledge in food science and technology. It will also serve as a reference guide for research scientists, students of food technology and the industries dealing with food science, technology and processing. On the whole, the book is well presented with number of tables, figures and good photographs, providing valuable information, and therefore, recommended as a valuable addition to the libraries in universities and research organisations.

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FOOD SAFETY 1995 - Prepared by Carol E. Steinhart, M. Ellin Doyle and Barbara A. Cochrane, Food Research Institute, Department of Food Microbiology and Toxicology, University of Wisconsin-Madison, Madison, Wisconsin; Published by Marcel Dekker, Inc., 270, Madison Avenue, New York, NY 10016, 1995 pp. 609, Price not mentioned.

"Food Safety 1995" a continuation of a series first prepared in 1993 by Carol E. Steinhart, M. Ellin Doyle and Barbara A. Cochrane of the Food Research Institute, University of Wisconsin-Madison

is a summary of the literature on food safety and food-borne illness, published during the later half of 1993 and the first half of 1994.

This hard bound book of 609 pages is divided into 12 major chapters, which are grouped into three parts. The first part is on "Diet and Health"; the second on "Safety of Food Components" and the third on :"Food-borne Microbial Illnesses".

Part I on "Diet and health" begins with a reference to an interesting theory on hominid evolution. Our pursuit of foods ever low in fibre (the driving force in our evolution) is now causing us grief, for it has led to the "scourge of diseases of affluence". This part, thus, covers research developments in the areas of diet in relationship to cancer and cardiovascular disease in depth and to a lesser degree on other systems of the human body. For the reader interested in the hot topic of today, "vegetarianism", there are 7 references, one of which is the Proceedings of a Symposium held on the subject in Arlington, USA in 1992. Judging by the references cited, opinions on the essentiality of n-3 fatty acids in human diet seem unequivocal, but the last word does not seem to have been said about the links between cholesterol and coronary risks or for that matter between dietary fibre intake and good health. References are also made of the increasing evidence of oxidant-antioxidant balance of the body, which is responsible for disease or health, depending on which predominates. A passing reference to the possibility of substances like phytic acid, lectins, tannins, amylase inhibitors and other so-called "antinutritionals" taking centre stage in the coming years due to their association with reduced cancer risks is also made. "Nutraceuticals" (substances that can neither be classified as drugs or as foods) are the subject of debate in the Food and Drugs Administration, USA, which is in the process of making guidelines for the labelling and regulation of these "health foods"; which must remind us as to whether we should not be doing something about our own plethora of "health foods". Developments in the areas of Biosensors, Biomarkers and Diet assessments are covered in the last chapter of Part I. For the reader requiring more information on Biosensors, the compilers strongly recommend "Food Biosensor Analysis" by Wagner, G. and Griffith G.G. (eds) 1994, Food Science and Technology, A series of Monographs, Textbooks and Reference Books, Vol. 60. Marcel Dekker, Inc. New York.

The chapters on 'Assessment of food safety', 'Intentional (Direct) additives', 'Indirect additives', 'Residues and contaminants', Naturally occurring toxicants and food constituents of toxicological interests' form Part II of this book. In the opinion of the compilers of this book, three recently published book series, "Target Organ Toxicology Series (1994)"; "Handbook of Natural Toxins (1992)" and "Food Science and Technology, A Series of Monographs, Textbooks and Reference Books Vol. 60, 1994" (Please see references 1, 2 and 3 on page 213 of this book) must be referred to by the reader interested in the subject of assessment of food components for their safety. Some of the important references cited in this book deal with the general design of toxicity assays and mutagenicity/ carcinogenicity testing for Human Risk Assessment of food components. Current literature on all classes of additives (direct); indirect additives and contaminants (like antimicrobial drugs, pesticides, packaging materials, heavy metals, radionuclides etc.) cover new findings on toxicity and new developments in their detection. Reference is also made to the growing concern of the general public in favour of "organic" and not "commercial" foods; to the paradox in the application of the Delaney clause to pesticide residues in foods; to the environmental contamination of radionuclides with special reference to the aftermath of the Chernobyl incident; to the important symposia that were held like the one on the subject of "Migration in food packaging plastics" to the "Coffee workshop". Research developments in the area of food allergy and food intolerance have also been covered in 45 recent references.

In the words of the reviewer of "Food Safety 1993", "no factual presentation on food safety is ever complete without including information on foodborne illness of microbial origin". Thus, Part III of this book is rightfully on 'Foodborne microbial Illness' which includes three chapters on 'Mycotoxins', 'Bacterial Intoxication' and 'Infections and parasitic infections' and also an Appendix on 'Food and water associated viruses' contributed by Dr. Dean O. Cliver of the same institute. The chapter on 'mycotoxins' has 232 references on the toxins of, mainly three genera of Fungi-*Aspergillus*, *Fusarium* and *Pencillium* and a few of others. Emphasis now seems to being increasingly paid to *Fusarium* toxins, particularly fulminasions. Recent research activities on all areas of mycotoxin research, be it epidemiology, biosynthesis, their occurrence, their detection and determination, metabolism, biological, molecular or genetic effects are conveniently presented to the reader. The bacterial

pathogens make up the larger chapter of Part III of the book with a whopping 1015 references. Important information on the epidemiology, occurrence, toxins produced, detection, identification and control of not only the familiar pathogens like *Staphylococcus, Clostridium, Bacillus, Vibrio, Shigella, Salmonella* and *E. coli*, but also of the lesser known pathogens - *Yersinia, Aeromonas, Campylobacter, Listeria* and others is presented to the delight of the food microbiologist. Keeping in mind that "thorough approach to quality assurance is not a bureaucratic exercise but a prescription for success: recent information on the concept of Hazard Analysis at Critical Control Points (HACCP) and 'Predictive modelling' is also given. Research developments on food preservation through irradiation and use of bacteriocins of the lactic acid bacteria are also presented. Information on food-borne parasitic infections caused by protozoa and helminths is presented with 32 references. Special mention is made of *Cryptosporidium* which is resistant to normal levels of chlorination. The year 1994 is thought of as an exceptional year in food virology, since a new three volume compilation of foodborne diseases includes 8 chapter concerning viruses.

Scientific research in all aspects of food safety (as in other areas) is taking place by leaps and bounds and so even the most meticulous researcher often finds his/her knowledge outdated. This book is an answer to this problem. Dealing with the various aspects of food safety independently and citing their references after the respective chapters and the provision of a subject index makes it very easy to update our knowledge on the new developments. Thus, the book gives an exhaustive survey of references from Journals covered by the "Life sciences and agriculture, biology and environmental sciences" editions of Current Contents.

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EVALUATION OF SEAFOOD FRESHNESS QUALITY: Edited by J.R. Botta, Published by VCH Publishers Inc., 220 East 23rd Street, New York, NY, 10010, USA, 1995, pp. 180. Price DM 138/-.

The book is very well brought out under Food Science and Technology series. Bibliographical references are included. More than half the book is on sensory quality, which is understandable, as "Freshness" can be directly evaluated only by sensory perceptions, whereas all the other methods provide only indirect indices. This useful publication provides an overview of different methods and their critical assessment for seafood purchasers and processors.

Freshness quality is neither a distinct object nor a specified actuality. It is a concept. The specific meaning of seafood freshness quality depends on buyer or user. It is first of all important to clearly define freshness quality and then think of measuring it. The major channels for measuring freshness quality are chemical, physical and sensory. The author has dealt with all the methods effectively with a critical appraisal of the advantages and disadvantages of each method.

Chapter I has been devoted to define freshness quality taking into account the various ideas from literature. Chapter 2 provides a critical appraisal of the chemical methods, which are only indirect indices of freshness. The tests have been dealt with under three heads: The first one comprising tests for determination or estimation of chemicals that are related to freshness quality. Under this group, determination of TVB-N, TMA, DMA and formaldehyde have been clearly explained along with the advantages and disadvantages of each test, followed by interpretation with respect to freshness quality.

The second group of tests is based on post-mortem nucleotide degradation products that occur in fish. The degradation of ATP into IMP and subsequently to hypoxanthine and the effect on freshness quality of dead fish over a period of storage have been considered in detail for various species.

The third set of tests is expected to provide information on oxidative rancidity. The estimators used for the purpose are anisidine value, peroxide value, TBA, malonaldehyde content, totox value and rapid head space analysis. Rightly, the point is brought home that the tests are product-specific and objective- oriented.

Chapter 3 deals with physical methods of evaluation of freshness quality viz., the colour, appearance and texture, using colour and texture measuring systems. Physical methods consist of measuring the magnitude of the physical parameter being assessed. The most commonly used instruments are the colour measuring systems. The book quotes the various types of end use, which the instruments can generate.

Chapters 4 and 5 deal with sensory analysis methods. Freshness quality grading is dealt with under chapter 4. The necessity of developing descriptors for valid grading, the importance of grading for the buyers and sellers have been explained. The importance of assessing the validity of the grades through critical reviews have been stressed. It has been confirmed that a realistic and accurate determination of the product freshness quality can be done only through sensory analysis. It has been shown that the procedure can easily be adopted beneficially for field use.

The last chapter No. 5, deals with attribute identification and assessment under which the quantification of the intensity of specific sensory attributes, which have direct bearing on the ultimate product quality have to be carried out. The laboratory set-up, screening, selection, training and performance of panelists and the various errors that may occur during the evaluation have been adequately explained. Methods of scaling from category/interval scales to free choice profiling, QDA and magnitudes have been documented with apt examples.

The book also deals with appropriate related topics like sampling methods, number of samples to be evaluated, method of handling collected samples, conditions of storage, preparation methods to be followed, which do not substantially affect the freshness quality, specific methods to be used for stipulated analysis critically chosen to reflect freshness quality, precision and accuracy of the methods, use of valid statistical procedures for data analysis and interpretation of the results.

Overall, it is a good publication which should find a place in all libraries dealing with quality of sea foods.

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FOOD ENZYMES - STRUCTURE AND MECHANISMS: Edited by Dominic W.S. Wong, Chapman and Hall, 2-6, Boundary Road, London SEI 8HN, UK 1995, pp. 390. Price: UK £ 69.00.

Dominic, W.S. Wong's "Food enzymes - Structure and mechanism" is an excellent treatise on structure function relationship of a wide range of hydrolases, oxido-reductases and an isomerase, the xylose isomerase, all of which are of considerable importance to the food industry.

It is in the area of food processing that enzymes have had the greatest impact in terms of the range and volume of their applications. The detergent industry is perhaps the only other enterprise, wherein a single enzyme, the bacterial protease is being exploited to a very significant extent. Enzymes have been in use even before Summer's (1926) time that marked the beginning of scientific knowledge of enzymes, in bread leavening, food fermentations, fibre retting and several others known to various ethnic communities all over the world. However, the advancements in enzymology during the past fifty years or so have enlarged the scope of applications of enzymes tremendously, more particularly in the field of food processing. The basic functions facilitated by enzymes in food processing are bioconversion, extraction, viscosity reduction, separation, functionality modification and biosynthesis of chemical additives.

Wong's volume "Food enzymes: structure and mechanism" focusses on considerations of enzyme structure *vis-a-vis* the reactions catalyzed by them. Such information on individual enzymes has appeared in different journals. But, the present volume is perhaps the first of its kind in which the information on several of the food enzymes have been compiled and critically presented. This volume has in all, 13 chapters. The first two are on the general themes of "Food enzymes and future developments" and Tailoring enzyme structure and function". The rest of the 11 chapters are devoted to the specific enzymes: amylases, cellulases, proteases, lipases, pectinases, lipoxygenase, polyphenol oxidase, glucose oxidase, peroxidase, catalase and xylose isomerase. The chapter on polyphenol oxidase is a guest contribution by the eminent enzymologist, John R. Whitaker of the University of California, Davis.

The chapter on "Food enzymes and future development" speaks on interesting future prospects of production of recombinant enzymes, heralded by the successful cloning and expression of bovine chymosin (milk clotting enzyme used in cheese manufacture) in microbial system for its economic production by fermentation. It also talks about innovative engineering of enzyme properties and functions to suit process needs and economic advantages. The first two chapters deal in general terms with the basic considerations of how enzymes function, how the functions can be modified and how even entirely novel enzymes that do not normally exist in nature can be "created" by

innovative approaches, combining the principles of molecular genetics, organic chemistry and biophysics.

Chapters 3 through 13 on the specific enzymes mentioned are very exhaustive, critical reviews of amino acid sequence, three dimensional structure and mechanism of catalysis of each category of the enzymes. The presentation of the comparative data on the primary sequence of each type of enzyme from different sources of organisms, revealing the extent of homology reflected in tertiary and quarternary structure of the enzymes, the active site generation and the mechanism of catalysis makes a very interesting reading. The volume can thus be regarded as a very valuable source of basic information on food enzymes, which a wide range of specialists in the areas of basic biochemistry, microbiology and molecular genetics will find interesting and useful. It will be particularly of immense value to food scientists.

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MICROBIOLOGICAL CONTROL FOR FOODS AND AGRICULTURAL PRODUCTS: Edited by C.M. Bourgeois and J.Y. Leveau, Published by VCH Verlagsgesellschaft mbH, Boschstrabe 12, Weinheim, Germany, 1995; pp. 542; Price: DM 228.

The title of the book justifies the principles of food microbiology - identification of the source of microbiological contaminants, factors governing deterioration of food and agricultural products from microbial growth and activities and detailing nature of microbial hazards.

The book contains 35 chapters arranged in 5 parts. Part I deals with general and basic techniques containing 10 chapters: Rapid methods and automation in food microbiology; Basic principles of industrial microbiology; Testing and uses of its findings; Sample removal, transport, and preparation; Rapid methods of enumerating microorganisms; Evaluation of microflora by non-microbiological techniques; Identification; Microbiological applications of immunology; Identification of microorganisms by nucleic acid probe hybridisation; Mechanisation and automation of techniques; and Prediction of product life span.

Part II deals with methods of evaluation of various technologically significant microflora such as: Total aerobic mesophilic microflora; Psychrophilic microflora; The lactic microflora; Bacteriophages of lactic starters - Detection and enumeration; The yeasts; The moulds.

Part III is on evaluation methods for microflora of sanitary significance. There are 7 chapters, which are as follows: Indicators of fecal contamination; The genus *Yersinia;* The genus *Clostridium* and the Sulfite reducing anaerobes; Coagulase positive *staphylococci*; and the genus *Listeria.*

Part IV deals with Microbiological testing of starting materials and finished products - water, milk and dairy products; Beer and soft beverages; Meat and meat products, Eggs and egg products; Fish, fishery products, crustaceans, and shell-fish; Vegetable products; Preserves and semi-preserves; Testing of intermediate moisture foods; Prepared meals; Psychrotrophic microflora; and Bacteriophagas of lactic starters.

Part V deals with miscellaneous applications of microbiological testing and contains two chapters - Testing of starter cultures for purity and Microbiological monitoring of factory equipment, atmosphere and personnel.

The presentation of the material is lucid and comprehensive - though at times tends to be brief. Reference are adequate, but slightly old; however, "suggested readings" are included to update the needs of supplementary information, which includes publications upto 1994. The first chapter by Fung is an useful update on Automated microbiology with 75 citations as reference material. Surprisingly, the initials of A.N. Shaspe, who has originated the concept of predictive microbiology are wrongly mentioned as 'A.W.'

The book gives a useful theoretical background to the practice of diagnostic microbiology. It covers various aspects of basic techniques and discusses the relevance of various quality parameters used in microbiology. It details preparation of samples for analysis, enumeration and identification of various groups of indicator groups of quality and sanitary significance. Several types of ingredients and products are covered. Special mention may be made of the microbiology of intermediate moisture foods, prepared meals, psychrotrophic, microflora and bacteriophages of lactic starters.

Introductory chapter on rapid methods in microbiology is supplemented with another on mechanisation and automation of techniques. These chapters indicate the trends of development in diagnostic microbiology.

Application of microbiological testing covered in the last part of the book covers two aspects - purity check of starter cultures and monitoring the source of contaminants in the processing environment. To this, may be related chapter 9, which discusses the role of predictive microbiology and shelf life prediction of processed food products.

Guideline specifications of various processed foods are given and these give an insight into the requirement of quality specifications for export into France. Further, these quality parameters may be models for excellence in the Indian industries.

There are valuable tips for the diagnostic microbiologist. Precautions on hydrothermal conditions of tests for intermediate moisture foods are useful to microbiologists for shelf life studies. GC analysis of spoilage volatiles and ergosterol in relation to moulds in foods deserves special mention as useful methods for quality control. On the whole, the book is recommended for students, teachers, food professionals as well as lay public on food microbiology. It deserves a place in private and public libraries as a useful source book.

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ANNOUNCEMENT

Late Prof. D. V. Tamhane Memorial Endowment Fund Essay Competition

Under the **Late Prof. D. V. Tamhane Memorial Endowment Fund,** students registered for graduate/post-graduate degree courses in Food Technology, Fermentation Technology and allied fields like Biochemistry and Microbiology, are invited to submit essays on any one of the following topics :-

(1) Waste generation and its management in food industry

(2) Probiotics

They essays should not exceed 3000 words. Only those students below the age of 28 years before **October 1, 1996,** are eligible to participate. Essays will be judged by an expert committee and their decision will be final. Best two essays will be awarded prizes of Rs. 500/- each.

Three copies of the manuscript, typed in double space on good quality paper (size 9" x 11") should reach the following address, not later than **15th November 1996.** The manuscript must carry an abstract of not more than 100 words and should be accompanied by certificates about date of birth and degree for which registered, from the Principal/Director of the Institute.

Address :

Prof. P. R. Kulkarni,

Head, Food and Fermentation Technology Division,
University Department of Chemical Technology (UDCT),
Matunga, Mumbai - 400 019.

CAC 96

CFTRI Annual Conference 1996

for

Fostering Synergies for Viable Food Processing

October 4-5, 1996

- Second annual event of vital importance to all-round growth of food industry
- Focus on first day of the CAC 96 on the theme *"Fostering Synergies for Viable Food Processing"*
- Participation is expected to grow to larger number in this year in view of highly successful CAC 95 held in last year
- Schedules for the second day of CAC 96 include events such as business discussions, demonstration of selected CFTRI processes, industrial exhibition and poster presentation by CFTRI/Food Industries/Business Organisations
- Ending of CAC 96 with plenary session for formulating recommendations and action plan for growth, modernisation and automation of Food Processing sector, in addition to formulating strategies for human resources development/food processing in rural development/ commercialization of viable processes as well as identification of thrust areas, policy plans for investors/ financial bodies/ Government departments and agencies
- Informative souvenir, as in the last year, which would reach the industry/agencies for efficient dissemination of information on viable food processing and CFTRI capabilities as a one stop centre for Food Science and Technology in the country
- CAC 96 brings the captains of India's food industry, investors, policy shaping personnel, Government agencies, professional bodies, funding/ financing institutions and a host of persons actively involved in different aspects of food sector on one platform
- Interactions during CAC 96 are expected to build up a vibrant food industry through avenues involving forging partnerships and fostering synergies with CFTRI
- Contact CAC 96 Secretariat at Central Food Technological Research Institute, Mysore - 570 013 (Phone: 0821-22304; Fax: 0821-37453) or write to Director, CFTRI, Mysore - 570 013 for further details

INDIAN FOOD INDUSTRY

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Contents of May - June 1996 Issue

EDITORIAL 5

INDUSTRY NEWS 7

Oprah Says No to Beef* Image Impasse* Kaveri Bio Proteins' New Project* Beer Parleys* A Slick Success* Parle Agro Launches Its First Jelly Drink in Gujarat* Praj Industries' Overseas Ventures* Indusmin Foods Citrus Fruit Processing Plant* Bhandari Food Plans Unit for Coconut By-products* A Case for Plastics in Packaging* A Food Giant Plans to Sell Indian Spices in US* Brooke-Bond Lipton Merges with Hindustan Lever* World Bank Aid Sought to Boost Tea Production* Thrust on Coconut Industry in 9th Plan* Use of Molasses in Liquor Manufacture* Mixed Trends in Exports of Agricultural and Allied Products* Karnataka Sales Internationals to Distribute Indian Made Foreign Liquor* Export-Oriented 100% Fruit Processing Unit at Tirupathi* Counting Chickens* DCM to Diversify into Sugar Business* Coca Cola's Fresh Investment Plants* Kool Breweries' New Venture* Parle Agro's New Drink* JK Dairy Registers 50% Rise in Sales* Shaw Wallace to Launch New Liquor Brands* Vintage Foods to Set up Integrated Dairy Complex* Vazir Sultan Tobacco Exploring US Processed Food Market* New Filtration Method to Improve Sugar Recovery

FEATURE ARTICLES 16

Tailored Plastics Film Laminates for Modified Atmosphere Packaging of Fresh Fruits
Mathew Prasad and *R.P. Singh* 17

ISO 9000 and Environment Management System
Sohrab 21

Geriatric Foods - A Fad Or A Need?
V.H. Potty 27

The Mad Mad Cows
D. Vijaya Rao 33

Fat Spread-A Changing Face
R.B. Verma, P.S. Prajapati, P.N. Thaker and *K.G. Upadhyay* 36

Status and Prospects of Soybean Industry in India
Nawab Ali 43

DEPARTMENTS

New Machinery 47

Research Round-up 49

Data Bank 51

Trade Fairs & Conferences 55

AFST (I) News 58

JFST Contents 59

Advertisers' Index 61

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