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FOOD SCIENCE AND TECHNOLOGY

ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS (INDIA)

Vol. 30, No. 2

March-April 1993

THIRD INTERNATIONAL FOOD CONVENTION
and
EXHIBITION

IFCON 93

7-12th September 1993 at Mysore, India.
Jointly Organised by the Association of Food Scientists and Technologists and Central Food Technological Research Institute, Mysore.

Through the First and Second Circulars already issued by AFST (I), you are aware that **IFCON 93** will be held during 7-12th September 1993 at the Central Food Technological Research Institute, Mysore. Already confirmation has been received from a large number of Indian/Foreign delegates regarding their participation in the Symposium/Workshop/Exhibition. International Union of Food Scientists and Technologists (IUFoST) is sponsoring a special workshop on post harvest technology of fruits and vegetables, which is likely to highlight modern developments in this critical area. In addition to this, M/s. U.S. Wheat Associates is sponsoring another Workshop on Wheat and Wheat Products. The convention will have General Sessions and Parallel-Technical Sessions, along with Poster Presentation Sessions on Recent Trends in Food Science and Technology.

REGISTRATION : Registration Fee : Rs. 300/- for AFST members and Rs. 600/- for others. The requisite fee in the form of DD drawn in favour of **IFCON 93** may be sent to the Secretary, AFST (I), before 15th May, 1993.

SOUVENIR CUM BUYERS' GUIDE : A Comprehensive Souvenir is being published containing state of art information on food industry world over. Tariff for advertisement : Outer Cover (back) Rs. 15,000/-, Inside Cover (each) Rs. 10,000/-, Full Page Rs. 5,000/-, Half Page Rs. 3,000/-, Insertion of Advertisement (already printed) Rs. 7,000/- (both sides), Art paper Rs. 7,500/-. Please book before 30th June 1993.

FOOD EXPO 93 : Stall rent for Food Expo is Rs. 9,750/- per stall (3.3 x 2.8 m) for Indian participants and US $ 500 for International exhibitors. Last date for booking is 31st July 1993.

For further details, please contact :

Secretary,
Association of Food Scientists & Technologists (India)
Central Food Technological Research Institute Campus,
Mysore - 570 013, India.

Telex : 0846-241 FTR IN
FAX : 91 - 821 - 27697
Cable : FOODSEARCH
Phone : 21747

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

Affiliated to the Institute of Food Technologists, USA

The Association is a professional and educational organization of Food Scientists and Technologists

Objectives :

1. To stimulate research on various aspects of Food Science, Technology and Engineering.
2. To provide a forum for the exchange, discussion and dissemination of current developments in the field of Food Science, Technology and Engineering.
3. To promote the profession of Food Science, Technology and Engineering.

The ultimate object is to serve humanity through better food.

Major Activities :

1. Publication of Journal of Food Science and Technology (bi-monthly) and Indian Food Industry (bi-monthly).
2. Arranging lectures and seminars for the benefit of members.
3. Holding symposia on different aspects of Food Science, Technology and Engineering.

Membership :

Membership is open to graduates and diploma-holders in Food Science, Technology and Engineering and to those engaged in the profession. As per the option exercised, each member will receive a free copy of the Journal of Food Science and Technology or the Indian Food Industry. The Chapters of the Association are located at Bangalore, Bhopal, Bombay, Calcutta, Delhi, Hissar, Hyderabad, Jabalpur, Jaipur, Jammu, Kanpur, Karnal, Kharagpur, Ludhiana, Madras, Manipur, Nagpur, Pantnagar, Parbhani, Poona and Trivandrum.

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For membership and other particulars, kindly contact :

The Honorary Executive Secretary
Association of Food Scientists and Technologists (India)
Central Food Technological Research Institute Campus, Mysore-570 013, India.

JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

Volume 30 Number 2 March-April 1993

CONTENTS

Journal of Food Science and Technology, devoted to original R & D contributions in all branches of science, technology and engineering of foods and food products, is a bimonthly publication of the Association of Food Scientists and Technologists (India), Mysore.

The Editor reserves the privilege of editing the manuscript to make it suitable for publication in the Journal.

The Editor assumes no responsibility for the statements and opinions expressed by the contributors.

Manuscripts for publication, books for reviewing and advertisements in the journal should be addressed to the Editor, Journal of Food Science and Technology, AFST(I), CFTRI Campus, Mysore-570 013, India.

The Instructions to Authors are given in the January/February issue of the Journal.

New members of AFST(I) are entitled to receive 'Indian Food Industry' journal or Journal of Food Science and Technology, free of cost Members opting for IFI can subscribe tc Journal of Food Science and Technology at a concessional rate of Rs. 70/- per annum. Those members who were earlier getting or had opted for IFI, can now also opt for JFST (once in a year only), if they so desire. For others, the annual subscription rates are: Inland: Rs. 336/- Foreign: Surface Mail US$ 106/- Air Mail US$ 131 (Inclusive of Reg. Book Post charges).

RESEARCH NOTES

INDEXED AND SELECTIVELY ABSTRACTED IN:

Current Contents - Agriculture, Biology and Environmental Sciences; Indian Food Industry; NCI Current Contents; Chemical Abstracts; Biological Abstracts; Food Science and Technology Abstracts; Food Technology Abstracts; Dairy Science Abstracts. Nutrition Abstracts and Reviews - Series A - Human and Experimentals; International Packaging Abstracts; PIRA CD-ROM-Paper, Printing and Packaging Database; Online PIRA Databases - Data - Star, Dialog, Orbit Search Service, PFDS Online and STN; Fisheries Review; Cambridge Scientific Abstracts - Microbiology, Biotechnology, Health and Safety Science; Food Adlibra Dialog File 79; Food Adlibra Alerting Bulletin; Food Adlibra Current Awareness Supplements for Food Science, Seafood; Food Adlibra Current Awareness Supplement for Snacks and Confectionery; Biology Digest. CABS Online database (Database host BRS Information Technologies); All relevant Current Advances Journals of CABS series "Current Awareness in Biological Sciences" NAPRALERT - Online access via Bitet, Interest Compuserve, Prodigy and Phone modem; NAPRALERT - Off-line access.

REVIEW *J. Food Sci. Technol., 1993, Vol 30, No.2, 77-87*

Methods for Determining Rheological Characteristics of Doughs : A Critical Evaluation

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Baking Technology Discipline,
Central Food Technological Research Institute, Mysore-570 013, India.

Rheological characteristics of doughs are of vital importance to bakery industry in predicting processing characteristics of dough and the quality of the end products. These also play a role in quality control programme and establishment of specifications for ingredients and the final products. Consequently, the reliability of the methods used for determining the rheological characteristics of dough assume vital importance. These methods are, therefore, critically analyzed and their limitations are pin-pointed. Use of computerized instruments is advantageous for more accurate, rapid and reproducible calculations of the curve parameters.

Keywords : Dough, Methods for rheological characterization, Farinograph, Mixograph, Research water absorption meter, Extensograph, Alveograph, Hagberg falling number, Visco-amylograph, Expansograph, Maturograph, Oven-rise recorder.

Wheat flour dough constitutes a highly complex and unstable colloidal system that undergoes continuous modifications in its physical characteristics through the action of physical, chemical and biological forces. Dough derives its properties mainly from the constituent components of flour, like proteins, carbohydrates, lipids and miscellaneous minor components. Other components like water, air and added ingredients also influence dough properties. Microscopic examination of dough reveals three phases, namely, starch, protein and gas cells (Bloksma and Bushuk 1988). The native starch granules retain their identity in dough and are embedded in a continuous phase which is a swollen protein. Air is entrapped in this phase, while lipids spread over the surface of the starch granule (Baker and Mize 1946; Hanssen and Erika 1952). The visco-elastic properties of dough are the results of the presence of a three-dimensional network of gluten proteins. The network is formed by thiol-disulfide exchange reactions among gluten proteins.

Dough is an intermediate stage in the transformation of wheat flour to bakery products. Consequently, dough characteristics are important because they influence the quality of the finished product. Rheology, the science which studies the flow of materials and characterizes the forces of deformations in terms of stresses and strains in relation to time, allows the determination of physical properties inherent in the material. Wheat flour dough exhibits visco-elastic properties (Schofield and Scott Blair 1932), wherein the stress is a function of a combination of applied strain and the strain rate. The visco-elastic behaviour of dough is non-linear. The ratios of stress/strain and stress/strain rate are not constants, but are functions of stress (Faubion and Hoseney 1990). Hence, characterization of non-linear visco-elastic wheat flour dough requires that the viscous or elastic components be determined as functions of testing rate and strain level (Bagley and Christianson 1986).

Experimental measurements of dough are difficult and selection of proper techniques are needed to measure the rheology of dough. Even though the rheology of dough has been studied extensively, the challenges of understanding the physical properties are still present (Bloksma 1988). The physical testing instruments give information about the physical behaviour of the dough. The empirical designing of the instruments does not allow absolute rheological measurements of dough or complete understanding of the physical characteristics (Shuey 1974). Empirical mechanical testing (physical testing) helps in evaluation of flour quality and functionality (Brabender 1973) and also the effects of additives like oxidizing and reducing agents, enzymes and emulsifiers (Anderson 1956; Smith and Andrews 1952). Physical testing methods have the limitations that the results cannot be described in fundamental rheological properties (Menjivar 1990).

The behaviour of the dough is highly complex and the model proposed by Bloksma (1978) is shown in Fig.1. The force on A and the displacement are equal to stress and strain of a dough. The total deformation is permanent due to viscous part and temporary due to elastic part. This is described in

* *Corresponding Author*

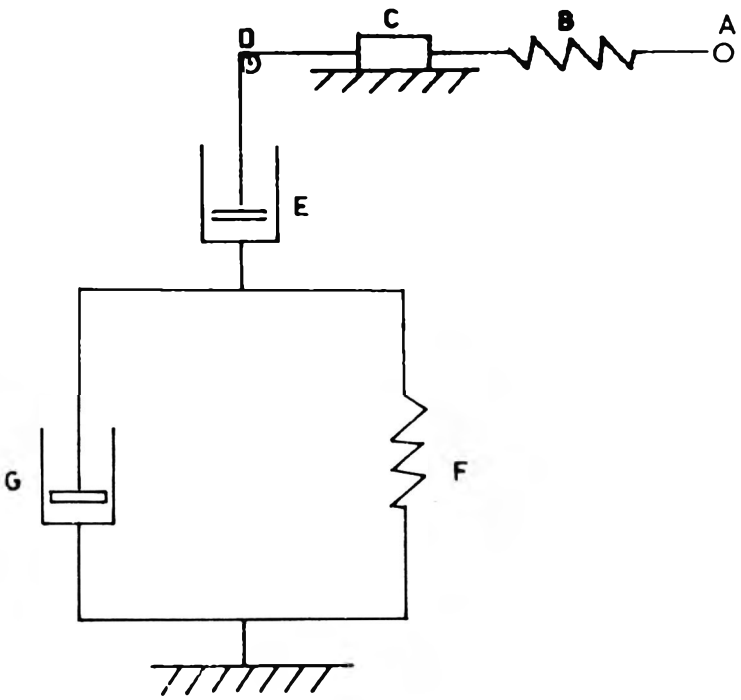

Fig. 1. Mechanical model for the rheological behaviour of wheat flour dough.

the Maxwell model shown above by viscous element E and elastic element F, connected in series. Since the elastic reaction is retarded, a second viscous element G is placed parallel to the elastic element F as in kelvin body. Spring B is introduced to account for the temporary elastic deformation with stress below yield value. Frictional element C denotes the frictional force related to yield value and D is the point of transition to dough structural characteristics.

Number of instruments are available to obtain objective data on dough properties in order to predict the suitability of flour for various bakery products. Some of the important instruments used for evaluating the rheological characteristics of dough by various methods are discussed in this article. The most important commercially available instruments are : recording dough mixers (Brabender farinograph, mixograph); load extension meters (Brabender extensograph, Chopin alveograph); extrusion meters (Research water absorption meter); viscometers (Hagberg falling number, Brabender visco-amylograph) and gas production and/or gas retention instruments (expansograph, Brabender maturograph, Brabender oven-rise recorder).

Brabender Farinograph

The farinograph is a dynamic physical dough testing instrument (Shuey 1974) involving the measurement of torque. The resistance offered by the dough during a prolonged and gentle mixing at a constant temperature is transmitted to a dynamometer, which is connected to a lever and scale system as well as a pen which traces a curve on a kymograph chart. The instrument consists of a mixing bowl (50 and 300 g flour capacity) dynamometer, lever system, scale system, kymograph recording mechanism, dash pot, thermostat and burette (Shuey 1972a).

The two basic methods for running the farinograph involve the use of 300 g flour on a 14% moisture basis (constant flour weight method) or 480 g dough (constant dough weight method). There are advantages and disadvantages in these techniques of operating the farinograph. A constant amount of dry matter is used in each test in the 300 g constant flour weight procedure. Consequently, the moisture determination of flour is a must before running farinograph. As the water absorption is corrected to 14% moisture basis, the weight of flour on 14% moisture basis has to be calculated. In the case of the 480 g constant dough weight procedure, the farinograph can be run as soon as flour sample is received. The ratio between flour and water is calculated and the water absorption is corrected to a 14% moisture basis. It is necessary to use a constant amount or mass of dough in the test (Shuey 1972b).

Procedure : Farinograph thermostat is adjusted to maintain the temperature at 30°C. The water from thermostat bath is made to circulate through the bowl jackets. The sensitivity setting of 1:5 towards the back of the machine is used for the large bowl (300 g), while 1:1 position at the front of lever arm is used with the small mixing bowl (50 g). The scale head pointer is adjusted to zero by changing position of threaded weights when instrument is running at fast speed with mixer empty. With a small mixing bowl, the smaller of two weights is removed. The writing arm is adjusted in such a way that the scale head pointer and writing pen coincide with zero reading. The band width is adjusted such that the scale head pointer moves from 1000 to 100 BU within 0.6 to 0.8 sec when dynamometer arm is raised and released.

Constant flour weight method : The thermostat is put on at least for 1h prior to using the instrument. The moisture of flour is determined by air-oven method and the flour weight on 14% moisture basis is calculated using the formula:

$$\text{Weight of flour on 14\% m.b.} = \frac{100 - 14}{100 - M} \times \text{weight of flour}$$

where M is the moisture of the flour.

Flour (300 g, 14% m.b.) is placed in the large mixing bowl. The burette is filled with water. The pen is adjusted to 9 min position, the instrument turned on and allowed to run. When the pen reaches zero position, water from burette is added. As the dough forms, the sides of mixing bowl are scrapped and the addition of water is continued till curve levels off at 500 BU line. If the first titration does not produce the peak of curve centered on 500 BU, titration is repeated to get correct water absorption by applying correction of 0.6 to 0.8% absorption (1.8 to 2.4 ml) for 20 BU. The curve at maximum dough development should centre on 500 BU line. The final farinogram is obtained by conducting the test afresh and adding all water within 25 sec after opening the burette stopcock and running the instrument beyond peak for 12 or 20 min. The water absorption is calculated using the equation :

$$\text{Absorption (\%)} = \frac{x + y - 300}{3}$$

where x = ml of water to produce maximum consistency centered on 500 BU line and y = g of flour used-equivalent to 300 g on 14% m.b.

For small bowl, the procedure is similar to that for large bowl, but 50 g flour (14% m.b.) is used at the sensitivity setting of 1:1 and the water is added using the small burette. The water absorption (%) = 2 (x + y – 50) where x = ml of water to produce the curve with maximum consistency centered on 500 BU line and y = g of flour used-equivalent to 50 g on 14% moisture basis.

Constant dough weight method : In this method, the water absorption of flour at its existing moisture level basis is determined and the curve is centered on 500 BU line. From the chart, the weights of flour and water which correspond to estimated water absorption are used to get 480 g constant dough. The curve is recorded by placing the flour in bowl, dry mixing for 1 min and then, adding the water. The curve obtained is evaluated. The flour water absorption is corrected to 14% moisture basis by using the formula :

$$A = 86 \frac{(B + M)}{(100 - M)} - 14$$

Where A = absorption on the 14% moisture, B = absorption on actual moisture basis and M = flour moisture.

A typical farinogram is shown in Fig. 2. The following measurements are made from the farinogram.

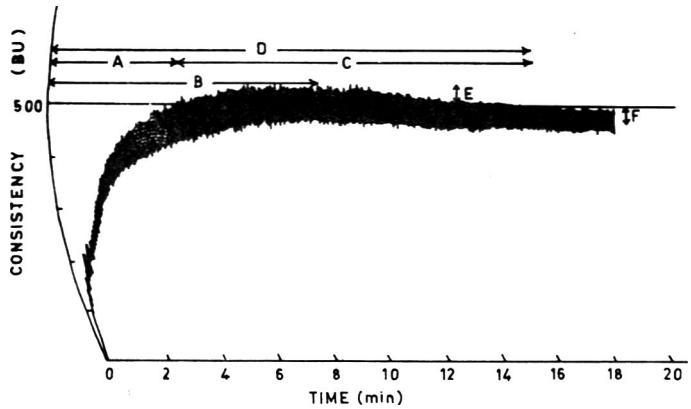

Fig.2. Typical farinogram: A) arrival time, B) dough development time, C) stability, D) departure time, E) mixing tolerance index and F) twenty minute drop.

Absorption : Absorption is defined as the amount of water necessary or required to centre the farinograph curve on 500 BU line for a flour-water dough.

Arrival time : The arrival time is the time required for the top of the curve to reach the 500 BU line after the mixer is started and the water introduced. The value is a measurement of rate of hydration of flour. In general, the arrival time also increases with the increase in protein content of the flour.

Dough development time : This is the time to the nearest half min from the first addition of the water to the development of the maximum consistency of the dough. This value is also known as peak time. The mid-point of the top of the flat curve or the second peak of two peaks are considered as peak time.

Stability : This is defined as the difference in time to the nearest half min, between the point where the top of the curve first intercepts 500 BU line (arrival time) and the point where the top of the curve leaves the 500 BU line (departure time). This value indicates the tolerance of the flour to mixing.

Departure time : This is the time to the nearest half min from the first addition of water until the top of the curve leaves 500 BU line and equals the sum of the arrival time and stability. The longer the time, the stronger is the flour.

Mixing tolerance index : This value is a difference in BU from the top of the curve at the peak to the top of the curve measured at 5 min after the peak is reached. Flours which have good tolerance to mixing exhibit low mixing tolerance indices. Similarly, the higher the mixing tolerance index, the weaker is the flour.

Twenty min drop : This is the change in the height of the centre of the curve at the peak and the centre of the curve at 20 min after the first addition of water, expressed to the nearest 5 BU. This value indicates rate of breakdown and strength of flour.

Valorimeter value : This is an empirical quality score which is based on the development time as well as tolerance to mixing and is derived from the farinogram by means of a special template. After the farinogram is placed in position in valorimeter, the left hand edge of the movable slide is placed on the peak. The valorimeter value is read at the right hand edge of the slide, 12 min past the peak, and is the value which corresponds to the line of stationary templates that intersects the centre of the farinogram at this point.

Time to breakdown : It is the time from the start of mixing to a decrease of 30 BU from peak point.

The official method for the farinograph by the International Association of Cereal Chemistry (ICC) uses constant flour weight (14% moisture basis). Apart from per cent water absorption and dough development time, degree of softening is also determined.

Degree of softening : This is the difference between the centre of the curve at the peak and the centre of the curve obtained at 12 min after the peak and reported to the nearest 5 BU.

Mixograph

It measures the resistance of dough to mixing (AACC 1980). The pull-fold-repull type of the mixing action is much more severe than that of the farinograph. The basic parts of mixograph include mixing pins, mixing bowl, swevel base, tension spring, and kymograph. Water absorption is based on protein content and is 65% at 15% protein (14% moisture basis). It increases or decreases by 1% for each 1% of increase or decrease in protein content. Another method employs the water absorption from farinograph.

Procedure : The instrument is adjusted for mixer head shaft to revolve at 85-90 rpm. The spring tension position is set between 8 and 11 for strong flours and at lower position for weak flours. The recording pen is adjusted to zero position on the chart. In the mixograph bowl, 35 g of flour (14% moisture basis) is placed and the equivalent water calculated as above is added. The mixing head is put into operating position and the pen at zero position on the recording chart before starting the instrument and allowing the mixing for 7 min. A typical mixogram is shown in Fig.3. The following measurements are made from the mixograph curves.

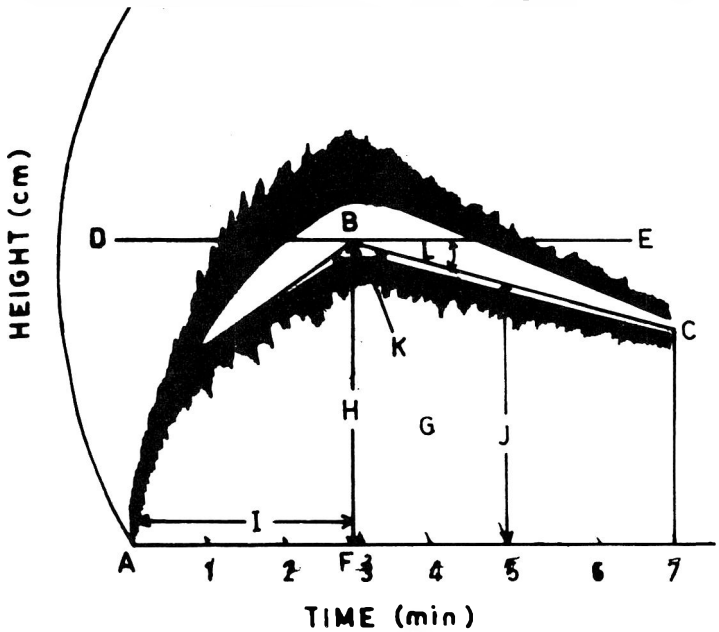

Fig.3. Typical mixogram: G) area under curve, H) peak height, I) peak time J) height of curve at specified time after peak, K) angle between ascending and descending lines and L) weakening angle.

Area under curve : The area is measured by drawing a line from beginning, along the centre of the recorded curve, to base line and back to the starting point.

Peak height : The height (cm) at peak of the curve is peak height.

Peak time : The time taken to reach the peak is measured in min.

Height of curve at specified time after peak : The tolerance index or drop-off is measured by determining the height of curve at a specified time beyond the maximum.

Angle between ascending and descending lines at peak : Using the lines drawn along the centre of the curve, the angle at the peak between ascending and descending lines is measured.

Weakening angle : It denotes the angle between the descending line and the line drawn at the centre of peak as well as parallel to the base line.

Research Water Absorption Meter

This is a simple instrument used to measure the water absorption of flour. Doughs, either yeasted or unyeasted, are made with known amount of water and relaxed for standard period. They are, then, extruded under a fixed pressure through a nozzle and the rate of flow is determined by means of a micrometer dial gauge and stop-watch (Kent-Jones and Amos 1967).

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PGS '94

CONFERENCE PROGRAMME AT A GLANCE

THURSDAY, 13TH JANUARY 1994

AM

COST, COMPETITION AND REGULATION

Chair:
Michael Hope, ANDERSEN CONSULTING

Forecasting Fuel Choice for Power Generation
Nigel Hawkins, HOARE GOVETT

Review of Latest Developments in the UK Gas Market
Dr. Michael Morrison, CAMINUS ENERGY

Keynote Address:
Professor Stephen Littlechild, OFFER

PM

STREAM A

CAPITALISING ON NEW BUSINESS OPPORTUNITIES FOR ENERGY COMPANIES

Chair:
Bill Watson
EASTERN ELECTRICITY

David Thomlinson
ANDERSEN CONSULTING

Peter Franklin
AGAS

Cynthia Dubin
MISSION ENERGY

John Harris
EAST MIDLANDS ELECTRICITY

STREAM B

THE FUTURE OF RENEWABLES IN THE UK AND ENVIRONMENTAL ISSUES

Chair:
Gordon MacKerron, SPRU
UNIVERSITY OF SUSSEX

Dr David Elliott
THE OPEN UNIVERSITY

David Frith
NNC

Dr Jim Skea, SPRU
UNIVERSITY OF SUSSEX

Professor David Newbery
UNIVERSITY OF CAMBRIDGE

FRIDAY, 14TH JANUARY 1994

AM

OPERATION & DEVELOPMENTS IN THE POOL

Chair:
Professor Derek Bunn, LONDON BUSINESS SCHOOL

Discovering the Latest from the Pool
Tony Cotton,
THE ELECTRICITY POOL OF ENGLAND & WALES

Pool Trading Costs
Dr Keith Miller, NATIONAL POWER

Panel Discussion:
Does the Pool Operate as an Efficient Market?

PM

STREAM A

POWER GENERATION: ECONOMICS & FINANCE

Chair:
David Porter
AIEP

Angus Morrow
Kennedy & Donkin Power

James Barry
Barclays Bank

Nick Coleman
BP Energy

STREAM B

OPPORTUNITIES/ CHALLENGES FOR THE INDUSTRIAL ENERGY USER

Chair:
Ken Green
ICI Chemicals & Polymers

Hugh Mortimer
BOC

Alan Yardley
Argyll Group

Steve Heywood
Tate & Lyle Sugars

Plenary
THE FUTURE OF NUCLEAR POWER IN THE UK?
Peter Webster
Nuclear Electric

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David De Casseres, Commercial Manager – Generation, Yorkshire Electricity

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Professor Stephen Littlechild, Director General, OFFER

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- ★ Capitalising on new business opportunities for energy companies
- ★ The future of renewables in the UK and an assessment of the impact of environmental issues and regulations on power generation
- ★ A close examination of the operation of and the latest developments in the electricity pool
- ★ The economics and finance of power generation
- ★ Opportunities and challenges for the industrial energy purchaser
- ★ The future of nuclear power in the UK

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Yours sincerely

Steve Scott

Steve Scott, Conference Manager
IIR Ltd - Industrial Division

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PGS '94

2nd Annual Cost, Competition and Regulation in POWER GENERATION & SUPPLY

DAY ONE – Thursday, 13th January 1994

COST, COMPETITION AND REGULATION IN THE UK ELECTRICITY AND GAS MARKETS

9.00 Registration and Coffee

9.30 Opening Remarks from the Chair
Michael Hope
Partner, MD for European Utilities Industries
ANDERSEN CONSULTING

9.40 **FORECASTING FUEL CHOICE FOR POWER GENERATION: EXAMINING FUEL SUPPLY, DEMAND, PRICE AND THE MAKE-UP OF BASE-LOAD GENERATION TO 2000 AND BEYOND**
- * Gas vs Coal vs Nuclear: assessing which will be the fuel of the future
  - – forecasting future demand for electricity
  - – analysing the potential share of base-load generation by fuel
- * Predicting the impact of the planned gas-fired stations on Electricity supply
- * What is the future of coal-fired generation?
- * How much of a threat is international coal/orimulsion?
- * Taking account of government policy
- * How will the UK and EC environmental policies affect fuel choice?
- * How will electricity prices be affected by fuel choice?

Nigel Hawkins
Utilities Analyst
HOARE GOVETT

10.20 **A REVIEW OF THE LATEST DEVELOPMENTS IN THE UK GAS MARKET: THE MMC'S RECOMMENDATIONS AND THE GOVERNMENT'S RESPONSE**
- * Analysing key MMC recommendations and the Government's response
- * The timetable for introduction and implementation of the reforms
- * The break-up of BG transportation and trading and its impact on the development of competition
- * The need for market mechanisms and the possible emergence of a spot gas market

Dr Michael Morrison
Director
CAMINUS ENERGY

11.00 Tea and Coffee

11.30 **KEYNOTE ADDRESS: REGULATORY AND MARKET DEVELOPMENTS IN ELECTRICITY GENERATION AND SUPPLY**
- * Analysing recent OFFER reviews
- * Discussing competition in generation
  - – the costs and margins study
  - – possibility of an MMC referral
- * What are the latest thoughts on competition in supply?

Professor Stephen Littlechild
Director General of Electricity Supply
OFFER

12.10 Lunch – At lunch you can choose which "Speaker Table" to sit at to discuss points raised at the conference with speakers and fellow delegates in a smaller, less formal forum.

STREAM A

CAPITALISING ON NEW BUSINESS OPPORTUNITIES FOR ENERGY COMPANIES

1.30 Opening Remarks from the Chair
Bill Watson
Managing Director (Generation)
EASTERN ELECTRICITY

1.40 **CAPITALISING ON OVERSEAS POWER GENERATION INVESTMENT OPPORTUNITIES**
- * Market potential based on energy demand, political and economic trends
  - – Asia Pacific
  - – Americas
  - – Europe
- * Defining a generic "blueprint" for IPPs

STREAM B

THE FUTURE OF RENEWABLES IN THE UK

1.30 Opening Remarks from the Chair
Gordon MacKerron
Senior Fellow, Science Policy Research Unit
UNIVERSITY OF SUSSEX

1.40 **HOW COMMERCIALLY VIABLE ARE ALTERNATIVE POWER SOURCES AND TECHNOLOGIES?**
- * Taking a fresh look at the viability of renewables
  - NOW - waste
  - - hydro
  - - wind
  - NEXT? - solar, biofuels, hydrogen, wave, tidal, geothermal

STREAM A

covering integration of business processes, people and technologies
* Securing competitive differentiation in international markets
* Optimising risk/reward through the Power Purchase Agreement

David Thomlinson
Partner and Director for Power Generation Europe
ANDERSEN CONSULTING

2.20 **ASSESSING AND CAPITALISING ON NEW DEVELOPMENTS IN THE UK GAS MARKET - AN INDEPENDENT'S VIEW**
* Where are the new areas of growth for independent gas suppliers?
* Which sectors of the existing and new markets will the independents concentrate on?
* Will there be a level playing field in the new Gas Market?
* Developing gas marketing strategies to take advantage of increased opportunities

Peter Franklin
Head of Marketing
AGAS

3.00 Tea and Coffee

3.30 **DISCOVERING NEW OPPORTUNITIES FOR EXPORTING YOUR ENERGY TECHNOLOGY AND KNOWHOW**
* Assessing the project's commercial viability
* Marketing the skills and technology
* Examining the mechanisms for providing assistance
  - funding
  - share in the project
* Effectively managing overseas operations

Cynthia Dubin
Manager, Project Finance
MISSION ENERGY

4.10 **EVALUATING THE RISKS AND REWARDS OF DIVERSIFICATION STRATEGIES FOR POWER GENERATORS AND SUPPLIERS**
* Strategic planning for competitive advantage
  - deciding your strategy for growth based on your corporate objectives
* Drawing on your strengths when identifying new business markets
* Moving towards the single "energy company"
* Is diversification really a strategy for securing competitive advantage?
* Exploiting future opportunities both inside and outside of the electricity market
  - gas supply
  - telecommunications

John Harris
Chairman
EAST MIDLANDS ELECTRICITY

4.50 Closing Remarks from the Chair

STREAM B

* Factoring in changes to the NFFO levy

David Elliott
Director, OU Technology Policy Group
THE OPEN UNIVERSITY

2.20 **EXPLAINING THE TECHNICAL ASPECTS AND ECONOMICS OF A SUCCESSFUL ENERGY FROM WASTE PROJECT**
* Retro-fitting of a steam turbine generator to an existing municipal waste incinerator: Coventry Waste Reduction Unit
* Examining the economics and return on investment
* Tackling the planning problems

David Frith
Project Manager
NNC

3.00 Tea and Coffee

THE IMPACT OF ENVIRONMENTAL ISSUES AND REGULATIONS

3.30 **THE LATEST ENVIRONMENTAL TRENDS AND POLICIES: EVALUATING THE APPLICATION AND IMPACT ON UK POWER GENERATION**
* What are the implications of the new sulphur protocol?
* What is on the horizon in Brussels?
* How are the HMIP applying and enforcing the environmental regulations?
* Will greenhouse gas control affect power generation?

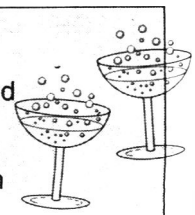
Dr Jim Skea
Senior Fellow, Head Environmental Group - SPRU
UNIVERSITY OF SUSSEX

4.10 **THE ECONOMICS OF CLEAN AIR MODIFICATIONS AND THE POTENTIAL IMPACT ON ELECTRICITY PRICES**
* The economics of retrofitting Flue Gas Desulphurisation
* Alternative methods of implementing LCPD and their implications
* The potential impact of the LCPD on UK electricity prices

Professor David Newbery
Director, Department of Applied Economics
UNIVERSITY OF CAMBRIDGE

4.50 Closing Remarks from the Chair

5.15 **Cocktail Reception**
At the end of Day One, delegates and speakers are invited by IIR Ltd to attend a cocktail reception. This is an ideal opportunity to discuss issues raised at the conference with your peers in an informal and relaxed atmosphere.



PGS '94

2nd Annual Cost, Competition and Regulation in POWER GENERATION & SUPPLY

DAY TWO – Friday, 14th January 1994

A CLOSE EXAMINATION OF THE OPERATION AND DEVELOPMENTS IN THE ELECTRICITY POOL

9.00 Registration and Coffee

9.30 Opening Remarks from the Chair
Professor Derek Bunn
LONDON BUSINESS SCHOOL

9.40 **DISCOVERING THE LATEST FROM THE POOL: WHAT ARE THE PLANS FOR THE FUTURE**
* How plans are made
* Current activities
* Further plans

Tony Cotton
Trading Director
THE ELECTRICITY POOL OF ENGLAND AND WALES

10.20 **POOL TRADING COSTS - WHO SHOULD PAY?: A GENERATOR'S VIEW**
* How should the price of electricity be set?
* When should it be set? day-ahead; on-the-day; after-the-event
* How should trading relate to operation?
* How should the costs of Uplift be allocated? – by what mechanism? to whom?
* The impact of developments in the pool on income to the Generators and costs to the customers

Dr Keith Miller
Pool Development Manager
NATIONAL POWER

11.00 Tea and Coffee

11.20 **PANEL DISCUSSION: DOES THE POOL OPERATE AS AN EFFICIENT MARKET?**
* Does the pool price mechanism need review?
* How could it operate more effectively? - in what form?
* Will demand-side bidding deliver competitive prices?
* Is dedicated generation (pool bypass) really a viable option? Avoidance of the fossil fuel levy

Tony Cotton
Trading Director
THE ELECTRICITY POOL OF ENGLAND AND WALES

Eddie Cumberland
Group Contracts Manager
HARRISONS & CROSFIELD

Ken Green
Commercial Manager, Electricity & Water
ICI CHEMICALS & POLYMERS

Dr Keith Miller
Pool Development Manager
NATIONAL POWER

Martin Stanley
Pool Development Manager
MANWEB

12.00 Lunch – At lunch you can choose which "Speaker Table" to sit at to discuss points raised at the conference with speakers and fellow delegates in a smaller, less formal forum.

STREAM A

POWER GENERATION: ECONOMICS AND FINANCE

1.30 Opening Remarks from the Chair
David Porter
Chief Executive
ASSOCIATION OF INDEPENDENT ELECTRICITY PRODUCERS

1.40 **AN ANALYSIS OF THE ECONOMICS OF POWER PLANT INVESTMENT AND START-UP**
* Forecasting the impact of market developments on continued investment in new plant build
* Calculating start-up costs
* Securing base-load operation and analysing

STREAM B

OPPORTUNITIES AND CHALLENGES FOR THE INDUSTRIAL ENERGY PURCHASER

1.30 Opening Remarks from the Chair
Ken Green
Commercial Manager, Electricity & Water
ICI CHEMICALS & POLYMERS

1.40 **ELECTRICITY PURCHASING: A LARGE CUSTOMER'S VIEWPOINT**
* How purchasing has changed since April 1990
* Current areas of concern
* Suggestions for improvement

Hugh Mortimer
Commercial Manager, Bulk & Tonnage
BOC

STREAM A

the impact on profitability if none is secured
Angus Morrow
Engineering Manager
KENNEDY & DONKIN POWER

2.20 **SUCCESSFULLY SECURING DEVELOPMENT FINANCE FOR POWER PROJECTS**
* Latest trends in project finance
* Sourcing finance
* Financing structures - which is best for you?
* Calculating and allocating risk
* What the banks want to know
* Taking into account legal considerations

Jim Barry
Director - Structured Finance
BARCLAYS BANK

3.00 Tea and Coffee

3.20 **REASSESSING SELF-GENERATION OPTIONS AGAINST CONTINUOUS MARKET DEVELOPMENTS**
* Looking again at the commercial viability of self-generation
* Is the return on CHP investment attractive enough?
  – "site" arguments, "export" arguments
* Which sectors of the market are most interested in CHP?
* Re-evaluating the attractiveness of other energy options
* Are regulatory changes going to make things better or worse?
* Focusing on the environmental factors affecting viability of on-site generation

Nick Coleman
Managing Director
BP ENERGY

STREAM B

2.20 **COST-EFFECTIVE PURCHASING STRATEGIES FOR THE MULTIPLE SITE PURCHASER**
* Defining a "site"
* Central Purchasing vs individual site negotiation:
  which is the better option for you?
* Special metering considerations
* Selecting the most appropriate supplier mix

Alan Yardley
Group Energy Controller
ARGYLL GROUP

3.00 Tea and Coffee

3.20 **BENEFITING FROM OPPORTUNITIES IN THE NEW GAS MARKET: EXPERIENCES OF A GAS PURCHASER**
* Detailing the purchasing options
* Are the independent gas companies interested in anything other than very large load purchasers?
* How to get the best deal
  – price
  – security of supply
  – service and support

Steve Heywood
Purchasing & Supply Manager
TATE & LYLE SUGARS

PLENARY

4.00 **THE FUTURE FOR NUCLEAR POWER IN THE UK?**
* Tackling the cost issues – can nuclear energy be competitive in the UK?
* Seeking a level playing field – can competition exist with subsidies?
* Understanding the new market place – what are contracts for differences?
* Can a baseload generator compete for business in the 100kW+ market?

Peter Webster
Sales and Marketing Manager
NUCLEAR ELECTRIC

4.40 Closing Remarks from the Chair
Professor Derek Bunn
LONDON BUSINESS SCHOOL

4.50 Close of Conference

"Excellent conference. Pertinent and topical with a good cross section of speakers"
Mr A Reece, Legal Adviser, Kerr McGee Gas (UK) Ltd

MEET OUR OUTSTANDING FACULTY OF KEY PLAYERS IN POWER GENERATION & SUPPLY

Professor Stephen Littlechild, Director General of Electricity Supply has had extensive experience of regulation both in the UK and abroad. He advised on the regulatory regime for BT and the water industry and was a member of the Monopolies and Mergers Commission for six years during which time he participated in reports on the North and South of Scotland Electricity Boards, Manchester Airport and British Gas. Before his appointment with OFFER, he was Professor of Commerce and Head of the Department of Industrial Economics and Business Studies at the University of Birmingham.

Michael Hope is a Partner with **Andersen Consulting** and is Managing Director of their European Utilities Industries. Michael has worked for Andersen Consulting for over 19 years and has extensive experience in the electricity, gas and water industries. Prior to transferring to Europe in 1990, he was responsible for Andersen's consulting practice in the Western United States and Canada.

Nigel Hawkins, is an Electricity Analyst with **Hoare Govett.** Previously he was Political Correspondence Secretary to the Prime Minister between 1984 and 1987. Prior to this he was employed at the Conservative research department as Desk Officer for trade, industry and Energy Affairs.

Dr Michael Morrison, has been a Director of **Caminus Energy** since 1988. He has a PhD in energy economics from the University of Cambridge and has also worked as an energy economist in the US, both as an academic and at the World Bank. Before joining Caminus, Michael worked for Shell International in Group Planning where he was responsible for oil market economics and scenario planning. He has particular experience in the oil, gas and electricity sectors. Dr Morrison is also a Council Member of the British Institute of Energy Economics.

Bill Watson, was appointed Managing Director (Generation) at **Eastern Electricity** in June 1993. Prior to this, he was both Engineering Director and Business Development Director. Eastern Electricity's current involvement in generation includes the combined cycle stations at Peterborough and Barking, and in two renewable projects. He has held the posts of Chairman of both Peterborough Power Ltd and Barking Power Ltd.

David Thomlinson, is a partner in the UK practice of **Andersen Consulting** and is Director responsible for the Power Generation industry in Europe. He is a Chartered Engineer and was formerly involved in the design and construction of a number of major building projects. Over the past five years he has specialised in consulting work for the electricity industry and has been responsible for leading projects in the UK, Italy, Czech Republic and Portugal.

Peter Franklin, joined **AGAS** in March 1993 as Head of Marketing and Sales Co-ordinator. Peter began his career in energy 15 years ago, joining Shell where he built up a broad portfolio of experience covering market research, industrial fuels marketing and sales management in the UK, petrochemicals supply and marketing in Italy and strategic development as Head of Downstream Strategic Planning in the Netherlands.

Cynthia Dubin, is Manager, Project Finance with Mission Energy. She is responsible for arranging and managing the project finance activities of the company in Europe. Additionally, Cynthia works closely with the business development team to ensure financeability of potential opportunities in the early stages of the project development. Before joining Mission, Cynthia was a Vice-President of the Mitsubishi Bank in New York City. She worked in the Project Finance Group, focusing primarily on independent power projects.

John Harris, has been Chairman and Chief Executive of **East Midlands Electricity** since 1990. He joined the electricity industry in 1955 and was appointed Chief Engineer at North Western Electricity Boards in 1978 and Deputy Chairman in 1979. Between 1978 - 1984 he undertook additional responsibilities as UK Director of a British Electricity International (BEI) contract in Saudi Arabia. He was Director of BEI from 1982 - 1987. John Harris is also a Director of National Grid Holdings.

Gordon MacKerron, is a Senior Feilow in the Energy Policy programme, **SPRU** at the **University of Sussex**. He is an economist and has specialised for over a decade in the economic and policy issues in the electricity sector, with a particular concentration on nuclear power questions.

Dr David Elliott, is Senior Lecturer in **The Open University Faculty of Technology** and is Director of its Technology Policy Group. He worked for the UKAEA and the CEGB, before joining The Open University, where he has focused on energy policy issues.

David Frith, has worked for **NNC Ltd**, the major project management and engineering company - a subsidiary of GEC - since 1976. He initially worked on station performance predictions and commissioning tests, including nuclear and oil-fired plant but has since become involved in developing and managing new projects.

Dr Jim Skea, is Senior Research Fellow at the **SPRU** of the **University of Sussex** and has been the leader of the Environmental programme since 1991. Prior to joining the SPRU in 1983 he was Visiting Assistant Professor at the Department of Engineering and Public Policy, Carnegie-Mellon University in Pittsburgh.

David Newbery, is Director of the Department of Applied Economics at Cambridge and Professor of Applied Economics. He was a specialist advisor to the recent House of Commons Trade & Industry Committee on British Energy Policy and the Market for Coal and has been researching the privatisation of electricity and the workings of the UK energy markets. He is a member of the Environmental Economics Academic Panel for the Department of the Environment. He has spent 2 years as Division Chief at the World Bank and has held visiting Professorships at Berkeley, Princeton and Stanford.

Professor Derek Bunn, is currently Professor and Chairman of Decision Sciences at the **London Business School**. He had held previous appointments at Oxford and Stanford. Author of six books and over 70 papers in the area of forecasting and decision-making, he is editor of the Journal of Forecasting. Professor Bunn's research in electricity capacity planning has been actively supported for the past 15 years by the research councils, the CEGB and the privatised utilities.

Tony Cotton is Trading Director with the **Electricity Pool of England & Wales**. Tony commenced his career in the transport industry and later joined the Energy, Water and Transport division of Coopers & Lybrand. He later moved to Eastern Electricity. As Head of Contract Negotiation, Tony assisted with the establishment of the trading arrangements which came into effect with the establishment of the pool. In 1991 he joined the pool where his main responsibility is to work with the pool members to ensure that both present and future trading arrangements meet their needs and comply with provisions of the Pooling and Settlements Agreement.

Keith Miller, is the Pool Development Manager with **National Power**. Following the vesting of the industry, he was responsible for the establishment of a department within National Power to oversee the operation and development of the electricity market and the pool. He represents National Power at Settlement sub-committee meetings, represents generator pool members on the Project Board (set up to oversee the development of new Settlement software systems) and is chairman of the LOLP group. Prior to this, Keith was part of the privatisation team. He led the team developing the contractual and pooling arrangements required for the privatisation of the electricity industry.

Martin Stanley, is Pool Development Manager at **MANWEB**. An economist, he has been at MANWEB for seven years, the last five of which have been in power purchasing and pricing related activities. In his current post, he has taken an active role in the Longer Term Review of the pool and has represented MANWEB and the RECs on a number of the pool working groups.

Ken Green, is Commercial Director, Electricity & Water for **ICI Chemicals & Polymers** and Director of ICI's subsidiary, Impkemix Energy, formed to trade on the pool. He is deeply involved in matters associated with the theory and operation of the new electricity arrangements. Operating within ICI's Energy Policy and Purchasing Department, he was fully involved in the negotiations to agree an electricity purchase contract with Teeside Power.

David Porter, is Chief Executive of the **AIEP,** the trade association representing around 100 companies involved in nearly every generating technology in the UK. He is a member of the Executive Committee of the Electricity Pool, a member of the CBI Council and of the CBI's Energy Policy Committee.

Angus Morrow, is Engineering Manager with **Kennedy & Donkin Power**. He has over 25 years' experience in power generation consultancy, most recently in the field of assessing and reporting on technical due diligence for major CCGT power projects. In addition, he has been responsible for a wide range of feasibility and planning studies for leading international lending agencies and for the development of software for the analysis and simulation of power plant performance.

James Barry, is Project Director, Capital Projects Team at **Barclays Bank**. The Capital Projects team is part of the structured finance division within the Barclays de Zoete Wedd division of Barclays Bank and has played a major role in a number of the recent independent power project financings in the UK, including Teeside, Barking, Medway, NIGen and Derwent.

Nick Coleman, is Managing Director of **BP Energy**. He joined BP as an engineer 20 years ago. After working in oil and gas field development engineering, production management and corporate planning, he was seconded to the government to work on the privatisation of the electricity industry in England and Wales, when he managed the restructuring of the industry and the simultaneous flotation of 12 RECs. He is also deputy Chairman of the Combined Heat and Power Association.

Hugh Mortimer, is Commercial Manager, Bulk & Tonnage with **BOC Ltd**. His responsibilities include electricity purchasing. He was a member of BOC's electricity privatisation team and conducted commercial negotiations with all members of the ESI. This resulted in a long term supply agreement between BOC and Scottish Hydro-Electric. Prior to electricity privatisation, as Senior Purchasing Manager, he led the BOC National Supply Agreements section responsible for purchasing a wide range of goods and services.

Alan Yardley, is Group Energy Controller with **Argyll Group**. An electronics engineer by trade, Alan spent over two years with Argyll Group as an electrical engineer and is now responsible for group purchase and control of energy in the UK. He is customer representative for the MEUC and British Retail Consortium regarding the 100KW markets and is the customer representative on the 100KW project group, responsible for the implementation of the 100KW market.

Steve Heywood, is responsible for **Tate & Lyle's** purchasing activities, including negotiating for supplies of energy on behalf of other members of the Tate & Lyle Group

Peter Webster, is Sales & Marketing Manager with **Nuclear Electric**, responsible for sales of electricity, principally to the RECs in the form of contracts for differences. Peter commenced his involvement with power generation working for Shell International - as Coal Sales Manager, Mediterranean and later in a post co-ordinating Shell's worldwide Energy Management business. In 1985 he moved to Dubai as Supply and Trading Manager, a role that included responsibility for local tanker movements during the Gulf War. More recently, Peter was Energy Sales Manager for Shell UK, covering industrial oil sales and coal imports. As Energy Sales Manager, he set up an electricity trading company and was awarded the first second tier supply licence issued to a company outside the ESI.

SELECT EXACTLY THE INFORMATION THAT IS RELEVANT TO YOU (and take away a full set of documentation)

Don't waste your time - choose from 21 different sessions and make sure that within the 2 concentrated days of the conference you hear only those talks that are most relevant to your particular business area and concerns. Thanks to the streamed format, you can mix and match and still be sure to hear industry leaders and key experts give an in-depth presentation on your chosen topic.

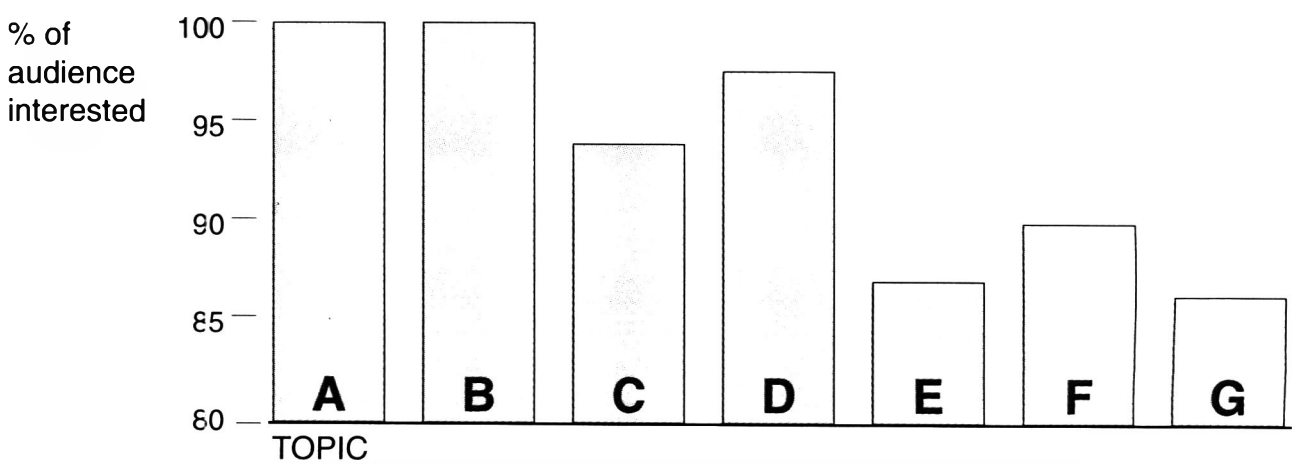
Take away a full set of documentation, including papers from all the sessions you didn't attend. No matter what your interests in Power Generation and Supply, you will find that this conference gives you vital new information on the latest developments. Don't miss this unique opportunity to get all the information you need to plan a successful future!

MAKE THE RIGHT CONTACTS - TAKE ADVANTAGE OF OUR NETWORKING SERVICE AND SPEAKER TABLES

Take advantage of this event to meet your industry peers and colleagues. We will provide a networking service for all conference speakers and delegates. Should you wish to contact a particular delegate or speaker (as available) please leave your business card at the reception desk with details of who you wish to be introduced to. We will make every effort to ensure this introduction is made. Also, most speakers will be available for conversation at luncheon tables - during the morning coffee break of the first conference day, a list of speakers' table numbers will be displayed, giving the delegates the opportunity to question and discuss points of their choice that are raised during the conference.

PGS '94 - A CONFERENCE BUILT AROUND YOUR NEEDS

THE RESULTS OF OUR RESEARCH WITH OVER 120 SENIOR POWER GENERATION AND SUPPLY MANAGERS AND INDUSTRIAL USERS



A Addressing key regulation and competition issues in the electricity market
B How the pool could operate more effectively and efficiently
C Examining the future of nuclear power in the UK
D Capitalising on new business opportunities for energy companies
E A close examination of industrial purchaser issues
F Analysing the economics and finance of power generation projects
G Examining the future of renewables and the impact of environmental regulations on power generation

TAKE ADVANTAGE OF THE EXTRA-CURRICULAR ACTIVITIES AT PGS '94 MEET YOUR PEERS AT THE CONFERENCE COCKTAIL PARTY

A cocktail reception will be held at the close of the first day of the conference - Thursday 13th January - sponsored by IIR Ltd. This is an ideal opportunity for delegates to network with speakers and other conference attendees in an informal atmosphere.

MIX BUSINESS WITH PLEASURE IN LONDON - AN IDEAL RENDEZVOUS FOR THIS INDUSTRY FORUM

Why not mix business with pleasure while in London for PGS '94! This year's annual Power Generation and Supply conference will be held in one of London's premiere hotels, The Langham Hilton, in the heart of the city's West End. Why not stay the weekend to enjoy the sites of London, the wealth of theatre, excellent shopping and the many restaurants just a short walk from the beautiful venue.

The Langham is truly a top-class hotel and venue. And don't miss the Langham Hilton's Czar's Bar - specialising in over 30 varieties of vodka!

SPECIAL WEEKEND BREAK RATES

If delegates wish to bring family, The Forte Crest Regents Park can offer weeknight rates of £80.50 per person including breakfast. If you would like to stay the weekend, the Forte Crest Regents Park has a special weekend break rate of £58.00 per person per night (incl VAT) - breakfast and dinner inclusive. Phone the Hotel reservations on 071 388 2300.

The hotel is ideally situated close to Regents Park and London Zoo. Delegates can take a canal trip from the buzzing market area of Camden to serene Little Venice. The hotel is also a short distance from the Planetarium and Madame Tussauds in Baker Street. Take advantage of the London Sightseeing buses that run from this famous street.

The Forte Crest Regents Park is a 10 minute walk from Oxford Street and Euston and Kings Cross train stations are a few minutes away for easy access to London - or trips into the English countryside.

For those delegates wishing to explore the city, The Langham Hilton or the Forte Crest Regents Park will be ready to answer your questions, suggest trips and book theatre tickets for you.

HEAR THE SESSIONS YOU MISSED

Tapes of our speakers' addresses will be a definitive source of reference and an invaluable "aide-memoire" back at the office. Should you require a copy of any of the speeches please ask at the conference reception desk for details.

TAKE ADVANTAGE OF THIS CONFERENCE AS A PLATFORM FOR YOUR SERVICES AND PRODUCTS

A special exhibition display will provide you with the opportunity to market your products and services to key industry decision makers.

Exhibiting at this event will add a further dimension to new product or service launches, expanding into new markets or heightening your company profile. Comprehensive packages are available that can be tailored to meet your business needs and budget. Exhibiting at this forum also has other benefits, including delegate places at the conference and an insert into the delegate's documentation pack.

There are also limited opportunities to:

- ★ advertise in the delegate documentation pack
- ★ sponsor and host a lunch or dinner

If you would like to communicate with the key decision makers among your audience, call Sara Fairman or Steve Scott on intl 44-71-379-8040 to receive further details.

PGS '94 POWER GENERATION & SUPPLY

Conference Registration Form

POWER GENERATION & SUPPLY
13th & 14th January 1994
Please complete and return to:
IIR Ltd, 28th Floor, Centre Point,
103 New Oxford Street, London WC1A 1DD.
Telephone: Intl. 44-71- 412-0141 Fax: Intl. 44-71- 412-0145
Please do not remove this label – it contains your customer code which we will request if you make a telephone booking

CODE: A B C D E F G H I J K L **M N O**

☐ Yes I would like to book on . . .
Please quote our reference number N6286 when making a telephone booking and on the reverse of your cheque

REGISTRATION DETAILS

Dr/Mr/Ms FORENAME SURNAME

.....

Title .....

Department .....

Name of Approving Manager *(Mr/Ms)* (PLEASE PRINT) .....

.....

Title .....

Department .....

Company.....

Address.....

.....

Country.....Postcode.....

Tel: .....Ext .....Fax .....

Name of Secretary in case of queries.....

Nature of your company's business.....

Number of employees on your site

0-49 ☐ 50-99 ☐ 100-249 ☐
250-499 ☐ 500-1000 ☐ over 1000 ☐

CONFIRMATION DETAILS

HOW MUCH?	FEE	VAT	TOTAL
	£895.00	£156.63	£1051.63

Please use this form as our request for payment. All posted registrations must be accompanied by a cheque or credit card details.

Please debit my ACCESS ☐ VISA ☐ EUROCARD ☐ AMEX ☐

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Signature..... Expiry date .....

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★ Confirmation will be sent only when FULL PAYMENT is received

CONFIRMATION DETAILS

A reservation can only be confirmed when full payment is received. On receipt of such payment, you will be sent a letter stating registration time and cancellation details, a copy of the brochure, and directions to the venue.

OTHER ALTERNATIVES

I would like to attend this event, but cannot so:

☐ please send me details of any future relevant events
☐ I am interested in buying documentation, please send me details
☐ I would like to purchase the tapes of the proceedings, (where release has been authorised by speakers). This includes a copy of the documentation. Enclosed is my cheque for £376 (inc.VAT)

WHO SHOULD ATTEND?

Managers involved in all aspects of Power Generation and Supply. Whether you are from a Generator or Regional Electricity Company, Independent Gas Marketer or oil company, this conference has something to offer you. Electricity and Gas purchasers will also find that this is the event you should not miss!

ADMINISTRATION DETAILS

WHEN? Thursday & Friday 13th & 14th January 1994

WHERE? The Langham Hilton, London
1 Portland Place
London W1N 3AA
Tel: 071 636 1000

HOW MUCH?	FEE	VAT	TOTAL
	£895.00	£156.63	£1051.63

HOW DO I REGISTER? Three easy ways!

1. Fax us on Intl: 44-71- 412-0145, to reserve your place provisionally then send the completed registration form with a cheque or credit card details to guarantee your place.
2. Telephone us on Intl: 44-71- 412-0141, any time from 9.00 am to 5.30 pm weekdays to reserve your place provisionally, then send the completed registration form with a cheque or credit card details to confirm your place.
3. Complete the registration form and send it with a cheque or credit card details to: IIR Ltd, 28th Floor, Centre Point, 103 New Oxford Street, London WC1A 1DD

* Please note. Payment, whether by cheque, bank transfer or credit card, must be included with your application to guarantee your place and must be received before the conference date.

WHAT HAPPENS IF I HAVE TO CANCEL? A prompt refund, less a service charge of 10% of the fee plus VAT, will be made in respect of notification of cancellation received in writing at this office no later than 30th December 1993. Where notice is given between this date and 6th January 1994, refunds will be 50% of the fee; thereafter no refunds will be made. A substitute delegate is welcome at no extra charge.

CAN I PURCHASE THE DOCUMENTATION OR TAPES IF I CANNOT ATTEND? – If you wish to receive copies of the documentation or the audio-cassette tapes (where release has been authorised by speakers), please tick the box on the registration form, complete the form and return it to IIR with your cheque or credit card details. The fee for the tapes (which includes a copy of the documentation) is £376 (inc VAT)

WHAT DO I DO ABOUT INCORRECT MAILING INFORMATION? – If you are receiving multiple mailings for this event, or perhaps there is an error in your own or your company details, we do apologise. To enable us to improve our service, please send us the incorrect brochure (with the mailing address label), so that we can update our database immediately.

DATA PROTECTION If you do not wish to receive other relevant direct mail offers, please write to the Database Manager at the address on the booking form.

HOTEL ACCOMMODATION: A special delegate rate has been organised with the Langham Hilton Hotel. Phone Hotel Reservations on 071-636 1000 for details stating that you are an IIR delegate. Special weekend rates have been arranged with the Forte Crest Regents Park. See Inside brochure for details.

Three doughs are made using the same flour with different quantities of 2.5% salt solution (usually 14, 15 and 16 ml for 28 g flour). For a yeasted dough, 0.35 g compressed yeast is added. The mixed doughs are placed in three containers and allowed to ferment for 3 h at 80°F. At the end of fermentation period, the dough is flattened on a glazed surface using a spatula to remove gas. It is cut into small strips and loaded into the gun of the instrument for extrusion by releasing the weight on the gun. The time taken for the piston to travel 1 cm down the gun, which is equal to the one revolution of the needle of the dial gauge, is recorded. The same process is repeated with other two samples of the doughs. A graph on the logarithmic graph paper of extrusion time against the amount of water added is plotted. A straight line is drawn through the three points and water absorption is recorded from the point at which the line cuts the 50 sec line. The points should be distributed above and below that of the 50 sec time and, accordingly, the test is repeated with amended water absorptions. When unyeasted doughs are used, the relaxation time of 1h instead of 3 h is allowed between mixing and extruding. The reproducibility of data can be improved by temperature control and use of equipment for shaping the test pieces (Muller and Baren 1958). The measuring range of instrument can be enlarged by changing the weight on the plunger (Wensveen and DeMiranda 1955).

Extensograph

The extensograph records a load-extension curve for test piece of dough stretched until it breaks (AACC 1980). The extensograph measurements are empirical in nature and difficult to be interpreted in terms of basic rheological properties because of inherent difficulties in separating viscous from elastic components in load extension curves and also due to the non-ideal visco-elastic behaviour of wheat flour dough. The measurements are used for assessing the quality of flour and also its response to improving agents. The basic parts of extensograph are cradle, cradle clip, motor, stretching hook, levelling system, scale head, damper and kymograph (Sietz 1991).

Procedure : The water absorption of flour is determined using farinograph. Dough is prepared in large farinograph bowl using 300 g flour (14% moisture), water and 6 g salt. The amount of water used is equivalent to farinograph water absorption minus 2% to compensate for the effect of salt. The dough is mixed for 1 min, rested for 5 min and the mixing continued till the peak reached 500 BU line. The dough is scaled to 150 g and rounded by applying 20 revolutions in the rounder. The dough ball is then shaped into a cylindrical piece in the shaping unit, clamped in the greased holder and kept in humidifier chamber. Remainder of dough is used for replicate test. After 45 min of rest, the test sample is placed on the balance arm of extensograph and the pen is adjusted to the zero position of the chart.

By starting and running the stretching hook, the load extension curve is recorded till the test piece breaks. The dough is reshaped as before and the test repeated at 90 and 135 min rest periods. A typical extensogram is shown in Fig.4.

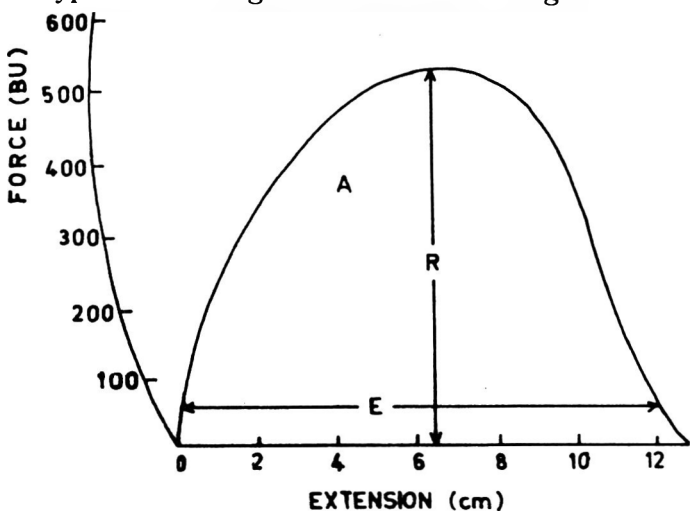

Fig.4. Typical extensogram : R) resistance to extension, E) extensibility and A) area.

The measurements made on load-extension curves or extensograms are :

Resistance to extension : It is the height of the curve at maximum in BU.

Extensibility : It is the total length of the curve in cm.

Area : It is the area under curve (sq. cm) and is measured using a planimeter.

Ratio figure : It is the ratio between resistance to extension and the extensibility.

The extensograms can be classified as weak, medium, strong and very strong based on dough strength. Flours that give areas less than 80 cm^2 and between 80-120 cm^2 are weak and medium, respectively. The areas of 120-200 cm^2 and more than 200 cm^2 are considered as strong and very strong, respectively. Similarly, flours with low extensibility are classified as short or buck, while those with high extensibility are known as extensible and pliable (Preston and Hoseney 1991).

Other extensograph procedures include structural relaxation method by Dempster et al. (1952, 1953, 1955) and work technique method by Muller et al. (1961, 1962, 1963).

Structural relaxation method : The structural relaxation method shows the changes in resistance to extension at a constant rate of extension, as the relaxation time between molding and stretching of dough is increased. Time dependent oxidation is measured in this study. In the work technique, the dough is stretched to various pre-defined resistance values prior to rupture, the movement of the hook is reversed to allow the test piece to recover and the hook is moved downwards after a fixed time period, until it contacts dough. The movement of hook is reversed again and the effective mass of the dough is then measured (Muller et al. 1961). Analysis of results enables to separate the viscous and the elastic components of the dough. Extensograph characteristics depend mainly on length of rest period allowed between shaping and stretching of dough. The change in load with rest period is the basis for determination of structural relaxation.

Procedure : Dough is made from 200 g flour (14% moisture), 1% salt and water based on farinograph water absorption (minus 4%) and mixing for 2.5 min in a Grain Research Laboratory mixer. The dough is scaled to 150 g and placed at 30°C and 95% RH. A total of six test pieces are made for complete structural relaxation curve. At the end of the rest period, the dough pieces are shaped and clamped and the load extension curves are recorded. The rest period used are 5, 10, 25, 45, 75 and 105 min. From the curve, the resistance at the end of 7 cm extension is read. The product of load and rest period along y-axis are plotted against rest period on x-axis, which gives linear transformation of stress relaxation curve. From the curve, the structural relaxation content and asymptotic load (L_A), are determined from the intercept and slope of the line, respectively. These determinations define the dough properties.

Variations in methods : Both the methods recommended by American Association of Cereal Chemists (AACC 1983) and the International Association for Cereal Chemistry (ICC 1980) employ 300 g flour (14% m.b.), 6 g salt and water to obtain dough consistency of 500 BU. In ICC method, dough is mixed for exactly 5 min, while it is mixed for 1 min, rested for 5 min. and then mixed to peak consistency in AACC method. Thus, the working of the dough and effect of oxygen during mixing are held constant in ICC method, whereas, dough development is optimal but work input and oxidation are variable in the AACC method. These differences can result in different extensograph characteristics for the same flour (Muller and Hlynka 1964). These two methods are identical beyond the mixing stage of the methodology.

The Royal Australian Chemical Institute (RACI, 1988) has published a standard extensograph method. Strong flours are mixed for 5 min, while biscuit flours are mixed for 1 min, rested for 30 sec, then mixed for further 30 sec. After this mixing methodology, the further procedure is the same as in AACC and ICC methods. Reproducibility of values is reported to be better at 45 min than at 135 min rest period in ICC method. The higher degree of oxidation due to longer exposure to air is probably responsible for higher resistance to extension values and shorter extensibility values at 135 min than at 45 min rest period (Aitken et al. 1944).

Small scale procedures using dough pieces weighing 75 g or less have been described by Oliver (1979) and Babyakin and Ishina (1981). The studies on the use of extensograph for determining the quality of flour; the effect of ingredients like oxidants and related compounds, lipids, salt, pH, other ingredients; and processing conditions like mixing, rest periods, absorption and temperature, have been reviewed by Preston and Hoseney (1991).

Chopin Alveograph

The Chopin alveograph consists of the mixer, bubble blowing portion and recording manometer (Kent-Jones and Amos 1967). The mixer and the alveograph are maintained at a constant temperature of 25°C. The moisture of the flour is determined and the quantity of 2.5% salt solution to be added to 250 g flour (15%, m.b.) is calculated. The flour is taken into the mixer, the calculated salt water is added and the mixing is carried out for 7 min. The mixer is stopped and the small shutter on the side of the mixer is raised. The mixer is started again to expel the dough in the form of a narrow strip. The small steel plate, on which the dough extrudes, is oiled and the first 2 inches dough discarded. Four pieces of dough are cut off and placed on a glass plate. Each piece of dough is cut into a circular disc, oiled, kept in tempering compartment and relaxed for 20 min. The dough pieces are tested individually on the alveograph by being blown into bubbles and four super-imposed curves are recorded (Kent-Jones and Amos 1967).

The measurement is based on the pressure attained by a carefully controlled flow of air against a dough sheet until the extended dough membrane bursts. The dough piece is held between two metal plates, the upper one having a circular hole of 58 mm in diameter, through which the expanding dough bubble rises, while the lower plate is provided with a small air valve. The air valve leads to a small air chamber, situated beneath the bottom plate. This air chamber is connected to a large burette which provides the air pressure by displacing the air for water. The air chamber is also connected to a manometer which records the air pressure within the dough bubble against time (Pyler 1979). The typical curve obtained is shown in Fig.5.

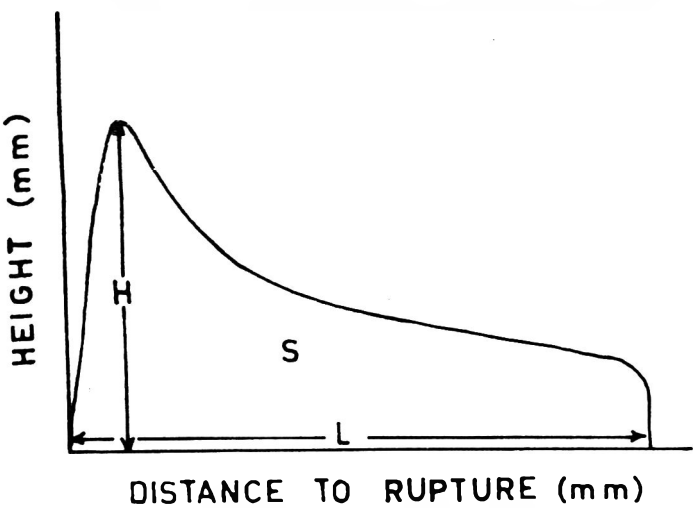

Fig.5. Typical alveogram : S) area, H) peak height and L) length of curve.

The measurements recorded are as follows :

Area : The area of the curve is obtained in sq. cm by means of a planimeter and is found to be related to the baking strength of flour.

Peak height : The peak height (mm) is found to be related to the stability of the dough.

Length : The length of the curve (mm) gives the stretching power of the dough.

Swelling index : It is square root of the volume of the air (ml) used to blow the bubble. ($G=\sqrt{Vrupt}$)

Dough tenacity : It is calculated by multiplying the height of the curve by 1.1. P is an indicator of the resistance to deformation.

P/L ratio : It is an indication of the balance of elastic to viscous components in a dough.

The deformation energy (W) : It is the mechanical work in 10^3 ergs to blow the bubble per g dough and is calculated by $W = 6.54 \times G \times 10^3$.

Unlike extensograph, the alveograph does not show the effect of flour improvers. This limitation is overcome by special procedures which provide for longer reaction times for structural activation (Bennett and Coppock 1952; Hlynka and Barth 1955). The advantage of alveograph over extensograph is the mode of expansion of dough. The dough expands in one direction at a constant rate of extension in extensograph, while the expansion is in two directions and the rate of expansion varies as the bubble grows in alveograph. This action is more related to the action on a piece of dough during fermentation and the early stages of baking (Launay and Bure 1977).

Hagberg Falling Number

The Hagberg falling number is based on the principle of Stoke's law, except that a specially designed stirrer is used in place of a falling sphere (Shuey 1974). The instrument utilizes the principle of the rapid gelatinization of a flour suspension with subsequent measurement of the liquefaction of the starch through the action of alpha-amylase. Falling number is the time (sec) required to stir and allow a viscometer-stirrer to fall a fixed distance through a hot aqueous flour suspension which is undergoing liquefaction.

Procedure : The water in the bath is brought to boil and the boiling continued during the test. Seven g flour sample is weighed and 25 ml distilled water at 20°C is taken into the viscometer tube. The flour is transferred into the viscometer tube. The flour water suspension is made by placing a stopper in the tube and inverting it 10 times. The upper part of tube is scrapped with the viscometer stirrer. The viscometer tube is placed with the stirrer in the boiling water bath and the timer started. The instrument stirs the flour water suspension automatically for 60 sec and leaves the stirrer at the top of the gel. The stirrer, due to its own weight, moves down during the liquefaction of starch gel by alpha-amylase. When the stirrer touches the lower edge, the timer stops automatically, gives the alarm and the time in sec is noted on the counter. Falling number is inversely proportional to the alpha-amylase activity. The liquefaction number which is directly proportional to alpha-amylase activity is given by

$$\text{Liquefaction number} = \frac{6000}{\text{Falling number} - 50}$$

The weight of wheat ground for preparing the sample (Tipples 1971) and dimensions of tube (Meredith 1970) influence the falling number. Greenway and Neustadt (1967) reported that water

bath level, temperature of water, weight of sample, volume of water used, particle size of flour, mill used for grinding, method of suspending flour, severity of mixing and bleaching of flour affect the falling number to varying degrees.

Brabender Visco-amylograph

It measures the change in viscosity of flour and water suspension as the temperature is raised at uniform rate. The instrument records the gelatinization temperature, the maximum viscosity on heating, the viscosity of the paste at the end of cooking, the viscosity increase on cooling and the viscosity of the cold paste (Rasper 1980). The visco-amylograph consists of a bowl and a stirrer which is connected to a highly sensitive measuring spring cartridge. The bowl is rotated at a uniform speed (75 rpm) and the stirrer deflects depending on the viscosity of the sample. The resistance encountered is transmitted to the spring system and continuously recorded by the recording system. Temperature is controlled by the thermoregulator. Cooling is effected by water circulation and a solenoid valve controls the supply of water. When increasing or decreasing the temperature during test, a synchronous motor drives the thermoregulator up or down by the gear train. The entire system is programmed by a pre-set timer which monitors the test run. The sensing element consists of a plate to which seven pins are attached. This element acts as a stirrer and is an extension of a shaft which is connected to a calibrated spring. The drag of the shaft against the resistance of the calibrated spring cartridge weighing system depends on the viscosity of the test slurry and is recorded on chart paper in torque units in terms of cm g or Brabender units. The instrument covers the range of 0 to 1000 BU or 0 to 5000 CP. The range can be increased with the addition of weights.

Procedure : A flour sample of 100 g on 14% moisture basis and citric acid-disodium phosphate buffer solution (pH 5.3 and 460 ml of buffer) are placed in the bowl. The instrument is put on with the thermoregulator engaged. The temperature rises at a rate of 1.5°C/min. During heating, the viscosity of the suspension increases as the gelatinization temperature of the starch is reached, while at the same time, the starch gel is liquefied by the amylase activity. The viscosity begins to decrease when liquefaction rate is greater than gel formation. Thus, the peak viscosity measured is inversely proportional to alpha-amylase activity.

AACC procedure : With 100 g of flour on 14% moisture basis and 460 ml buffer solution, the peak viscosity in BU is determined. This value is called as the malt index of the flour. The effect of different malt flours or varying levels of malt flour can be determined.

ICC procedure : With 80 g of wheat flour or Rye flour, weighed on 14% moisture basis, and 450 ml of water, the test is conducted. The test is run from initial temperature of 30°C to final temperature of 96°C for 44 min. The viscosity at 96°C is recorded.

Special rapid amylograph accessories reduce the running time to obtain curve in 5 to 15 min. The instrument is also available with automatic programmes. With a modified procedure, the alpha-amylase activity in fungal amylase preparation can also be determined.

The visco-amylograph has been adopted for many types of materials (Tipples 1980). When using standard procedure, a water suspension of starch or starchy material is heated from 25°C to 95°C at the uniform rate of 1.5°C/min and under constant stirring at 75 rpm. The sample is maintained at 95°C for 30 min, while being continuously stirred. The paste is, then, cooled down to 50°C at the specified rate of 1.5°C/min and held at the temperature for another 30 min. A typical amylogram is shown in Fig.6.

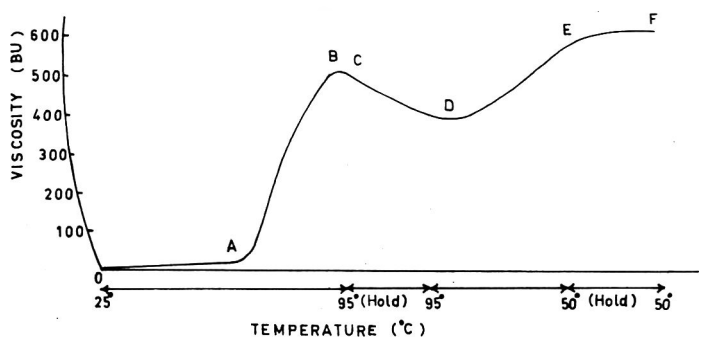

Fig.6. Typical amylogram : A) gelatinization temperature, B) peak viscosity, C) viscosity at 95°C, D) viscosity after cooking for 30 min at 95°C, E-D) Set-back and F) viscosity after holding for 30 min at 50°C.

The visco-amylograph is used to determine the following parameters :

Gelatinization temperature : It is the temperature at which starch starts gelatinizing.

Peak viscosity : It is the viscosity in BU at peak irrespective of temperature at which it is attained.

Viscosity at 95°C : It is viscosity in BU on attaining 95°C temperature. The relation of this value to peak viscosity reflects the ease of cooking the starch.

Viscosity after cooling for 30 min at 95°C : It is viscosity in BU after holding period of 30 min at

95°C. It illustrates the stability of paste during cooking.

Set-back : This is the difference in viscosity after cooking at 95°C and cooling to 50°C. It reflects the retrogradation tendency of starch, with inhibited starch exhibiting minimum viscosity increase on cooling.

Viscosity after 30 min at 50°C : It is viscosity after 30 min of holding at 50°C. It indicates the stability of cooked paste.

Expansograph

It measures the gas retained by the fermenting dough. The dough volume during fermentation is registered in the form of a curve (Shuey 1974).

Dough prepared with 20 g flour, 2.5% yeast, 50-55% water and 2.0% salt is kept at 30°C constant temperature during fermentation in a vessel filled with water. The water level rises due to the expansion of the dough. The gas retaining ability of the dough is related to the water level which is measured and recorded by a manometer. The temperature is automatically regulated by a built-in thermostat. The typical expansogram is shown in Fig. 7.

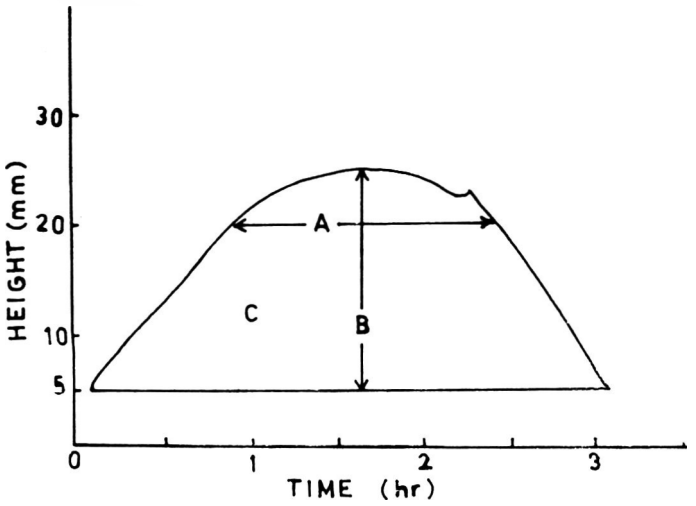

Fig.7. Typical expansogram : A) stability, B) gas retention capacity and C) area

The following parameters are measured:

Stability : It is the distance between the points where the curve cuts 20 mm line. The more the distance, the stronger is the flour.

Gas retention ability : It is the height of the curve from 5 mm line to its maximum.

Area : The area above 20 mm line is measured using planimeter.

It is stressed that the height of the curve indicates maximum dough volume. The dough holding large volume of gas for longer period indicates better baking quality than a dough that collapses in a short time after attaining same volume.

Brabender Maturograph

It is used to determine the proofing characteristics of fermenting dough (Seibel 1968; Shuey 1974). The dough is prepared using a standard recipe containing 300 g flour, 3 g yeast, 4.5 g salt, 3 g fat, 3 g sugar and variable water. The dough is mixed in farinograph for 5 min and 150 g dough is allowed to ferment at 30°C and 85% RH for 60 min. The maturograph records the proofing behaviour of dough through a sensing probe which touches the dough. With the additional loading on the sensing probe, which occurs periodically, the elasticity of the fermenting dough is recorded. The sensing probe and counter-weight are connected by a steel band. The latter is guided over a pulley which is frictionless. The sensing probe contacts the dough with a weight of 5 g and the increasing volume of dough lifts the sensing probe. The movement is transmitted and recorded on a chart. A cam lever equilibrates the counter weight via lever arm and drops full weight of sensing probe on the dough for a short period. The sensing probe penetrates the dough and the depth of the penetration depends on the elasticity of the dough and its gas pressure. The cycle is repeated every 2 min which produces the typical zig zag curve. The curve rises until maximum dough maturity is attained and drops thereafter. The typical maturogram is shown in Fig.8.

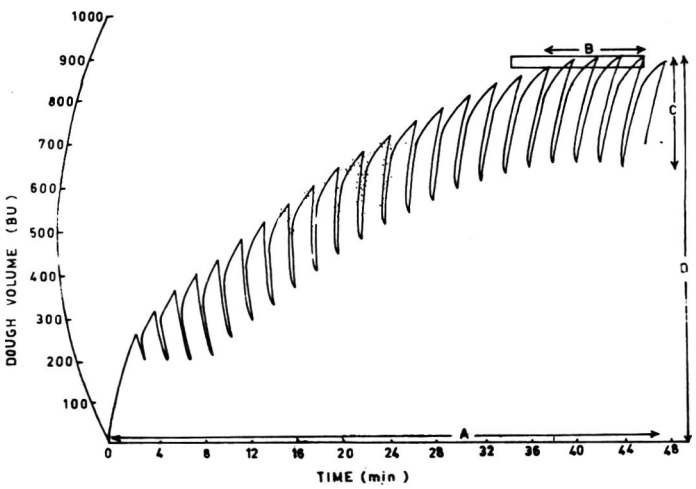

Fig.8. Typical maturogram: A) final proof, B) proofing stability, C) elasticity and D) dough level

Various measurements are :

Final proof : It is the time in min from the start of final proof to the first drop of the curve after the maximum. This indicates optimum maturity.

Proofing stability : It is the stability at the peak measured using stencil. This indicates tolerance in min during which the loaf has to be put into the oven.

Elasticity : It is the band width in BU at peak which shows elasticity of the dough.

Dough level : It is the height of the curve in BU at the peak.

Brabender Oven-rise Recorder

This instrument records change in volume of dough during baking (Shuey 1974). After proof period (as determined in maturograph), a separate test piece of 50 g held at 30°C and 85% RH, is kept in a metal basket and is baked in an oilbath heated from 30°C to 100°C for 22 min. The suspension hook is connected to a scale head which, in turn, is linked to the chart recorder. The volume of the dough increases with the temperature and the test piece ascends in the oilbath. This action is sensed by the scale system and recorded. A typical curve is shown in Fig.9.

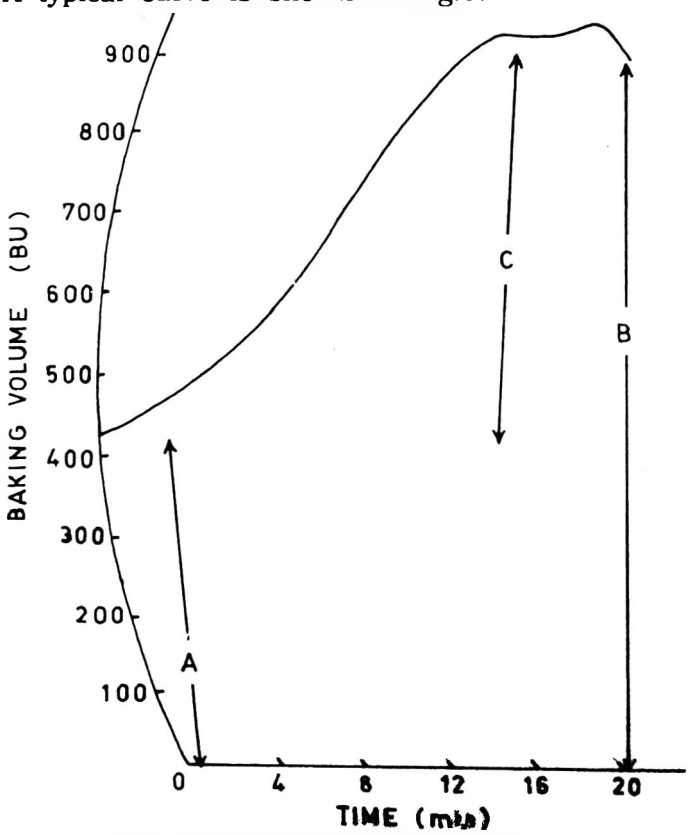

Fig.9. Typical oven-rise recorder curve : A) dough volume, B) baking volume and C) oven-rise.

The curve is evaluated for the following criteria :

Dough volume : It is the height of the curve at the beginning of the test and indicates the volume of dough at the start of baking period.

Baking volume : It is the height of the curve after 22 min at the end of test.

Oven rise : It is the difference between final volume and dough volume.

There are two drawbacks in measurements from this instrument. The temperature applied to dough in actual baking is not gradual as is the case in this instrument. The differences in temperature lag and immersing the dough in oil as against the hot moist air in an oven vary with the baking process.

Conclusion

In recent years, efforts are being made to modify the instruments and procedures to suit to smaller flour sample size. This has shown usefulness in the development of newer cultivars by the breeders. Some developments have also taken place in reducing the time for determination and also to find out the effect of various levels of different ingredients on the dough properties.

The determination of rheological characteristics of wheat flour dough is becoming faster with the increased use of computers with recording of curves on a computer through substitution of transducer-computer combination for the pen recording system. This system helps in more accurate, rapid and reproducible calculation of curve parameters.

Presently, increasing attention is being paid to the rheological properties of wheat flour dough because of the usefulness of the information in predicting processing characteristics of dough and the quality of end product. Also, the dough rheology helps in the quality control programme and in establishing specifications for ingredients and final product. Though the different rheological parameters, measured in the instruments described, are expressed mostly in arbitrary units, these properties are highly related to processing characteristics and end product quality.

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Evaluation of Thermal Process and Shelf-Life of Kinnow Juice

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The slowest heating point was found to be at the geometric centre and at 1/10th of the height from the bottom along vertical axis for pouched and bottled Kinnow juice. The thermal processing time on the basis of pectinmethyl esterase inactivation was 28.3 and 17.0 min for bottled and pouched juice, respectively. Invert sugars increased, while total sugars declined with storage under ambient conditions. Cans, being opaque to light, retained higher amounts of ascorbic acid during storage. Various sensory attributes were significantly affected by types of packaging containers and storage.

Keywords : Thermal process, Pouch, Storage, Shelf-life, Kinnow-juice, Bottle, Cans.

Kinnow-mandarin is an important commercial fruit crop of Punjab. A fully ripe Kinnow has bright and deep attractive colour. It has a thin tight and compact skin, which is easy to peel by hand. The fruits are juicy and fresh juice, extracted from the fruit harvested at appropriate stage of maturity, has refreshing flavour with characteristic pleasing aroma. Reports on storage of fruits after waxing (Subba Rao et al. 1967), storage of juice concentrate (Sandhu et al. 1985) and pulp (Adsule and Roy, 1975) are available.

The flexible pouches are possibly one of the most thoroughly researched food packaging innovations in recent years due to their logistic advantages like lower prices, functionality, light weight and saving in freight. The packaging of food products in bottles and cans is cost intensive and poses disadvantages like fragility, metallic toxicity etc. Therefore, the use of flexible packs can be economically viable. Scanty work has been reported on the thermal process requirements of such packs, although Nath and Ranganna (1977) worked out processing requirements for canned orange segments. The processing schedules so far used have been based upon inactivation of pectinmethyl esterase (PME) using hit and trial methods. There is a need to determine the heat transfer characteristics in flexible pouches to establish the time temperature relationships and provide basic information to the processors interested in shifting from rigid to flexible containers. Therefore, the present investigation was undertaken to study the heat penetration characteristics and to calculate the processing schedule as well as shelf-life of Kinnow juice in flexible pouches.

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Materials and Methods

Kinnow-mandarin oranges harvested during 1988-89 were procured, washed and handpeeled. The juice was extracted using superfine pulper (Raylon's India) and divided into two lots. One lot was used as such for thermal studies, while the second lot was packed and stored for shelf-life studies. Heat penetration characteristic of the juice in pouches (300 gauge polypropylene (PP), 15 cm x 10 cm) as well as bottles (200 ml) was investigated by inserting the thermometer from top at the centre cold point. In case of pouches, a specially designed rack with compartments to hold a single pouch was used. The heat penetration was studied by recording the temperature at regular intervals, keeping the temperature of the immersion medium (water) constant. The cold point was determined by inserting thermometer at the centre along the vertical axis at heights of 1.25, 3.10, 6.25 and 7.50 cm in case of bottles and 3.75, 5.00 and 6.25 cms from bottom in case of pouches. After establishing the cold point, heat penetration studies were conducted to calculate the process schedule using the graphical method of Ball and Olson (1957). The inactivation rates on the heat penetration curves, during heating and cooling at various points, were calculated using the expression :

$$I = \log^{-1} \frac{T-T_x}{Z}$$

Where I = Inactivation rate at temperature T
T_x = Temperature at which F is 1
Z = Number of degree F required for TIT curve to traverse one log cycle

The thermal inactivation rate curve was drawn by plotting inactivation rate against time. The F values for process calculation in case of pectinmethyl

esterase (PME) in Kinnow juice was taken as $F^{21.6}_{206.5}=1$ at pH 4.0 (Nath and Ranganna 1977).

The process times required to achieve F value were calculated by drawing cooling curves at different intervals, parallel to the original cooling curves. Area under these curves was determined using an automatic digital planimeter. The actual processing time was determined by the graphical interpolation method i.e. plotting F value versus process time and determining the process time required to achieve F value of one. Analyses of fresh and stored juice were conducted using the standard procedures as described by Ranganna (1986). Tintometric colour values were measured using Lovibond tintometer and colour expressed in yellow, red and blue units. Sensory quality was evaluated by a semi-trained panel consisting of 6 to 7 judges.

Results and Discussion

Composition of fresh Kinnow juice : The fresh juice, immediately after extraction, possessed highly attractive colour with characteristic pleasing aroma and was practically free from bitterness. Total solids (14.5%) comprised mainly of reducing and total sugars, acids, proteins and pectins with their respective values of 3.3, 7.0, 0.7, 0.4 and 0.2%. TSS value was 13.5° Brix with Brix/acid ratio of 18.7 and these values are higher than the recorded values (Bal and Chohan 1983; Josan et al. 1983), but similar to those noted by Ranote and Bains (1982). The ascorbic acid content was 20.4 mg/

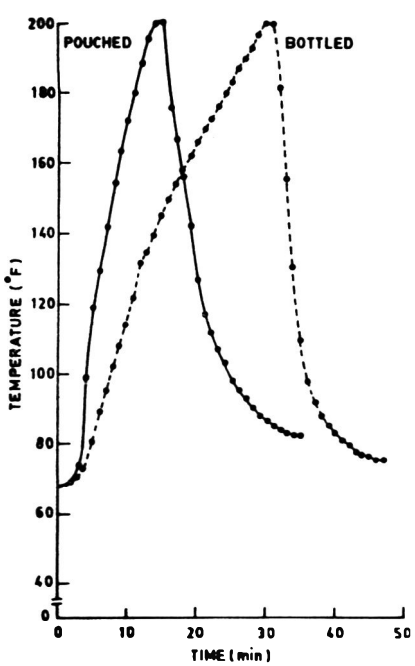

Fig.1. Heat penetration and cooling curves for Kinnow-juice

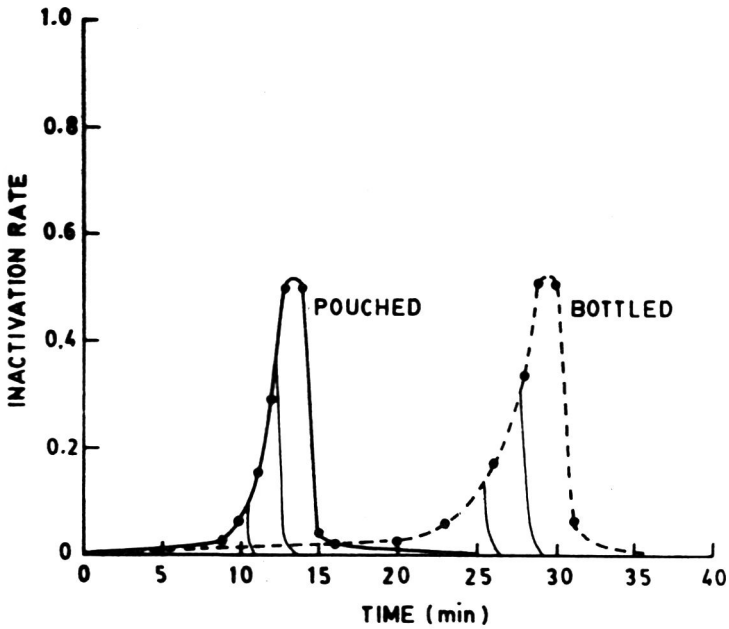

Fig.2. Inactivation rate curves for Kinnow-juice

100 g, similar to that recorded by earlier workers (Josan et al. 1983; Ranote and Bains 1982; Sarmah et al. 1981). The absorbance values for tannins (760 nm), total carotenoids (450 nm) and browning (440 nm) were 0.75, 0.32 and 0.06, respectively.

Process calculations : The heat penetration data at various heights, from bottom of the container on vertical axis, indicated that slowest heating took place at a distance of 1.25 cm from the bottom for bottled and 5 cm for the pouched juice. The heating and cooling curves are presented in Fig.1. The heat penetration was faster in pouches as compared to bottles and processing temperature was achieved much earlier. The whole process of heating and cooling was completed within 35 and 45 min, respectively. The inactivation rates are depicted in Fig.2., while F values are presented in Fig.3. The process times required to achieve an F value/inactivation at 200°F was 28.25 and 17.00 min, respectively for bottled and pouched samples.

The evaluation of heat penetration characteristics of bottled and pouched Kinnow juice, in relation to size of the container, revealed that the slowest heating took place at 1/10th (1.25 cm) of the height from the bottom on vertical axis in case of bottled and at the geometric centre (5 cm) of the filled in pouched samples. Thus, the data indicated that the heating in bottled and pouched juices was by convection and conduction, respectively. The lower processing time required to achieve F value in pouches was approximately 60%

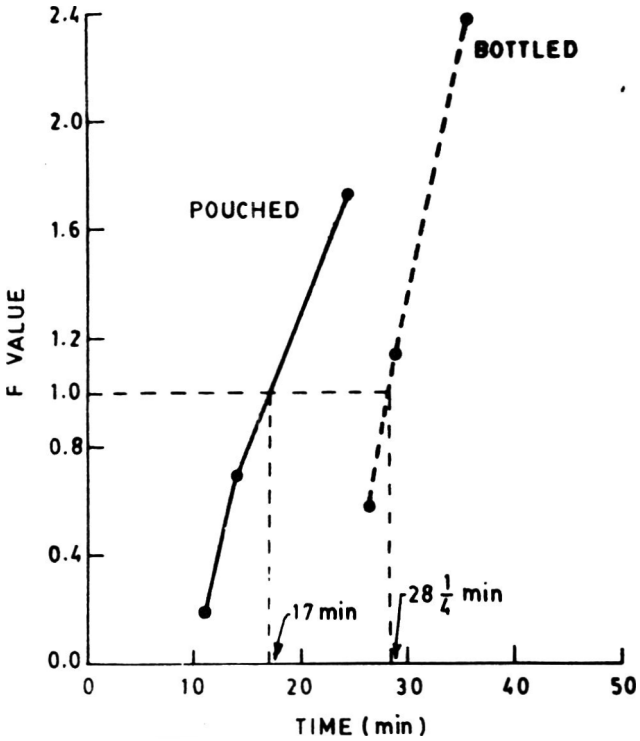

Fig.3. F values vs process time plots for Kinnow-juice

period was more in canned samples as compared to bottled or pouched samples, which can be attributed to the preventive effect of cans against natural light. There was a noticeable decline in total carotenoids in all the samples. However, the decrease was minimum in canned samples due to reasons attributed for ascorbic acid. Tintometric colour values did not change much during storage except for marginal decline by yellow colour.

Sensory evaluation of Kinnow juice packed and processed in different containers and stored upto 6 months at ambient temperatures showed that acceptability declined for all the attributes in stored samples. The decline was gradual and more pronounced in case of flavour irrespective of the container. The colour was also adversely affected during storage. The undesirable effect of storage on colour and flavour can be attributed to catalytic effect of light on deteriorative changes in flavour and colour. The shelf-life of pouched juice was comparatively lower (Approx. 4 months) as compared to canned samples. As the deteriorative changes during storage in pouches were mainly light-related, these can be prevented by using opaque/coated pouches or by storing in closed cabinets. The pouches have potential for use as substitutes for traditional costly rigid containers based upon the factors like cost, energy and time requirement for processing of Kinnow juice.

TABLE 1. EFFECT OF PACKING AND STORAGE ON KINNOW-ORANGE JUICE

	Storage period, weeks											
	0	8	16	24	0	8	16	24	0	8	16	24
	Can				Bottle				Flexible pouch			
Reducing sugar, %	3.3	4.0	4.5	5.9	3.3	3.5	4.5	5.2	3.3	3.4	3.9	4.1
Ascorbic acid, mg/100 gm	18.6	16.5	14.3	14.2	22.2	20.8	15.2	12.0	20.0	15.0	12.0	10.2
Total carotenoids, OD at 440 nm	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.2	0.3	0.2	0.2	0.2
Browning OD at 440 nm	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2

of that required for the identical product in bottles.

Storage changes : There was a marginal decline in total soluble solids. Decrease in TSS of Kinnow juice was slightly more for flexible pouch as compared to bottled and canned products. Total solids did not change much. The pH and acidity also remained almost constant throughout the storage period of six months.

The storage resulted in an increase in reducing sugar contents of all the samples with marginal decline in total sugars. The increase in reducing sugars (Table 1) was marginally higher in canned as compared to bottled or pouched juice. There was decrease in ascorbic acid content of all the samples. The initial variation in ascorbic acid was due to the kind of process each sample had undergone. The retention of ascorbic acid at the end of storage

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A Non-Destructive Measurement of Pigments of Whole Tomato by Light Reflectance Technique

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A Simple non-destructive method for estimating pigment content of tomato during ripening is described. Tomatoes sorted out subjectively into six ripening stages, from mature-green to over-ripe, were subjected to light reflectance measurements using a tristimulus photovoltic colour instrument and also analysed for lycopene, chlorophyll and β-carotene contents. Simple linear coefficient of correlations between pigment values and ten reflectance parameters viz., lightness (L), redness (a), yellowness (b), hue (a/b), hue angle {θ=tan^{-1}(b/a)}, chroma (ΔC), total colour difference (ΔE), a/L, arc length {θ* sqr (a^2 + b^2)} and tomato colour (2000 * cosθ/L) were determined and suitable regression equations fitted to estimate lycopene, chlorophyll and β-carotene contents of tomatoes, using the best linear/non-linear function.

Keywords : Tomato, Pigment, Non-destructive measurement, Light reflectance technique, Ripening.

Subjective evaluation based on visual perception has been an accepted method of sorting tomatoes for colour, although it is subjected to errors (Gould 1956; Robinson et al. 1952), and this seems to vary greatly with variety, soil condition and environment (Jayadeviah et al. 1965). Colour evaluation requires a high degree of accuracy, as the differences in colour among tomatoes are usually smaller. This has led to a considerable research in developing instruments (Francis 1952; Von Beckmann and Bulley 1978; Desrosier et al. 1952; Powers et al 1953). Non-destructive tests for measurement of pigments (Worthington 1974; Birth et al. 1957; Watada et al. 1976) are rapid, easy and reduce number of replicates of experiments. Changes in surface reflectance values during ripening of tomatoes are mainly due to pigment changes. Higher degrees of correlation of surface reflectance values or Hunter colour parameters with subjective and objective evaluations have been reported by several authors (Karmer 1950; Halsey and Jamision 1958; Mavis and Gould 1954). Watada et al. (1976), used Hunter D25 colour differences meter which was standardized with a reference white tile and reported lower degree of coefficient of correlation, of Hunter colour values L, a, b and tristimulus values X, Y, Z, with pigments of tomato as compared to absorbance values. However, the Hunter colour values thus measured were limited to the blossom end of tomato placed on a 5 cm aperture of the instrument.

This paper highlights modifications aimed at minimizing the errors inherent in measurement of reflectance values and communicates the results of the study conducted to estimate the pigment contents of whole tomato by a non-destructive method using light reflectance technique.

Materials and Methods

Freshly harvested mature-green tomatoes (cv. 'Rupali') of size ranging from 5.5-6.5 cm (dia) were brought to laboratory and held at 20-22°C until they reached the desired stages of ripeness. Fruits were classified into six ripening stages namely green, breaker, turning, light-pink, firm full-ripe and over-ripe. Tomatoes were sorted into 3 fruits per lot and 6 lots per ripening stage. Parameters determined were reflectance values {L, a, b, a/b, ΔC, ΔE, a/L, 2000* cosθ/L, θ * sqr(a^2+b^2)} and pigments (chlorophyll, lycopene, β-carotene).

Reflectance measurement : A colour instrument model 'Photovolt 575 (Sergen Inc. Indianapolis, USA) having illuminant C and aperture dia 1.25 cm was used, after being calibrated with a pink tile (X_{CIE} = 53.6, Y_{CIE}= 46, Z_{CIE} = 41.5). Colorimeter readings (A, G, B) using amber, green and blue filters were taken at six points, which were selected randomly but spread well over the surface of each fruit. Average surface reflectance values of six points were used to derive seven hunter colour parameters (Hunter 1975; Thiagu et al. 1991) and three other reported parameters (Little 1975; Yeatman et al. 1960) for each tomato and mean values of six lots of each ripening stage were reported.

Pigments : Tomatoes which were earlier subjected to reflectance measurement were blended and analysed for chlorophyll, lycopene and β-carotene

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content according to the method described by Ranganna (1986). The absorption of each eluate was measured at the appropriate wavelength in spectrophotometer (Bausch & Lomb, Spectronic 20) and concentration of pigments were calculated. Mean value of pigment concentration of selected 6 lots in each ripening stage was reported as pigment content of tomato at the selected ripening stage.

Statistical analysis : The reflectance parameters and pigment data were subjected to DMRT (Kwanchai and Arturo 1984) for finding out the trend of change in these data with ripening. Simple linear coefficients of correlation between pigment and measured reflectance parameters were calculated and compared to obtain the best linear relationship. Finally, suitable empirical equations were fitted to the experimental data by regression analysis, using the best linear/nonlinear function.

TABLE 1. CHANGES IN REFLECTANCE COLOUR PARAMETERS# AND PIGMENT CONTENTS# OF 'RUPALI' TOMATO AT DIFFERENT STAGES OF RIPENING

Reflectance parameters*/ pigments*	Ripening stages					
	Green	Breaker	Turning	Light pink	Full ripe	Over ripe
L	49.43 ± 0.382a	50.75 ± 1.011a	48.83 ± 0.628a	45.17 ± 0.395b	36.39 ± 0.352c	31.68 ± 0.399d
a	-9.61 ± 0.882f	-6.34 ± 0.647e	4.50 ± 0.234d	13.48 ± 0.893c	24.21 ± 0.892b	26.72 ± 0.686a
b	15.06 ± 0.494b	17.24 ± 0.610a	17.27 ± 0.518a	6.18 ± 0.538ab	10.70 ± 0.293	7.25 ± 0.330d
a/b	-0.64 ± 0.058f	-0.37 ± 0.040e	0.26 ± 0.018d	0.84 ± 0.067c	2.28 ± 0.115b	3.72 ± 0.141a
θ	122.18 ± 2.340a	110.13 ± 1.963b	75.29 ± 0.983c	50.34 ± 2.415d	23.98 ± 1.234e	15.18 ± 0.547f
a/L	-0.20 ± 0.018f	-0.12 ± 0.011e	0.10 ± 0.005d	0.30 ± 0.021c	0.67 ± 0.023b	0.84 ± 0.020a
2000 Cos θ/L	-21.47 ± 1.451f	-13.47 ± 1.114e	10.44 ± 0.787d	28.19 ± 1.167c	50.20 ± 0.913b	60.99 ± 0.867a
$\theta(a^2+b^2)^{0.5}$	38.40 ± 2.032a	35.46 ± 1.461a	23.51 ± 0.897b	18.55 ± 0.815c	11.03 ± 0.338d	7.34 ± 0.340f
ΔC	---------	5.03 ± 0.648e	14.35 ± 0.906d	23.27 ± 1.395c	34.13 ± 0.987b	37.17 ± 1.346a
ΔE	---------	5.71 ± 0.609e	14.48 ± 0.981d	23.70 ± 1.364c	36.57 ± 0.916b	41.26 ± 1.077a
Chlorophyll	14.63 ± 0.398a	10.13 ± 0.500b	4.67 ± 0.221c	1.52 ± 0.112d	0.97 ± 0.056d	0.00 ± 0.000e
Lycopene	0.84 ± 0.040e	1.45 ± 0.047e	8.44 ± 0.309d	20.75 ± 0.426c	55.77 ± 0.462b	81.64 ± 0.499a
β-carotene	0.99 ± 0.050d	1.89 ± 0.150c	4.07 ± 0.046a	4.26 ± 0.48a	2.64 ± 0.109b	1.99 ± 0.025c

Average of 6 samples, each containing 3 tomatoes, Mean ± SE

* Values within the same row not followed by a common letter are significantly different ($p \leq 0.05$).

Results and Discussion

Lightness, arc-length and hue angle decreased with advancement of ripening, whereas redness, (a/L), tomato colour, hue, chroma and total colour differences increased with ripening of tomato (Table 1). The yellowness (b) improved significantly upto breaker stage and reduced very much during further ripening. Lightness (L) did not change significantly up to turning stage of tomato. However, significant loss in lightness was found after turning stage. Similarly, significant change in parameter arc-length was noticed only after the breaker stage of ripeness. The a/b ratio is an important parameter which decides the visual impression of fruit colour. The a/b value at light pink stage was 0.8426 above which the tomatoes appeared very impressive red in colour.

Pigments : There was no significant change in lycopene content of tomato from green to breaker stage (Table 1). After the breaker stage, lycopene synthesis significantly increased and continued till over ripening stage. Drastic breakdown of chlorophyll was observed as ripening progressed. β-carotene increased up to the light-pink stage and declined afterwards. At light pink stage of tomato, the lycopene content was approximately 5 times greater than the β-carotene and 14 times greater than chlorophyll contents. After light pink stage, further increase in the ratio of lycopene content to chlorophyll as well as lycopene to β-carotene occurred, resulting in the enhancement of hue of tomato fruit which exhibited deep red colouration. There are also varieties with high lycopene contents (Theymoti Balasubramanian 1984).

Correlation and Regression : Lycopene content showed highest correlation (r = 0.9**) with a/b ratio (Table 2). Examination of data of tomatoes reported by Watada et al. (1976) showed that the coefficient of correlation (r = 0.96) of lycopene content with a/b ratio was higher than the coefficient of correlation (r = 0.92) of lycopene with "a" value which was used to compare the absorption values. Similarly, his results of chlorophyll content had better correlation (r = 0.90) with hue angle than the reported correlation (r = 0.85) with "a". In this

TABLE 2. LINEAR COEFFICIENTS OF CORRELATION FOR REFLECTANCE PARAMETERS AND PIGMENTS

	L	a	b	a/b	θ	ΔC	ΔE	a/L	2000 cos θ/L	$\theta(a^2+b^2)^{0.5}$	Chloro -phyll	Lyco -pene	β-caro -tene
L	1.00	-0.93	0.96	-0.98	0.91	-0.93	-0.94	-0.97	-0.97	0.90	0.76	0.98	0.06
a		1.00	-0.78	0.95	0.99	0.99	0.99	0.99	0.99	0.99	-0.94	0.92	0.32
b			1.00	-0.92	0.75	-0.79	-0.81	-0.87	-0.79	0.75	0.55	-0.95	0.32
a/b				1.00	-0.94	0.95	0.97	0.98	0.96	-0.94	0.83	0.99	0.06
θ					1.00	-0.99	-0.99	-0.98	-0.99	0.99	0.96	-0.91	-0.37
ΔC						1.00	-0.99	0.98	0.99	-0.99	-0.94	0.93	0.31
ΔE							1.00	0.99	0.99	-0.98	-0.93	0.94	0.26
a/L								1.00	0.99	-0.98	-0.89	0.97	0.16
2000									1.00	-0.99	-0.94	0.93	0.31
$\theta(a^2+b^2)^{0.5}$										1.00	0.90	-0.90	-0.37
Chlorophyll											1.00	-0.77	-0.56
Lycopene												1.00	-0.05
β-carotene													1.00

study, chlorophyll registered significant linear correlation (r= 0.96**) with hue angle and arc-length. The improved linear correlations of lycopene and chlorophyll with the selected reflectance parameters were due to the following reasons which are responsible for minimizing the errors inherent in reflectance technique: Average surface reflectance values were used for each tomato by measuring the values at several points all over the surface of the fruit instead of reflectance value measured only at blossom end. Photovoltic colour instrument with smaller aperture (1.25 cm dia) which was used in this study was more appropriate for use with tomatoes that have a relatively regular exterior surface contour and arc within EEC grades of small to large (40-67 mm dia) (Hobson et al. 1983). The instrument was calibrated with pink colour tile as it has very close hue to tomato-red-colour. Ten colour parameters were tested to obtain one with a high degree of linear correlation with each pigment.

It is very clear from the correlation analysis that parameters (a/L), (2000* Cos θ/L) and [θ*sqr (a^2+b^2)] did not improve linear correlation with pigments. No significant linear relationship was found for β-carotene with all calculated colour parameters. All the three Hunter colour values L, a, b were taken into consideration while predicting pigment contents and simple linear coefficient of correlations were calculated for different combinations of the three values (Table 3). The parameters a/bL and ab/L registered high coefficient of correlations of 0.99 and -0.96 with lycopene and chlorophyll, respectively, but they failed to improve

TABLE 3. SIMPLE LINEAR COEFFICIENTS OF CORRELATION FOR PARAMETERS DERIVED FROM HUNTER COLOUR VALUES L, a, b.

	Parameters			
Pigments	ab/L	aL/b	a/bL	bL/a
Lycopene	0.83	0.97	0.99	0.14
Chlorophyll	-0.96	-0.89	-0.76	-0.56
β-carotene	0.45	0.18	0.04	0.80

the correlation coefficients which were computed by a/b and θ (Table 2). Though the linear coefficient of correlation of β-carotene with bL/a was 0.80, a good non-linear relation (0.992) was found with θ.

Equations to predict lycopene and chlorophyll contents of tomatoes at any stage of ripening from mature green to overripe stage, were fitted with best linear parameter a/b ratio and hue angle, respectively. The ripening range (green to overripe) was split into two suitable ranges to improve linear coefficient and each range was subjected to regression analysis separately. A second degree polynomial equation was fitted to determine β-carotene with independent variable hue angle. The fitted equations were regressed with observed data of pigments to calculate r-values. The regression equations fitted for estimation of pigments of tomato by a rapid non-destructive method are given below :

Lycopene

1. Lycopene (μg/g.f.w.) = $4.1428\ e^{2.6025\ (a/b)}$
   (R^2 = 0.996, $-0.64 \leq a/b \leq 0.26$: Green to turning stage)

2. Lycopene (µg/g.f.w.) = 3.4386 + 21.5217(a/b) (R^2 = 0.986, 0.26 ≤ a/b ≤ 3.72 : turning to over ripe stage)

Chlorophyll

1. Chlorophyll (µg/g.f.w.)= −1.1768+1.0113 $\theta^{2*}10^{-3}$ (R^2 = 0.986, 122.8 ≥ θ ≥ 50.34: green to light pink stage)
2. Chlorophyll (µg/g.f.w.)= 2.2339 − 33.1590/θ*10² (R^2 = 0.994, 50.34 ≥ θ ≥ 15.18: light pink to over ripe stage)

β-carotene

1. β-carotene µg/g.f.wt.) = 3.1519 * 10^{-1} + 1.2440 θ * 10^{-1}−9.8288 θ^{2*} 10^{-4}
   R^2 = 0.964, 122.18 ≥ θ ≥ 15.19: green to over ripe stage)

The graphical representation of estimated relationships between observed pigments and selected Hunter colour values are shown in Figs. 1 and 2. Accumulation of lycopene in tomato was slow (exponential increase) upto turning stage and, later, increased linearly at a higher rate with hue (a/b) which gave best linear correlation with lycopene synthesis during ripening. The fitted square function

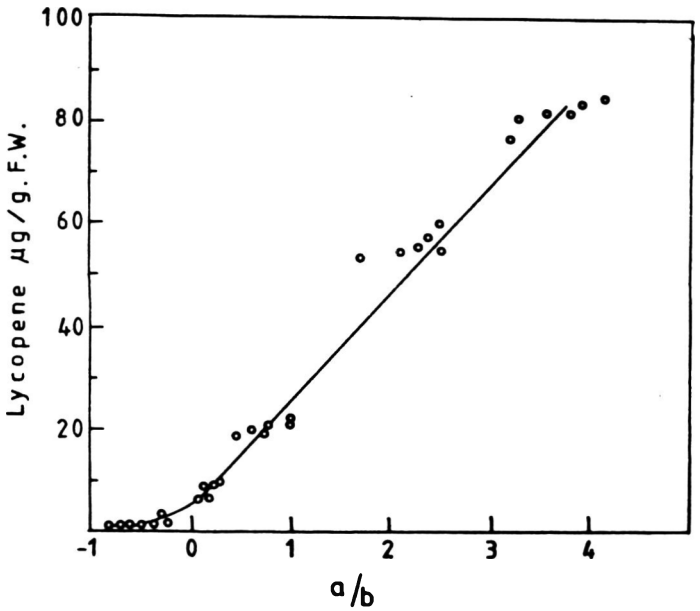

Fig.1. An estimated relationship between lycopene content of tomato and a/b ratio computed from data observed on six ripening stages from green to over-ripe stage.

of hue angle (θ) for chlorophyll breakdown till light pink stage revealed the rapid reduction as compared to changes found (inverse function of 0) in later stages of ripening. During ripening (when hue angle reduced) β-carotene increased up to light pink stage and reduced drastically on further ripening. This

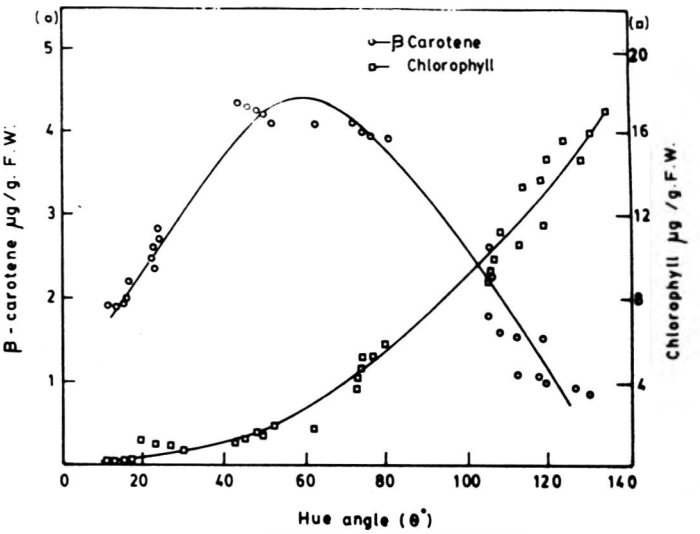

Fig.2. Estimated relationship for chlorophyll and β-carotene contents of tomato with hue angle (θ^0) computed from data observed on six ripening stages from green to over-ripe stage.

was expressed by the fitted 2nd degree polynomial equation.

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Low-Moisture Parboiling of Paddy

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Soaking paddy at 70°C for 1 h, draining and tempering hot for 4 h, restricted the kernel moisture to about 25% (wb) with even distribution of moisture in core - a condition just enough to get a normal parboiled rice without white core. This paddy, on steaming at 0 kg/cm² for 10 min to gelatinize the starch, contained 26-27% (wb) moisture and resulted in 20-25% saving in drying time. Pre-steaming/high soaking temperature/longer soaking period increased the grain moisture appreciably.

Keywords : Low - moisture parboiling, Short soaking, Moisture migration, Equilization, Hot tempering, Drying.

Parboiled paddy, as produced under commercial practices in Asian countries by adopting single steaming, double steaming and CFTRI (hot soaking) process (Pillaiyar 1988), contains 33-35% moisture (wb). In the pressure parboiling process, the parboiled paddy had a kernel moisture of 24% as against 30-35% in that of hot soaking process (Iyengar et al. 1974; Kulkarni and Bal 1984); but its deep colour (Mohandoss and Pillaiyar 1978), undue long cooking time (Pillaiyar and Mohandoss 1981) and tough texture in cooked kernels (Mohandoss and Pillaiyar 1982) forced the millers to discontinue this process. In the modified pressure parboiling technique (Ali and Bhattacharya 1982), aiming to produce an acceptable quality, 20% of the grains were having white core, but such rice cannot be marketed under the existing Indian specifications. Production of an acceptable pressure parboiled rice without white core was also worked out (Iyengar et al. 1974); but the grains had more than 30% moisture. The moisture content was also more than 30% in the method involving mere soaking at 80-85°C (Unnikrishnan et al, 1982). This study was undertaken, as it was felt that a parboiled paddy with a low moisture and normal cooking time, can be produced by manipulating the soaking-diffusion conditions.

Materials and Methods

'Tkm 9', 'Adt 36' and 'IR 50' varieties of paddy (0.5-3 kg) were soaked individually (paddy : water ratio of 1:1.2) for different durations ($^1/_2$ to 2 h), as such or after pre-steaming. The water was drained and the paddy left in the same vessel, till the kernel core attained sufficient moisture for complete parboiling. The time allowed for the diffusion of surface moisture and its equilization within the kernel is termed 'tempering' ('hot tempering', if performed in insulated vessel and 'normal tempering', if in un-insulated vessel). During tempering (1 to 6 h), paddy samples were drawn periodically, kept in wire basket and soon steamed at 0 kg/cm² for 10 min, using captive steam to ascertain as to whether sufficient moisture has reached the kernel core for complete parboiling. Parboiling was considered complete when no portion of the kernel exhibited white core.

At laboratory level, the parboiled samples were shade-dried for 48 h, shelled in Satake laboratory dehusker and milled in McGill miller (No. 3) to constant degree of milling (6%). At mill level, six trials were carried out. In all the places, an uniform procedure (1 h soaking at 70°C after circulation of water, draining and hot or normal tempering by leaving the paddy in the same vessel) was followed. Long probes of digital thermometer (Digirad-2000 Radix pyrotech) were inserted at different points in the mass of paddy to record the variations in temperature during tempering. After desired period of tempering, paddy was steamed at 0 kg/cm² for 10-15 min, (soaking vessel capacity 3.5-6 T) dried in LSU dryer, using hot air at 120-100°C till 14-13% moisture content (wb), held for 3 h soon after discharge and then milled in rubber-sheller emery-polisher combinations with constant settings.

For determining moisture content, representative sample of soaked/tempered paddy was taken in double-folded filter paper, gently pressed in between folds and dried in hot air oven at 105°C for 24 h. In case of parboiled paddy, sample was drawn to the brim of a pre-weighed screw-capped aluminium dish, tightly closed, weighed after cooling, the moisture determined as above, but without sub-sampling. The moisture content was expressed on wet basis.

Equilibrium moisture content (EMC-S) value was determined by the method of Indudhara Swamy et al, (1971) and the cooking time by double

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pot-excess water method (Ranghino 1966; Bhattacharya and Sowbhagya 1971), but to an identical softness of that of normal parboiled rice (fully saturated paddy steamed at 0 kg/cm² for 10 min). The alkali value (increase in breadth after immersing in 1.1% KOH for 4 h) was determined as described by Mohandoss and Pillaiyar (1980).

Results and Discussion

The optimum soaking-tempering combination for getting parboiled rice without white core depended mostly on the soaking conditions employed (Table 1). Except in case of 70°C soaking for 1 h, which required about 25% optimum moisture for parboiling, other soaking conditions resulted in higher moisture levels (28.6-31.1%). Hence, optimising the factors influencing the practical application of this technique was confined to 70°C and 1 h soaking condition. The moisture content of paddy during 3, 4 and 5 h tempering was found to be 25.3, 24.5 and 24.5%, while it was 25.5% at the end of 1 h soaking. At the same time, the grains with white core have reduced from 40 to 20% in normal tempering and from 13 to 0% in hot tempering over a period of 4 h. This suggests that during tempering stage, the film of water clinging to the surface of grain and the moisture that had already seeped into the husk and peripheral layers of brown rice may diffuse towards the core of the grain, though the intergranular water is absent. By 6 h tempering, the grains with white core were absent in normal tempering. Since soaking was limited to 1 h in this study, the moisture required for complete parboiling could be restricted to, about 25% (wb) as against earlier reported values of 30-35% (wb) (Bhattacharya and Subba Rao 1966; Bhattacharya and Indudhara Swamy 1967; Ali and Ojha 1976; Bandyopadhyay and Roy 1976; Unnikrishnan et al. 1982). In earlier studies, paddy was allowed to imbibe water till saturation resulting in a higher grain moisture.

TABLE 1. OPTIMUM DURATION OF SOAKING AND TEMPERING FOR COMPLETE PARBOILING.

Soaking temperature °C	Time, h	Duration of normal tempering*, h	Moisture content %(wb) Soaked and tempered paddy	Parboiled paddy
95	1/2	3 1/2	31.1	33.1
90	2	2 1/2	31.1	33.8
80	1	4	30.5	32.0
70	3	1	28.6	30.3
70	1	6	24.8	26.0
65	3	1 1/2	29.0	30.5

* accomplished in non-insulated vessel.

Soaking at 80-85°C (grain moisture 30% wb) as suggested by Unnikrishnan et al. (1982) would lead to certain undesirable consequences. In commercial parboiling installations, varieties falling under classification fine, common etc., are pooled and soaked together. Varieties under fine have different gelatinization temperature (GT) and other properties. Under such compelling situations, slender as well as low GT grains would undoubtedly over-imbibe moisture leading to grain splitting, leaching, loss of 2% weight and aggravation in colour (Bhattacharya and Subba Rao 1966). These problems are alleviated with the use of conditions as standardized in the present method.

Pre-steaming of paddy, higher soaking temperature (Table 1) or longer duration soaking at 70°C for 1, 2 and 3 h resulted in 24.8, 28.6 and 29.0% grain moisture, thereby indicating appreciable increase in grain moisture.

Attempts were made to reduce the total processing time of this method. The time required for the inward migration of moisture and its equilization in the kernel could appreciably be reduced by adopting hot tempering. The temperature variation between peripheral and central layers of paddy mass, kept in insulated soaking tank, is minimal as compared to that in un-insulated vessel (Table 2). Thus, hot tempering aided in rapid migration of moisture to the kernel core. Consequent to this, 6 h normal tempering duration for the paddy soaked at 70°C for 1 h could be brought down to 4 h by adopting hot tempering.

TABLE 2. TEMPERATURE VARIATIONS DURING TEMPERING (70°C, 1 h soaking).

Tempering duration, h	Un-insulated tank* Centre → Periphery, °C	Insulated tank* Centre → Periphery, °C
0	70 → 70	70 → 70
1	70 → 69	70 → 70
2	69 → 68	70 → 69
3	67 → 65	70 → 68
4	66 → 61	69 → 68
5	65 → 59	-
6	63 → 56	-

* 3 1/2 to 6 tonnes

The results of the bulk scale trials, carried out at six locations, involving 3.5-6 tonnes of bold and slender varieties of paddy/batch, indicated that 4 h hot tempering or 6 h normal tempering (for 70°C,

1 h soaked paddy) is sufficient for getting parboiled rice without white core. As a result of low moisture in parboiled paddy (28-30% against 35-37% in parboiled paddy produced in these mills, based on the use of either double steaming or hot soaking process), a considerable reduction (1.0 to 1.5 h) in drying time under yard drying and mechanical drying (unpublished) was noticed.

The colour of the milled rice produced in the short soaking-tempering (SST) process was lighter than that produced in hot soaking process. This may be due to a shorter soaking time employed in this case. The difference in EMC-S and alkali values as well as cooking time for the milled rice produced by SST and routine method was marginal (Table 3).

TABLE 3. PROPERTY OF PARBOILED RICE

Particulars	Bold		Slender	
	SST method	Routine* method	SST method	Routine* method
EMC-S, % on dry basis	69.2	70.9	64.6	64.7
Alkali value, % increase over raw	118	120	103	123
Cooking time, min	35	36	34	35

* 70°C soaking for 5 h, draining and steaming at 0 kg/cm² for 15-20 min.

Practical significance : Rice is classified into three groups viz., superfine, fine and common, based on the length:breadth ratio under the Indian specification. Mixing of groups to a level of 10-15% is allowed under commercial practices. Therefore, the slender varieties present in bold group during soaking tend to over-imbibe water till the bold grains attain the optimum moisture required for complete parboiling without white core. Over-imbibition of moisture leads to husk splitting and leaching of solid constituents. To alleviate this situation, the SST-process, wherein over-imbibition of moisture is avoided, would be a suitable processing technique. Under commercial parlance, irrespective of the GT, different varieties are considered under a particular group based on their size. Under prevailing soaking conditions (4 to 5 h), over-imbibition of moisture by low GT grains would lead to the above problems.

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Physico-chemical and Biological Properties of Raw and Used *Mahua* Oil

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Groundnut oil (GNO) and *Mahua* oil (MO) were heated at 180°C for 8 h both with and without intermittant frying of 'fryums' (a commercial ready-to-fry snack). Thermal degradation as measured by changes in colour development, viscosity, smoke point, acid value, peroxide value, iodine value and conjugated diene hydroperoxide values (CDHP) were found to be higher in MO than in GNO. Albino rats of either sex fed on diets with raw MO for a period of three months shewed good growth and were found to be comparable to raw GNO diets. Intake of used (heated and fried) MO and GNO adversely affected the food intake and consequently weight gain of female rats. Rats of either sex fed on heated GNO exhibited normal histology, while heated MO fed rats showed moderate hepatic hypertrophy, with only one rat out of four exhibiting unilateral atrophic testicular damage. Fried GNO and MO showed more damage to liver of the male rats, while the kidneys and ovaries of all the rats fed either raw or used GNO and MO depicted normal histological picture.

Keywords : *Mahua* oil, Raw, Used, Physico-chemical and biological properties.

Mahua (*Madhuca latifolia* J.F. Gmel; Syn. *M. indica*, *Bassia latifolia* Macb, family *Sapotaceae*) seeds have been identified as good sources of oil. About 1.11 million tonnes of seeds and 400,000 tonnes of oil are available annually, while edible grade oil is being used in hydrogenation industry (NIN 1987). Multigeneration breeding studies carried out recently (NIN 1989) revealed that the raw *Mahua* oil, when fed to rats, showed nutritional quality comparable to groundnut oil as indicated by growth, biochemical and toxicological parameters. However, in the second and third generations, the male rats exhibited sterility with testicular atrophy and degenerative changes.

Heated oils have been shown to be poorly absorbed and to produce cancerous tumours (Artman 1969). Thus, severe decomposition of frying oils not only compromises the quality of the food being fried, but also poses a potential hazard to human health and nutrition (Huang et al. 1988). The deterioration of frying oils at high temperature is a complicated phenomenon, because of the simultaneous occurrence of oxidative and thermolytic reactions. Recently, the effect of frying on the quality of oil has been investigated in detail (Rojo and Perkins 1987). Todate, no information is available on the changes in physico-chemical and/or biological properties of *Mahua* oil during deep-fat-frying operations. Secondly, although the refined *Mahua* oil is specified to be edible as per PFA (1976), the villagers and the tribals usually consume the crude oil expressed in local *ghanis* (expeller). Hence, the present study on the adverse effects of feeding heated/fried crude *Mahua* oils to the rats of generation one itself was undertaken.

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Materials and Methods

Sun-dried, brown coloured *Mahua* kernels of good quality were procured from the Forest Department of Nagpur District. The oil was extracted in an expeller and filtered in De Lavals' filtration unit to remove suspended material. The oil was stored at room temperature in brown coloured bottles till used. Unrefined GNO and 'fryums', (a commercial ready-to-fry snack) were procured from the local market. GNO and MO in 1.5 kg lots were heated in stainless steel *Kadais* (frying vessels) of 14" diam and 4" depth at 180 ± 5°C continuously for 8 h. In another experiment, 100 g of 'fryums' were fried, separately in GNO and MO, in three batches, each batch after 0.5, 4 and 8 h of heating. A stop watch was used to note the frying time which was found to be 4 min. 'Fryums' were drained, cooled and weighed. Each batch of 'fryums' were stored at room temperature in sealed low density polyethylene bags.

After respective storage period, oil from 'fryums' was extracted in Soxhlet apparatus using petroleum ether (B.P. 60°C to 80°C). These extracted oils were used to measure colour development and CDHP by the method of St. Angelo et al. (1975). Spectrophotometric readings of colour development and CDHP measurements were taken at 280 nm and 234 nm, respectively. Physico-chemical characteristics such as acid value (AV), peroxide value (PV), iodine value (IV), saponification value (SV)

and unsaponifiable matter were evaluated by AOCS methods (1971).

Animal feeding studies : The raw oils (GNO/MO) and their used forms were utilised in animal feeding experiments to check their nutritional quality. The study was conducted on 120 (60 female and 60 male) albino rats ('Wistar' strain), weighing between 100-130 g. The male and female rats were housed in separate cages, divided into six groups and each group was provided with the experimental diet containing g/100 g total diet : casein 13.5, starch 67.5, cellulose powder 3, salt mix 4, vitaminized starch 1, and vitaminized oil 1. The quantity of oil was kept constant (10 g) in all the diets. The variable ingredients in the diets include kind and nature of oils, viz, raw GNO, raw MO, heated GNO, heated MO, fried GNO and fried MO.

After 4 weeks of feeding, 6 animals (3 males and 3 females) from each group were picked randomly, killed under mild anaesthesia and their blood and organs (liver, kidney, testes/ovaries) were collected. The blood was allowed to clot and the serum was stored in deep-freeze for further analysis. The fresh organ weights were recorded. The livers were wrapped in polythene papers and stored in the freezer for further analysis. At the end of 8 and 12 weeks, the same experiment was repeated. At the end of the 12 weeks, 1 cm cuts of liver, kidney, ovaries and testes were subjected to histopathological examination after fixing in 10% buffered formalin. Daily food intake, body weight gain and fresh organ weights were also recorded after 12 weeks. Serum was analysed for total (Zlatkis et al. 1953) and HDL (high density lipoproteins) cholesterol (Burstein and Samille 1960) and triglycerides (Van Handel et al. 1957). Liver was subjected to total lipids (Folch et al. 1957) and total cholesterol (Zlatkis et al. 1953) analysis. Fixed tissues were transferred through progressive ethanol and xylene grades, embedded in paraffin, sections were cut (4 µm thick) and stained with eosin and haematoxylin (Culling 1963).

Statistical analysis : The results were subjected to standard deviation and significance was tested by student's 't' test (Garrett 1966).

Results and Discussion

Fifty kg of *Mahua* kernels provided 15 kg of filtered oil. The characteristics of the fried food/s have their impact on the nature and extent of deterioration of the oil and therefore, in the present study, only one type of commercially available product 'fryums' was fried in MO and GNO. The time required to fry 'fryums' in 8 h heated MO and GNO were similar (4.6 min and 4.8 min, respectively) and oil absorption by 'fryums' during frying was also comparable (24 g and 23 g, respectively). Frying in prolonged heated oils (8 h) and increasing storage periods (30 days) of the 'fryums' increased the colour and CDHP in the absorbed oil.

Table 1 presents the physico-chemical characteristics of raw and heated (8 h) samples of GNO and MO. As is evident, the thermal oxidation of GNO and MO showed increases in all the physico-chemical values except for smoke point and iodine values. The raw MO illustrated higher percentage values than raw GNO in almost all the characteristics considered except for smoke point and iodine values. However, when the physico-chemical characteristics of the used forms of GNO and MO were compared with their respective raw oils, the used GNO illustrated higher percentage

TABLE 1. PHYSICO-CHEMICAL ANALYSIS OF RAW AND USED SAMPLES OF GNO AND MO

Physico-chemical characteristics	GNO			MO		
	Raw	Heated	Fried	Raw	Heated	Fried
Colour, 280 nm	0.15	0.43	0.71	0.21	0.73	1.16
Viscosity CPS	66.00	87.00	88.00	79.00	96.00	98.00
Smoke point, °C	242.00	236.00	235.00	228.00	217.00	219.00
Acid value	1.02	7.04	5.72	7.10	15.83	12.10
Peroxide value, meq O_2/kg of oil	1.76	6.73	6.90	2.15	7.72	6.96
Iodine value, wij's	97.68	86.41	86.72	59.80	52.23	50.76
Saponification value	190.89	211.91	212.53	195.53	211.81	217.12
Refractive index, 40°C	1.4678	1.4681	1.4683	1.4622	1.4629	1.4627
Unsaponifiable matter, %	1.00	1.60	1.80	3.20	3.50	3.50
CDHP, 234 nm	0.28	0.35	0.41	0.32	0.38	0.48

Each value is mean of three determinations.

changes in the acid value, viscosity and unsaponifiable matter, whereas used MO illustrated higher percent increase in CDHP values. Rest of the percentage increases and decreases of the used forms of GNO and MO were found comparable.

Food intake and weight gain : Feeding heated or fried oils significantly decreased food intake and growth rate in female rats, while male rats maintained comparable food intake and weight gain.

cholesterol levels were evident in case of male rats fed on heated MO (0.32 g %) and fried MO (0.31 g %) as against the rats fed raw MO (0.44 g %). The serum HDL cholesterol values and hepatic total lipids of all the rats, fed either raw or used oils, were comparable.

Liver : The transverse section of the liver of rats of either sex, fed on raw oils (GNO/MO) revealed characteristic hepatic profile. The hepatic profiles of rats of either sex fed on heated GNO did not

TABLE 2. AVERAGE SERUM AND HEPATIC TOTAL CHOLESTEROL (mg/dl) AND SERUM TRIGLYCERIDE (mg/dl) LEVELS OF RATS FED GROUNDNUT AND *MAHUA* OILS FOR 12 WEEKS

Diet	Serum total cholesterol		Hepatic total cholesterol		Serum triglycerides	
	Female	Male	Female	Male	Female	Male
			Groundnut oil			
Raw	56.74 ±11.0	75.30 ±1.99	0.28 ±0.05	0.40 ±0.07	123.6 ±21.7	124.8 ±18.1
Heated	65.60 ±6.40	100.64 ±14.9	0.28 ±0.02	0.37 ±0.04	116.8 ±17.6	82.95** ±25.6
Fried	57.14 ±7.59	99.05 ±15.01	0.35 ±0.01	0.29 ±0.05	86.46 ±7.28	106.3 ±28.3
			***Mahua* oil**			
Raw	58.19 ±10.6	82.80 ±7.63	0.31 ±0.05	0.44 ±0.06	130.6 ±8.27	115.0 ±51.7
Heated	48.67 ±8.88	114.66* ±12.6	0.31 ±0.07	0.32* ±0.03	90.27** ±10.1	110.4 ±26.0
Fried	65.34 ±15.1	69.04 ±21.1	0.35 ±0.01	0.31* ±0.00	142.6 ±17.8	85.50 ±21.9

*P = 0.05, **P = 0.01 indicate significant difference from corresponding raw oil.

Organ weights : On an average, the weights of liver, kidneys, ovaries/ testes of the rats of either sex, fed on GNO/MO, (either raw or used), compared well and the differences were statistically insignificant. However, one rat out of the four rats exhibited unilateral atrophic testi with noticeable reduction in size in case of the feeding of heated MO for 12 weeks.

Total cholesterol (serum and hepatic) and serum triglycerides : The male rats fed on heated MO showed significant increase (Table 2) in total cholesterol levels as compared to the rats fed raw MO (114.66 mg/dl Vs 82.90 mg/dl). Serum TG levels of male rats fed on heated GNO decreased significantly when compared to the rats fed raw GNO (82.95 mg/dl Vs 124.8 mg/dl). Similarly, the female rats fed heated MO showed decreased serum TG levels against those fed raw MO (90.27 mg/dl Vs 130.6 mg/dl). Serum total cholesterol and TG levels of rest of the rats, fed on either raw or heated oils, were comparable. Decreased hepatic

differ from those of the rats fed on raw oil. The transverse section of the liver of only male rats fed on fried GNO and all rats fed on used (heated and fried) MO showed signs of cellular and nuclear hypertrophy. This hypertrophy of rats fed on used oils were not due to an accumulation of excessive fat, since the biochemical findings show comparable hepatic lipids. In substantive agreement, recent reports (Huang et al. 1988; Alexander 1978) clarify that the hepatic lipid content of rats fed on used oils decrease, while the hypertrophy, if observed, is accounted due to the increment in hepatic protein.

Ovaries and kidneys : Ovaries and kidneys of the rats were least altered due to the consumption of any one of the experimental diets.

Testes : The transverse section of the testes of rats fed on raw oils (GNO/MO) showed normal histological profiles, wherein several seminiferous tubules with occasional patches of interstitial cells of Leydig were observed (Fig.1). Incorporation of used (heated/

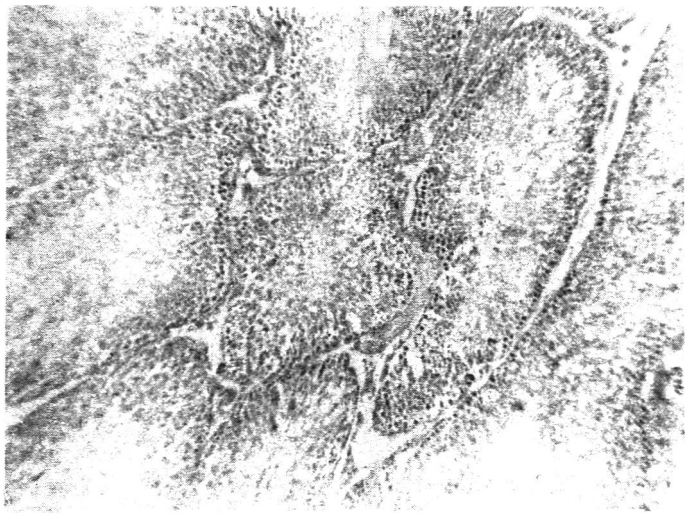

Fig.1. Stain : hematoxylin - eosin 10 x 7. Testi section of rat fed on raw oil (GNO/MO) diet.

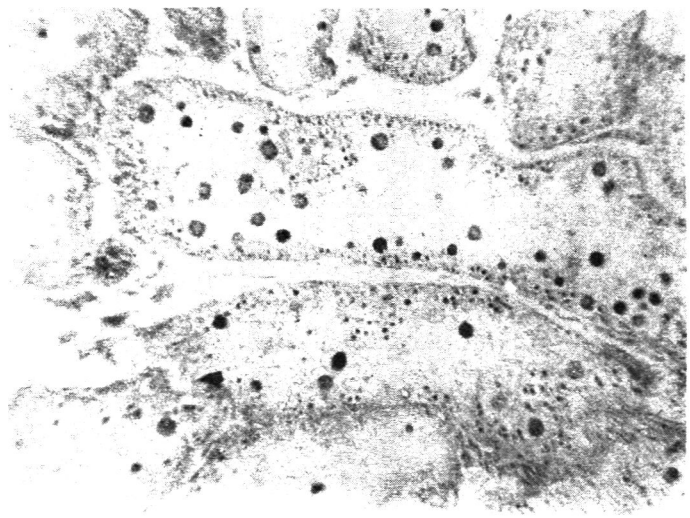

Fig.3. Stain : hematoxylin - eosin 10 x 7. Testi section of rat fed on heated MO diet.

fried) GNO and fried MO in the diets of rats did not alter the histological profile of the testes. The seminiferous tubules appeared normal and all the stages of spermatogenesis were observed. However, one rat, out of four male rats, fed on heated MO for a period of 3 months, exhibited drastic unilateral degenerative changes which were prominently seen in many of the tubules. At majority of the places, the basement membrane was thickened and there appeared a gross reduction in the number of different spermatogenic stages. Some of the seminiferous tubules were empty without any

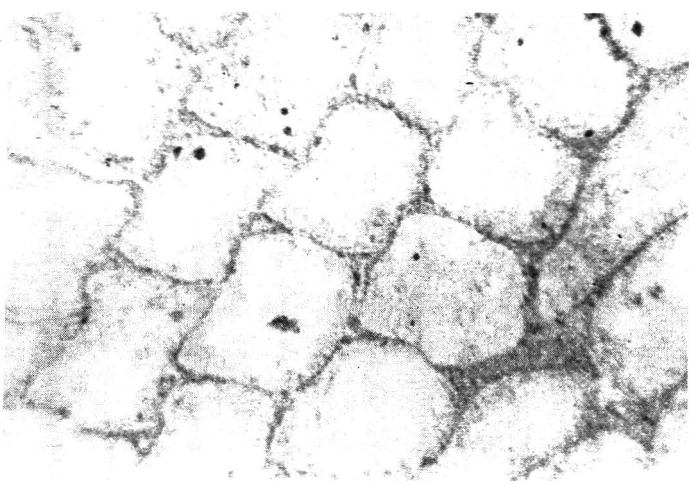

Fig.2. Stain : hematoxylin - eosin 10 x 7. Testi section of rat fed on heated MO diet.

evidence of spermatogenesis with moderate thickening of basement membrane (Fig.2). Some of the seminiferous tubules showed giant spermatocytes and absence of spermatids and spermatozoa with sloughing of tubular lining at some places (Fig.3).

General impression of this testicular tissue was unilateral maturation arrest. Thus, the overall changes symbolize testicular atrophy with an arrest of spermatogenic process at the primary or secondary spermatocytic stage. The affected features resemble those described recently (NIN 1989) in the rats of generation two and three, but fed on raw MO. This biological test has been of short duration and may not have detected substances that would elicit a response on prolonged administration or in massive doses. Effect of male sterility due to consumption of heated MO by the rats of generation one, merits further study.

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Kinetics of Deep-Fat-Frying of Potato and Optimization of Process Variables

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Effects of deep-fat-frying time, temperature and thickness of potato slices on oil absorption, moisture content and colour of chips have been studied. The loss of reducing sugars was found to have an average diffusivity of 5.06 x 10^{-9} m^2/s in case of blanching of 1.5 and 2 mm thick slices in boiling water. Colour development followed first order reaction kinetics with a Q_{10} value of 1.39 and 52.27 kJ/kg mole activation energy. Multiple regression equations were developed for moisture, oil and colour values in the final product as a function of frying time, oil temperature and thickness of slice. Use of linear programming technique yielded 220-222 sec frying time, 145-146°C oil temperature and 2 mm thickness of slice as optimum parameters.

Keywords : Optimization, Potato frying, Colour development, Kinetics, Potato chips, Multiple regression equation.

Potato chips are made by deep-fat-frying of potato slices in hot oil. Blanching of slices in hot water lowers the reducing sugars and improves the colour. Diffusivity of reducing sugars plays an important role in deciding the time of blanching. Moisture content, oil content and colour are important factors which determine the quality and cost of the chips (Anand et al. 1982). For longer shelf-life, the moisture content of chips should be within 2-3% (Simpson 1969) and from the economic point of view, the oil content of the chips should also be as low as possible. Good appearance calls for a light yellow colour (Misra and Premchand 1988). Tuber variety, storage condition prior to processing, thickness of slice, blanching time and temperature, nature of oil used, temperature and time of frying are the factors which affect final quality of the chips. This work was undertaken to optimize the processing parameters by developing regression equation between dependent and independent variables.

Materials and Methods

Potatoes ('Chandramukhi'), purchased from the local market, had moisture 84-87, fat 0.10-0.15 and reducing sugars 0.9-1.0%. Commercially refined groundnut oil, having 1.4627 refractive index and 240°C smoke point, was used as frying medium. Potatoes were washed and sliced to thickness of 1.5 and 2.0±0.2 mm and blanched in boiling water. Reducing sugar content in the slices was measured by dinitro salicylic acid reagent method (AOAC 1965) at 20 sec intervals. Diffusivity of reducing sugars (D_r) was estimated by using the equation of Crank (1957).

$$\ln \frac{X_r}{X_{ro}} = \ln \frac{8}{\pi^2} - \frac{\pi^2 D_r \theta_b}{b^2} \qquad (1)$$

Where X_r=reducing sugar content at time θ_b, wt %; X_{ro}= initial reducing sugar content, wt %; b= thickness of slice, mm; θ_b=time of blanching, s; D_r=diffusivity of reducing sugar, m^2/s. The diffusivity, D_r was computed from the straight line plot (Fig.1) between blanching time and ln (X_r/X_{ro}).

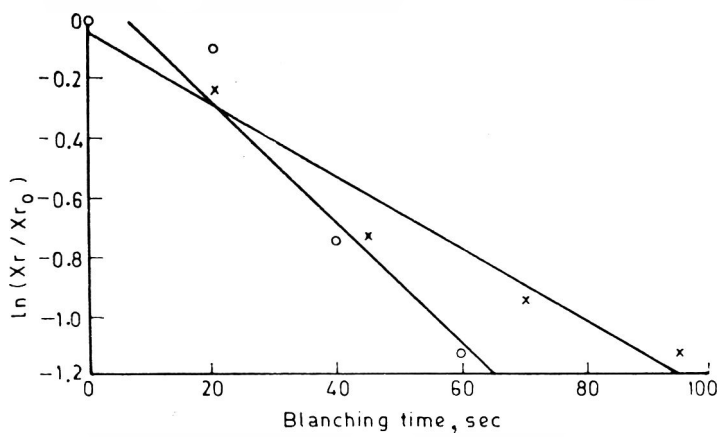

Fig.1. Relationship between reducing sugar and blanching time of potato slices —O— 1.5 mm —x— 2.0 mm

The moisture contents of the slices did not change during blanching. From Fig. 1, the computed values of diffusivity D_r are 4.92 x 10^{-9} m^2/s for 1.5 mm slices and 5.2 x 10^{-9} m^2/s for 2 mm slices. In order to decrease the reducing sugar content to 0.2% (Burton and McWeemy 1964) (i.e., X_r=0.002), the desired blanching times θ_b as obtained from eqn. (1) were 68 sec for 1.5 mm and 109 sec for 2 mm slices.

Blanched slices (20g) were fried in hot groundnut oil (1kg) in electrically heated aluminum

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container at 145, 165 and 180°C. The surface area of oil exposed to atmosphere was 370 cm^2. Potato slices to oil ratio of 25:1000 was chosen to give an initial temperature drop of 10°C. Potatoes were placed in hot oil when the temperature was 5°C higher than the set temperature maintained by a thermocouple type on-off controller. Potato slices were taken out at 30 sec interval and placed on an absorbant paper to remove surface oil. The frying medium was changed (Sultana and Sen 1979) every 3 h of frying, during which time its refractive index increased from 1.4627 to 1.4629. The moisture content was measured by heating 5 g samples at 105°C for 24 h in an oven. Oil content was estimated by extracting in hexane in Soxhlet's apparatus for 4 h. Colour of all the fried chips was matched against red, yellow and blue colour slides of a Lovibond tintometer (Model-E) followed by arithmetic summation, C of the red, yellow and blue colour value. The colour intensity was not measured.

The rate constant k_T was estimated from a straight line plot between lnC and frying time, θ_f. The effect of the temperature T on the rate constant, k_T is represented by the Arrhenius type equation (Kessler 1981).

$$k_T = A \exp [-E_a/(R(T+273)] \quad (2)$$

Where, E_a is the activation energy, kJ/kg mole; R = 8.314 kJ/kg mole ^0K; T is the oil temperature during frying, (°C); and A is a constant. The value of E_a was obtained from the slope of the straight line plot between $\ln k_T$ and 1/(T+273). The effect of temperature on k_T is also represented by Q_{10}, the value of which was determined from Kessler (1981).

$$Q_{10} = 10^{(10/z)} \quad (3)$$

Where, z is obtained from a straight line plot of log $(2.303/k_T)$ and T. The slope of the line is $(-1/z)$.

Optimization analysis : Linear regression equations were developed for each of the dependent variables, namely, moisture content M, oil content O and colour C, as a function of all the three independent variables, namely time of frying θ_f, oil temperature T and thickness of slice b. These equations were used to find out the values of θ_f, T and b in such way that the sum [M+O+1nC] becomes minimum under the constraints :

$$T_1 \le T \le T_2 \quad (4) \qquad b_1 \le b \le b_2 \quad (5)$$

$$M_1 \le M \le M_2 \quad (6) \qquad O_1 \le O \le O_2 \quad (7)$$

$$\theta_{f1} \le \theta_f \le \theta_{f2} \quad (8) \qquad C_1 \le C \le C_2 \quad (9)$$

The suffixes 1 and 2 used in eqns. (4) to (9) represent the lower and upper limit of the variables.

It was decided to have the oil temperature vary between 145 and 185°C and the slice thickness between 1.5 and 2.0 mm. Therefore, in eqns. 4 and 5, T_1 =145, T_2=185, b_1=1.5 and b_2= 2.0. The values of θ_{f1}, θ_{f2}, M_1, M_2, O_1, O_2, C_1 and C_2 were fixed from subsequent analysis. The problem was solved with a quantitative systems in business (QSB) package on a microcomputer.

Results and Discussion

The moisture content (Fig.2) follows a linear relationship for the greater part of the frying cycle except the beginning and end of the cycle. The

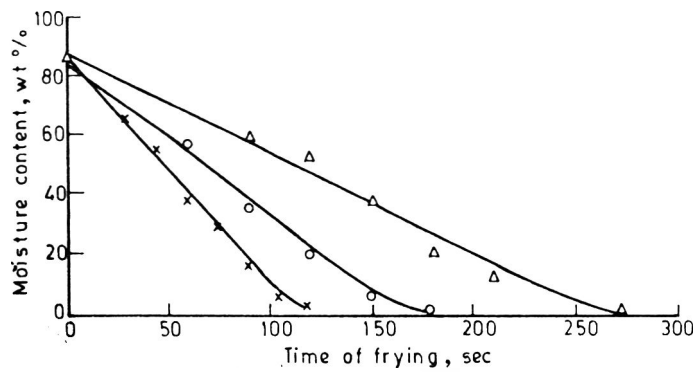

Fig.2. Moisture content of 2 mm potato slices during frying at various temperatures. —Δ— 145°C, —O— 165°C, —x— 185°C.

minimum frying times required to reach a final moisture content of 3% were found to be 255 sec at 145°C, 165 sec at 165°C and 110 sec at 185°C for 2 mm slices. The corresponding times for 1.5 mm slices were 220 sec at 145°C, 150 sec at 165°C and 100 sec at 185°C. The oil content of the chips increased with increase in frying time upto 240 sec at 145°C, 150 sec at 165°C and 105 sec at 185°C for 2.0 mm slices (Fig.3). The corresponding times for 1.5 mm slices were 260 sec at 145°C, 170 sec at 165°C and 100 sec at 185°C. Beyond these

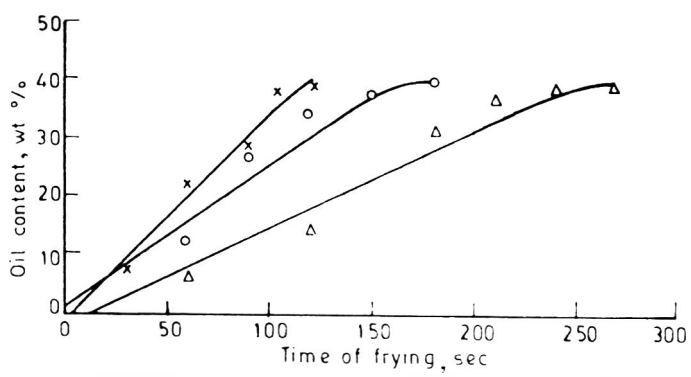

Fig.3. Oil content of 2 mm slices at different oil temperatures and time of frying. —Δ— 145°C, —O— 165°C, —x— 185°C.

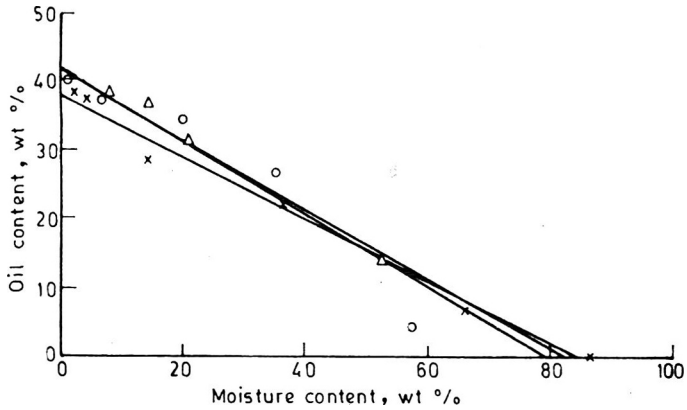

Fig.4. Oil content and moisture content relationship for 2 mm slices at various oil temperatures. —Δ— 145°C, —O— 165°C, —x— 185°C.

periods, the increase in oil uptake and moisture loss were very small (Fig.2 and 3).

The relationship between oil and moisture contents of chips is shown in Fig.4. The oil content at any time is found to be independent of oil temperature and thickness of slice, but is closely related to the moisture present. A correlation coefficient of 0.98 was obtained between oil and moisture contents. The same oil content of 39-41% was observed for both 1.5 mm and 2.0 mm slices, when the residual moisture content was 2-3%. These observations were well in agreement with the results of Sweetman (1936), who reported that oil temperature had no effect on final oil content when the frying temperatures were above 121°C. Lowering initial moisture content and reducing the frying time may be used to produce chips with low oil content. But, this will necessitate a post-fry drying operation, which automatically takes place when hot chips are removed from oil and cooled in air. From this analysis, the constraints for M (eqn. 6) and O (eqn. 7) were, therefore taken as : M_1=2, M_2=3, O_1=39 and O_2=41.

Colour development during deep-fat-frying of potato followed a first order reaction kinetics as

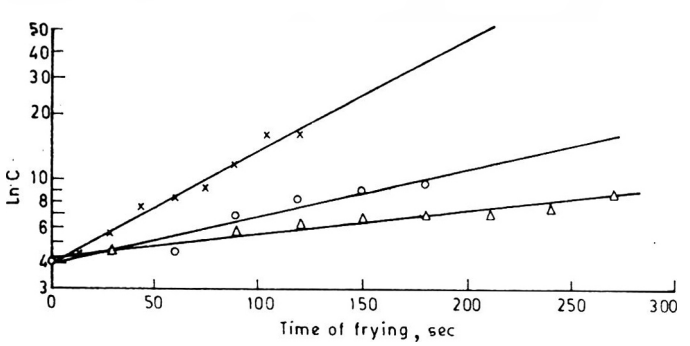

Fig.5. Ln C and time of frying relationship for 2 mm slices at various oil temperatures. —Δ— 145°C, —O— 165°C, —x— 185°C.

indicated by the linear relationship of logarithm of colour with time for all oil temperatures (Fig.5).

TABLE 1. REACTION KINETIC PARAMETERS FOR COLOUR DEVELOPMENT.

Kinetic parameters	Thickness of slice, mm	
	1.5	2.0
Reaction rate constant, k_T (S^{-1})		
145°C	0.00342	0.00338
165°C	0.00607	0.00543
185°C	0.01312	0.01234
Activation energy, E_a (kJ/kg mole)	53.35	51.40
z value, (°C)	68.54	71.08
Q_{10} value	1.40	1.38

With the increase in temperature, the rate constant, k_T increased (Table 1). Also, the kinetic parameters for colour development did not vary much with the thickness of potato slice.

Sensory evaluation of the chips revealed that for consumer acceptance, the colour of the chips should be between 7 and 9. Below 7, the colour was too light and above 9, it became very dark, both being unacceptable. So, the limits of C in eqn. 9 were taken as C_1=7 and C_2=9. From Fig.5 and a similar Figure for 1.5 mm slice, the amount of colour developed at the end of minimal frying times when the moisture content is 3% are shown in

TABLE 2. COLOUR INTENSITY AND MINIMUM TIME TO ATTAIN 3% MOISTURE IN CHIPS DURING FRYING

Oil temperature	Thickness of slice			
	1.5 mm		2.0 mm	
(°C)	Colour	Min. time required(sec)	Colour	Min time required(sec)
145	8.2	220	8.0	255
165	11.5	150	9.4	165
185	17.0	100	14.8	110

Table 2. It may be observed that frying at 165°C and 185°C results in unacceptable colour. So, the limits of frying time (eqn. 8) were selected corresponding to an oil temperature of 145°C yielding θ_{f1}=220 sec and θ_{f2}=255 sec for 1.5 mm and 2.00 mm slices, respectively.

Optimal values : Following regression equations were used for prediction of moisture, oil and colour of the chips for different time, temperature and thickness of slices.

$$M=192.42-0.426807\ \theta_f-0.795\ T + 9.958\ b \quad (10)$$
$$(R^2=0.875)$$

$$O=-54.98+0.21156\ \theta_f+0.398\ T-4.904\ b \quad (11)$$
$$(R^2=0.877)$$

$$\ln C=-1.1619+0.00463\ \theta_f+0.0178T-0.1546\ b \quad (12)$$
$$(R^2=0.714)$$

TABLE 3. OPTIMAL PROCESS PARAMETERS FOR DEEP-FAT-FRYING OF POTATO

	Feasible solution	
	I	II
Temperature of frying, T (°C)	145.0	146.0
Thickness of slice, b (mm)	2.0	2.0
Moisture content of chip, M (wt%)	2.0	2.0
Oil content of chips, O(wt%)	40.1	40.1
Colour value of chips, C	8.6	8.7
Time of frying, θ_f (sec)	222.0	220.0

Using the above equations and the values of constraints (i.e, T_1=145, T_2=185, b_1=1.5, b_2=2.0, M_1=2, M_2=3, O_1=39, O_2=41, C_1=7, C_2=9, θ_{f1}=220 and θ_{f2}=255) in the QSB package, two feasible solutions for the minimum value of (M+O+1nC) were obtained. The results shown in Table 3 reveal that, to get good quality chips (2-3% moisture, 40% oil content, 7-9 colour value), the temperature of oil should be low (145-146°C) and the time of frying high (220-222 sec). Although the frying time can be reduced by using oil at higher temperatures, this is likely to lead to a loss of chip quality by colour darkening.

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Effect of Using Different Sources of Milk Products on the Quality of Bread

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Studies were carried out to determine the effect of different milk products, such as skimmed milk powder, whole milk powder, whole milk and condensed milk on the quality of bread. All these milk products, in general, reduced the farinograph water absorption, increased the farinograph dough stability and made the dough more stiff. Incorporation of any type of milk product at 6.0% level (on dry basis) lowered the loaf volume by 4.8 to 12.4%, hardened the texture, and made the grain coarser. The quality of milk bread could be improved by using 7.5% sugar, 4.0% fat and either a mixture of 15 ppm potassium bromate and 100 ppm ascorbic acid, or 0.5% of di-acetyl tartaric acid ester of monoglyceride along with 100 ppm ascorbic acid. The above formulation improved the loaf volume (445 to 559°C) and crumb texture of the milk bread. The studies indicated that sterilized whole milk, which is less expensive than the dried or condensed milk, could be effectively used in milk bread formulation.

Keywords : Milk bread, Storage of bread, Dough characteristics, Bread additives, Effect of different milk sources.

Milk solids improve the nutritional quality, taste and keeping quality of bread. These form an essential ingredient in milk bread and a minimum level of 6% (dry basis) has to be used as per the specifications of Indian Standards Institution (ISI 1985). The inclusion of milk solids in bread leads to various changes such as increase in the bread water absorption (Larson et al. 1951; Swanson et al. 1964; Dubois and Patrick 1984), reduction in the volume of bread (Larson et al. 1951; Marston 1971) and imparting open grain and hard texture (Marston 1971; Baldwin et al. 1964). The extent of these changes depends on the method of manufacture of the milk solids and the type of its pre-heat treatment (Swanson et al. 1964). Heat treatment of milk during processing has been reported to overcome the deleterious effect in bread and therefore, milk powder is specifically processed in some of the countries for use in bakery industry and is known as "High heat" non-fat dry milk (NFDM) or special baker's milk powder (Lee 1952).

In India and some other developing countries, normal NFDM is used in bread. Many other sources of milk solids, such as whole milk powder, condensed milk and whole milk could be used in bread. However, comparative information regarding their effect on the quality characteristics of bread and dough is not available. The results of such studies are presented in this paper.

Materials and Methods

Wheat flour (*Maida*) was procured from the local market. Commercially available skimmed milk powder, whole milk powder, condensed milk and whole milk were procured from reputed manufacturers. Whole milk was boiled for 5 min before using in the formulation.

Chemical characteristics : Estimation of moisture, total ash, dry gluten, Zeleny's sedimentation value and Kent-Jones colour grade value were carried out, as per the standard AACC (1969) methods. Dough raising capacity of flour was determined according to ISI method (ISI 1985).

Rheological characteristics : Farinograph and extensograph characteristics of bread dough were assessed by AACC (1969) methods. General food texturometer characteristics of bread were evaluated by the method adopted by Tanaka (1975) with the following conditions : 0.5 V voltage; 2 mm clearance; 50 mm plunger diameter.

Baking characteristics : Breads were prepared by following the remix baking test (Irvine and McMullan 1960). Fat (1%) and malt (0.5%) were included in the formulation. Milk products were incorporated on dry weight basis. Loaf volume of bread was measured in a loaf volume meter using rapeseed displacement method (Mallock and Cook 1930). Sensory evaluation of breads, for crust and crumb characteristics, was carried out by a panel of semi-trained judges.

Storage studies : Storage trials were carried out by packing the breads in polypropylene pouches (150 gauge) and storing at 27±2°C and 65±5% RH. The breads were observed for mould growth and assessed for the textural characteristics using general foods texturometer (Tanaka 1975) at regular intervals.

* *Corresponding Author*

All the tests were carried out in triplicate and the average values are reported.

Results and Discussion

The flour used for the study had the following quality characteristics as expressed on 14% moisture basis: dry gluten 11.66%, sedimentation value 24 ml, ash 0.46% and colour grade value 3.2. The reasonably high values for gluten and sedimentation suggest the suitability of flour for bread preparation. The composition of different milk products (Table 1) agrees with the values reported by Eckles et al (1951).

TABLE 1. COMPOSITION OF DIFFERENT MILK PRODUCTS

Composition, %	Skimmed milk powder	Whole milk powder	Whole milk	Sweetened condensed whole milk
Water	4.00	4.00	87.25	26.75
Protein	37.40	27.20	3.50	7.85
Milk fats	1.00	26.00	3.80	8.99
Lactose	49.20	36.80	4.80	12.94
Ash	8.40	6.00	0.65	1.77
Sucrose	-	-	-	40.59
Total milk solids	96.00	96.00	12.75	73.25

Effect of milk products on the rheological characteristics of wheat flour dough : Table 2 illustrates the changes in farinograph characteristics of flour due to incorporation of differently processed milk solids. There was a gradual decrease in farinograph water absorption with the addition of all the milk products. The reduction was negligible upto 2% level of addition. Incorporation of skim milk powder, whole milk powder and whole milk at 6% level (on dry basis), decreased the water absorption from 59.6 to 55.4-58.0%, while it was reduced to 49.4% with the use of condensed milk. The greater reduction in farinograph water absorption with condensed milk could be attributed to the presence of high level of sugar (about 40%) in the milk product (Eckles et al. 1951). The dough development time as well as dough stability increased with increase in the level of incorporation of milk solids. In these cases, the extent of increase was similar in all the sources of milk used. This could be attributed to the presence of high levels of calcium in milk solids. The salts are known to increase the mixing time and stability (Bennett and Ewart 1965).

Use of differently processed milk solids (6% level) made the dough stiff as evidenced from the increase in the resistance to extension from 485 to 550-735 BU, and also the ratio figure from 2.77 to 3.27-4.32 (Table 2). Larsen et al. (1951) also reported the increase in the resistance to extension on incorporation of skimmed milk solids.

TABLE 2. EFFECT OF DIFFERENT MILK SOLIDS ON THE RHEOLOGICAL CHARACTERISTICS OF THE DOUGH

Form of milk used	Level of milk solids* (%)	Farinograph				Extensograph			
		Farinograph water absorption %	Dough development time, min	Stability, min	Mixing tolerance index, BU	Resistance extension, BU	Extensibility, mm	Ratio figure, R/E	Area, cm^2
Control	0	59.6	4.0	6.0	70	485	175	2.77	120.35
Skimmed	2	59.4	4.5	7.0	55	-	-	-	-
milk powder	4	59.0	5.5	9.0	55	-	-	-	-
	6	58.0	5.5	10.0	50	555	170	3.27	133.65
	8	57.2	6.0	10.0	45	-	-	-	-
Whole	2	58.5	4.5	6.0	60	-	-	-	-
milk powder	4	57.0	5.0	7.0	60	-	-	-	-
	6	55.4	6.0	9.0	60	600	160	3.70	138.60
	8	54.8	6.0	10.0	50	-	-	-	-
Whole milk	2	59.0	4.0	9.5	45	-	-	-	-
	4	58.8	4.5	10.0	45	-	-	-	-
	6	57.8	6.0	10.0	40	550	175	3.13	130.70
Condensed milk	2	55.6	4.0	8.5	70	-	-	-	-
	4	52.4	4.5	10.0	60	-	-	-	-
	6	49.4	5.0	10.0	60	735	170	4.32	174.80
	8	47.0	6.0	10.0	50	-	-	-	-

* - On dry basis

Extensibility of dough, on addition of milk solids, did not show any considerable change. Use of condensed milk at 6% level had maximum improvement in total strength of the dough as indicated by the area of the extensogram, which increased from 120.4 to 174.8 cm^2. Maximum change in the extensograph characteristics was observed with the incorporation of condensed milk.

Effect on bread quality : Inclusion of differently processed milk products in the bread formulation gradually decreased the bread loaf volume with increase in their level (Table 3). With the addition of 6% milk solids, the reduction in bread loaf volume ranged between 4.8 and 12.4%. Larsen et al. (1951) and Dubois et al. (1984) have also reported similar reduction in loaf volume with the addition of skimmed milk powder. Among the various milk products, condensed milk had the least effect on the loaf volume. This could be due to the oxidation of sulfhydryl groups during processing of condensed milk which otherwise is known to be responsible for the deleterious effect (Swanson et al. 1964).

Addition of milk solids darkened the crust colour, and the crust colour was acceptable only upto 6% addition of milk solids. Beyond this level, the crust colour could be made acceptable by slightly reducing the bake time. Hubbard (1971) observed definite improvement in crust colour at a lower level (2-3%) of milk powder. Addition of milk solids upto 2% did not affect the texture or grain of the crumb, but the crumb texture became increasingly harder, while grain became coarser at higher levels of milk powder. At all levels of incorporation, bread containing condensed milk had better texture and grain when compared to those containing other milk solids. Though incorporation of milk solids improved the taste of breads, in general, the bread containing condensed milk ranked higher as indicated by higher score.

Improvement in the quality of milk bread : In order to overcome the deleterious effect of incorporating milk solids in bread, ingredient levels were varied and additives were used in the formulation. These studies were carried out in bread containing 6% skimmed milk solids. As illustrated in Fig. 1, optimum levels of sugar and fat were found to be 7.5% and 4.0%, respectively. Further increase in their addition reduced the volume of bread. Incorporation of both sugar (7.5%) and fat (4%) increased the bread volume to 570 cc as compared to that of 470 cc in case of control bread containing 2.5% sugar and 1% fat.

TABLE 3. QUALITY OF BREAD, AS AFFECTED BY DIFFERENT MILK PRODUCTS

Form of milk used	Level milk solids*, %	Volume, cc	Specific volume, cc/g	Crust colour	Cell structure and texture **	Taste **
Control	0	525	3.91	GB	8.5	6.0
Skimmed milk powder	2	515	3.81	GB	8.0	6.0
	4	495	3.67	B	7.0	7.5
	6	470	3.40	B	4.0	7.0
	8	470	3.39	DB	3.0	6.0
Whole milk powder	2	510	3.80	GB	8.0	6.0
	4	485	3.62	B	7.5	7.0
	6	470	3.44	B	5.0	8.5
	8	450	3.40	DB	4.0	6.0
Whole milk	2	505	3.75	GB	8.0	6.0
	4	495	3.69	B	6.5	8.0
	6	480	3.57	B	5.0	5.5
Condensed milk	2	515	3.74	GB	8.5	7.0
	4	505	3.54	B	8.0	9.0
	6	500	3.50	B	7.0	8.5
	8	490	3.50	DB	5.5	6.0

GB - Golden brown, B - Brown, DB - Dark brown, * - On dry basis,
** - Sensory evaluation was carried out on 9 pt. Hedonic scale

The quality of milk bread as affected by different additives is given in Table 4. The results indicated that all the additives improved the volume and texture by varying degrees. However, the improvement was better, when different combination of additives were used. Maximum improvement was observed in bread containing diacetyl-tartaric acid

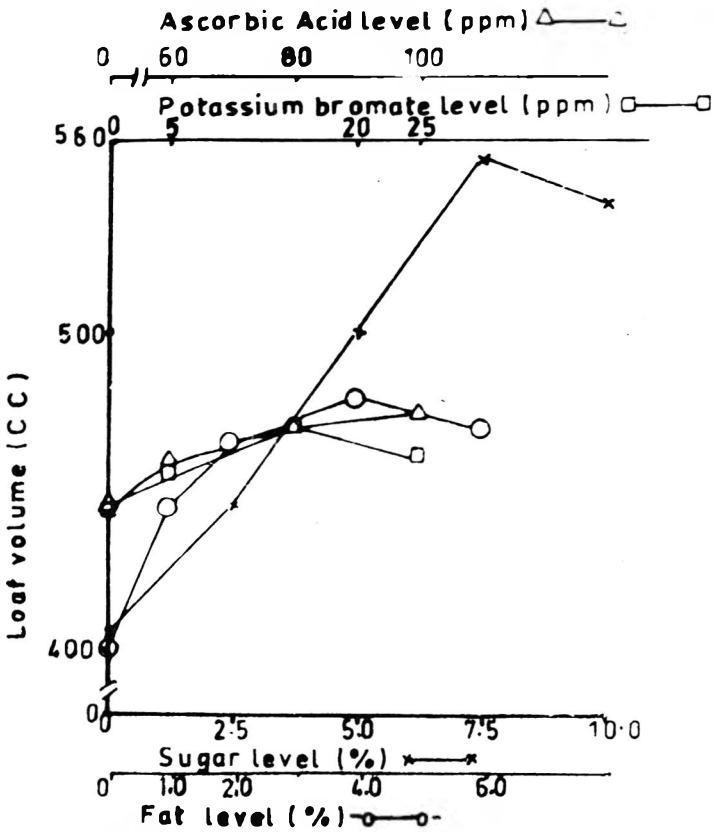

Fig.1. Effect of ingredients and additives on the loaf volume of milk bread.

ester of monoglyceride (DATEM) or Tween 60. Greater improvement in bread volume was observed when either a mixture of ascorbic acid and potassium bromate or DATEM and ascorbic acid was used.

TABLE 4. EFFECT OF ADDITIVES ON THE QUALITY OF MILK BREAD*

Additive used and level	Volume, cc	Specific volume, cc/g	Cell structure and texture** g
Control, no milk	525	3.90	8.5
Milk bread	445	3.30	4.0
$KBrO_3$, 15 ppm	470	3.49	6.5
AA, 100 ppm	475	3.53	7.0
$KBrO_3$, 15 ppm + AA, 100 ppm	510	3.80	9.0
SSL, 0.5%	465	3.53	6.5
DATEM, 0.5%	495	3.68	8.0
DATEM, 0.5% + AA, 100 ppm	510	3.79	8.5
TWEEN-40, 0.5%	480	3.53	6.5
TWEEN-60, 0.5%	490	3.61	7.0

$KBrO_3$- Potassium bromate, AA - Ascorbic acid, SSL - Sodium stearoy-2-lactylate, DATEM - Diacetyl tartaric acid ester of mono glyceride, TWEEN-40 - Polyoxyethylene sorbitan mono-palmitate, TWEEN-60 - Polyoxyethylene sorbitan mono-stearate, * - At 6% skimmed milk powder, dry basis, ** - Sensory evaluation was carried out on 9 pt. Hedonic scale.

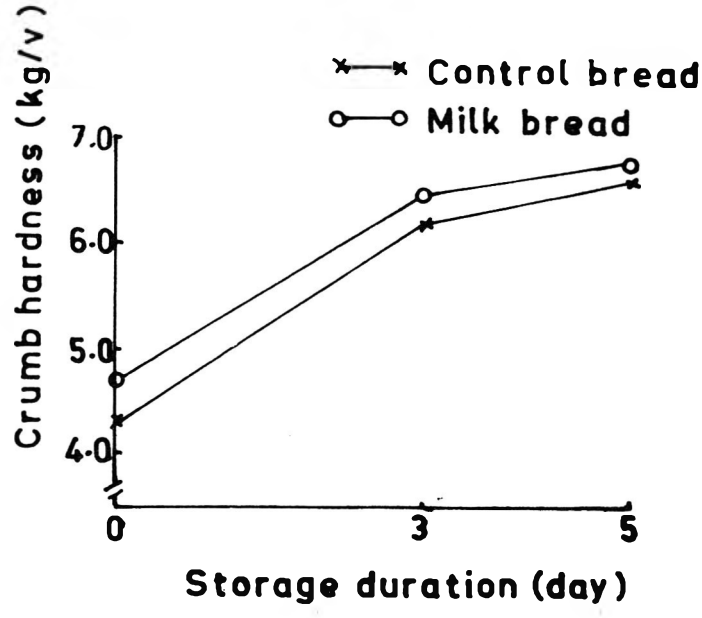

Fig.2. Changes in the crumb hardness of bread during 5 days storage. —X X— Control bread, —O-O— Milk bread.

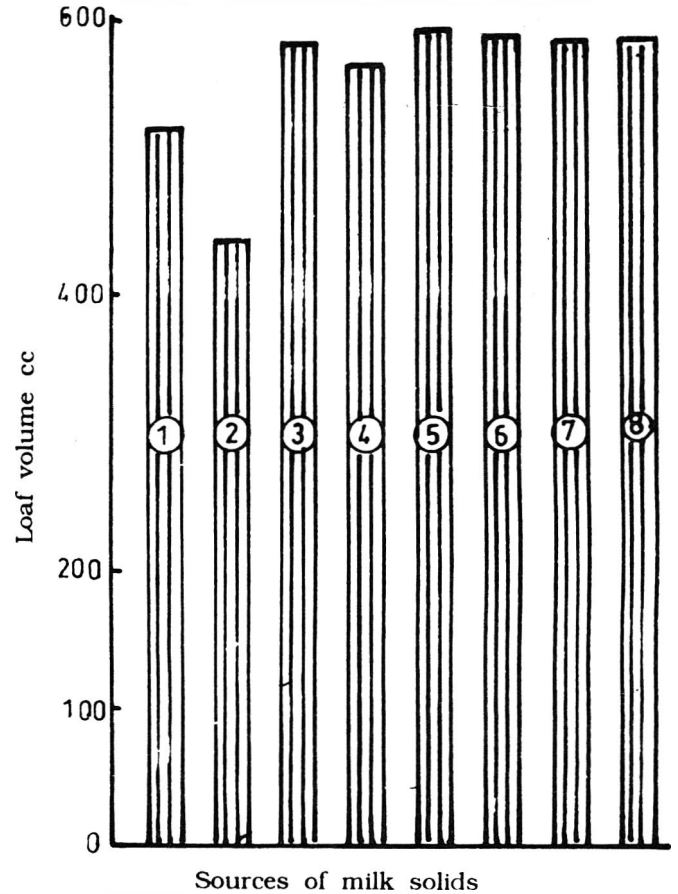

Fig.3. Loaf volume of bread, as influenced by different sources of milk solids. 1. Control bread, no milk solids; 2. Milk bread, 6% SMP, d.b., 3. Control bread+Sugar (7.5%) + fat (4%); 4. Milk bread+sugar (7.5%)+fat(4%); 5. SMP (6% db) bread+ sugar (7.5%)+fat(4%)+additives; 6. WMP (6% db) bread+sugar (7.5%)+fat (4%) + additives; 7. WM (6%db) bread+sugar (7.5%)+fat (4%) + additives; 8. CM (6% db) bread + sugar (7.5%).+fat(4%)+additives. SMP = Skimmed milk powder; WMP = Whole milk powder; WM = whole milk; CM = Condensed milk.

The above two combinations of additives also improved the dense and coarse crumb texture of milk bread into soft and velvety texture with uniform fine cells.

Breads made with optimum level of ingredients and additives using different milk solids indicated that the loaf volume of bread was almost the same in all cases (Fig.2). The other quality parameters were also found to be similar. This suggested that any type of milk solids including whole milk could be effectively used in bread.

Storage studies : Storage studies carried out indicated delayed mould growth in milk bread (6th day) as compared to control bread (5th day). Earlier studies indicated that wrapping in sorbic acid impregnated paper could preserve well upto a period of 6 months (Ghosh et al. 1973; Chakrabarthy et al. 1974). Though the initial hardness in milk bread was higher, the increase in hardness during storage was slightly lower in milk bread (2.1 kg/v) as compared to control bread (2.3 kg/v) (Fig.3.)

To conclude, bread made using condensed milk had better quality characteristics as compared to that containing non-fat dry milk, whole fat milk solids and whole milk. Quality of milk breads could be improved by using the combination of either potassium bromate and ascorbic acid or diacetyl tartaric acid ester of monoglyceride and ascorbic acid. The studies also showed that sterilized whole milk could be used in milk bread, in place of costlier milk powder.

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Development of a Laboratory Method for Preparation of *Nan*

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A laboratory method for preparation of an Indian traditional fermented food - *nan* has been developed, based on a questionnaire survey and evaluation of the dough and the *nan* from hotels. Research water absorption meter (RWAM) has been adapted for determining *nan* dough water absorption (NWA) to arrive at the desired dough consistency, expressed as the dough extrusion time in the range of 65-76 sec. Conditions have been optimised for (i) preparation of the dough based on refined wheat flour (*maida*), curd/yoghurt, milk, table salt, egg, fat, sugar, food grade sodium bicarbonate and water equivalent to NWA, (ii) fermentation and sheeting of the dough and (iii) baking of *nan* in a gas *tandoor* (oven).

Keywords : *Nan*, Ingredients, Preparation method, Evaluation, Dough water absorption, Research water absorption meter, Gas *Tandoor*.

Nan, a flat leavened bread made from *maida* (refined wheat-flour) is a popular traditional food of the Indian sub-continent. It is relatively more nutritious than *chapati/roti*, as it is prepared from a fermented dough containing milk, curd (yoghurt) and egg. Due to its specific method of preparation and baking in a special type of oven - *tandoor*, *nan* is generally made only in a few households and its consumption is confined mostly to *'Dhabas'* (the road side food stalls) or hotels.

No scientific information is available on the method of *nan* preparation *vis-a-vis* the influence of ingredients and processing conditions. Such a situation necessitated a survey of the existing preparation methods, including the recipes, ingredients and baking ovens, to be followed by scientific studies to develop a reference preparation methodology for *nan* of desired quality parameters in the laboratory. The results of such a study are presented in this paper.

Materials and Methods

Samples of *nan* dough and *nan* were procured locally from 6 hotels. Eight different *maida* samples were obtained from different sources locally, while one was processed in a laboratory roller flour mill (MLU-202) using 'Punjab' wheat. Essential ingredients such as curd, refined groundnut oil, milk, egg, table salt, sugar and food grade sodium bicarbonate (baking soda) and optional ingredients such as milk and sugar were procured from local market.

Maida of different fineness (21.6-31.7% throughs of 62 μ sieve opening) was processed from 'Punjab' wheat, by changing the laboratory roller mill settings from normal (B_2-0.13 mm, B_3-0.1 mm, R_1-0.07 mm and R_3-0.03 mm) to varying clearances of R_3 (0.044-0.024 mm). *Maida* samples were analysed for moisture, ash, damaged starch, particle size, wet gluten, Pelshenke value, sedimentation value, farinograph water absorption (FWA) by AACC (1976) methods and flour hydration capacity by the method of Yamazaki (1953). The texture parameters like hardness, cohesiveness, chewiness and springiness were determined for laboratory made as well as hotel samples of *nan* dough and *nan* by adapting the method of Tanaka (1975), using texturometer (Model GTX, General Foods).

Determination of nan-*dough water absorption (NWA):* Softness of the dough and absence of stickiness by handfeel were considered as desirable attributes for determining NWA subjectively. Consequently, an objective method based on the measurement of the extrusion time of the dough was developed by adapting research water absorption meter (RWAM) under operative force of 3.39 kg. Dough was prepared by hand mixing or in a Hobart mixer (N-50) using 100 g *maida* and water equivalent to NWA. A portion was then rolled by hand to a diameter and length, similar to that of the gun (cylindrical steel tube) of RWAM. The gun was filled with rolled dough and the piston was released for extruding the dough. The time for extruding 1 cm length of dough was considered as an index of dough consistency.

Preparation of the nan *dough and* nan: Two hundred grams of laboratory milled *maida* along with optimum levels of other ingredients, arrived at after preliminary trials, and the required quantity of water (NWA) were mixed in a Hobart mixer for an optimum period of 3 min to obtain a *nan* dough of desired consistency. The prepared dough was allowed to ferment for 4 h. Based on preliminary trials, about 80 g fermented dough was taken for sheeting to the desired thickness of 2.5 mm by using a wooden

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rolling pin and a specially designed aluminium platform (Haridas Rao et al. 1986) and baked in gas *tandoor* (Supercook, India) for an optimum period of 1.5 min at 350-365°C to obtain a *nan* with pleasing appearance, spongy texture and desired chewing/eating characteristics.

Evaluation of nan: The *nans* were graded on a 5 point scale viz. poor, fair, satisfactory, good and excellent by a panel of six trained judges for the quality attributes of appearance, handfeel (texture), chewing/eating quality and overall quality. Optimum levels of different ingredients and processing conditions were arrived at, on the basis of *nan* judged as good/excellent for overall quality.

Survey questionnaire : To get acquainted with the present status of information on *nan*, before undertaking scientific studies, information was sought from 77 hotels and catering establishments about the ingredients, dough preparation, fermentation time, leavening agents, dough consistency, size, shape and thickness of the dough sheet, method of baking, texture profile, eating quality and frequency of consumption.

Results and Discussion

Physico-chemical attributes of maida : The ranges of values for attributes like ash, flour hydration capacity, wet gluten, sedimentation values and Pelshenke values, presented in Table 1, indicated that the commercial *maida* samples used in the present studies were milled from soft or medium hard wheats. Values for laboratory milled *maida* indicated that 'Punjab' wheat used was of good quality medium hard wheat. Variation in damaged starch influencing the water requirement of the dough may be attributed to the severity of grinding, which affects the particle size pattern of *maida* samples.

Nan *dough water absorption (NWA) :* The data (Table 1) on the farinograph water absorption (FWA), NWA and extrusion time showed that NWA could be obtained by adding 1–3% extra water to FWA. Therefore, Brabender farinograph, normally used for determining water requirement for a bread dough, could be employed for determining NWA.

Hand mixed *nan* dough of desired consistency required 1–2% more water than Hobart mixed dough. The extrusion time determined on RWAM had ranges of 40-55 sec and 65-76 sec for hand and Hobart mixed doughs of desired consistency, respectively. The corresponding extrusion times for laboratory made doughs were 54 and 76 sec,

TABLE 1. PHISICO-CHEMICAL ATTRIBUTES AND *NAN* DOUGH WATER ABSORPTION OF COMMERCIAL AND LABORATORY MILLED *MAIDA* SAMPLES

Attributes	*Maida*	
	Commercial[a]	Laboratory[b]
Flour hydration capacity, %	206 - 225	236
Particle size,[c]	18.6 - 22.7	21.6-31.7
Moisture, %	11.8 - 13.1	12.3
Damaged starch, %	11.4 - 13.7	9.4-12.6
Wet gluten, %	21.7 - 23.9	29.6
Total ash, %	0.59 - 0.80	0.48
Sedimentation value (ml)	17.7 - 28.2	28.2
Pelshenke value, min	85 - 106	124
Farinograph water absorption, %	58.1 - 62.1	62.3
NWA		
hand mixed, %	61.0 - 65.1	64.5
Hobart mixer, %	59.8 - 64.1	63.2
Extrusion time, sec		
handmixed dough	40 - 55	54
Hobart mixer dough	65 - 76	76

[a] Range for 8 samples

[b] Milled from 'Punjab' wheat to varying degrees of fineness.

[c] As throughs of 25 p sieve of 62 μ opening

respectively. This finding has shown the possibility of adapting a portable RWAM, in place of imported high cost farinograph, for quick determination of NWA.

Evaluation of nan *dough and* nan: The pH variation range was 6.6-6.9 for fresh doughs and 5.6-4.8 for doughs fermented for 2-14 h, while the respective acidity values, expressed as % lactic acid were 0.06 and 0.4%. The data on textural parameters of *nan* dough and *nan* from hotels as well as those made in laboratory are presented in Table 2. The

TABLE 2. DESIRED TEXTURAL ATTRIBUTES OF *NAN* DOUGH AND BAKED *NAN*.

Attributes	Dough		*Nan*	
	Laboratory[a]	Hotel[b]	Laboratory[a]	Hotel[b]
Farinograph peak consistency[c], B.U	610	680	-	-
Hardness, kg/volt	10.7	8.6	7.0	11.9
Cohesiveness	0.95	0.79	0.84	0.71
Chewiness, kg/volt x mm	-	-	50.3	84.0
Springiness, mm	-	-	10.2	10.0

[a] Average of 4 samples prepared in laboratory from 'Punjab' wheat *maida*

[b] Average of 6 samples

[c] Determined by transferring Hobart mixed and hotel doughs to farinograph.

farinograph peak consistency (680 BU) for hand mixed doughs from hotels was higher than Hobart mixed laboratory dough (610 BU), thereby, indicating the underdeveloped nature of hotel doughs. This was further reflected in the lower values of hardness and cohesiveness for hotel doughs. The lower values of hardness and chewiness of laboratory made *nan*, as compared to hotel *nans* from hand mixed doughs, indicated softer texture, which may be attributed to more uniform distribution of ingredients and better development of the dough prepared in Hobart mixer.

Effect of ingredients on the overall quality of nan: The optimum levels of different ingredients were arrived at, after a series of preliminary trials covering the ranges of essential ingredients (g/100 g *maida*): curd 6-24, salt 1-4, baking soda 0.25-1.00, fat 2-8, and egg 1-4, and optional ingredients such as: sugar 1-4, and milk 3-12 and on the basis of *nans* graded as excellent or good for overall quality by the judges. The data on trials regarding optimum levels of essential ingredients based on overall grading of *nan* are presented in Table 3.

Curd with a lower pH of 4.8 was better suited for dough, when fermentation period was 4 h. With the increase in the level of curd beyond 12 g, the texture of *nan* became increasingly leathery and tough. Inclusion of 6 g of optional ingredient milk (i.e. a milk : curd ratio of 1:2) improved the soft and spongy texture of *nan*. Salt level higher than 1 g (judged as optimum), tended to affect the dough softness adversely. Baking soda at 0.5 g level yielded an optimally leavened *nan* of desired spongy texture; higher levels affected the taste and the product showed fine surface cracks. Optimum levels of fat and egg for obtaining a soft dough and spongy textured, tasty *nan* were 4 and 3 g, respectively. At higher levels of egg, though the texture of *nans* was softer, its smell became unacceptable. Inclusion of 2 g sugar as an optional ingredient improved the taste of *nan*.

Effect of processing conditions on the quality of nan: Of the varying period (2-8 min) tried, a 3 min mixing of ingredients in a Hobart mixer was found optimum for obtaining a well developed homogeneous dough of desired consistency. Under or over-mixing resulted in a non-homogeneous, underdeveloped or sticky dough, respectively. Among the period (2-14 h) tried, a 4 h fermentation period yielded a non-sticky and adequately leavened dough with desired aroma and softness. Such a dough could be rolled with ease. From the different thicknesses of 1.5-4.0 mm tried for sheeting, 2.5 mm sheet yielded on baking, a *nan* of desired spongy texture and chewing/eating quality. Because of the desired short duration baking, thicker *nan* remained somewhat under-baked, while thinner *nan* lacked soft and spongy texture and tended to be somewhat tough to chew.

A commercially available 'Supercook' gas *tandoor* (Fig.1) has been successfully adapted for baking of *nan*. When gas flame was maintained at maximum for 1-3 min time, a baking time of 1.5 min was found optimum for obtaining a *nan* with desired softness, spongy texture and eating quality. This

TABLE 3. EFFECT OF LEVEL OF INGREDIENTS (g/100 g *maida*)[a] USED ON THE OVERALL QUALITY GRADING[b] OF *NAN*

Curd[c]		Salt[c]		Baking soda[c]		Fat[c]		Egg[c]	
Weight	Grading of *nan*	Weight	Grading of *nan*	Weight	Grading of *nan*	Weight	Grading of *nan*	Weight	Grading of *nan*
6	Fair	1[d]	Good	0.25	Fair	2	Satisfactory	1	Satisfactory
12[d]	Excellent	2	Satisfactory	0.50[d]	Good	4[d]	Excellent	2	Good
18	Satisfactory	3	Fair	0.75	Satisfactory	6	Good	3[d]	Excellent
24	Poor	4	Poor	1.00	Fair	8	Fair	4	Fair

[b] Based on attributes : appearance, handfeel (texture), eating and chewing quality; [c] Except for the varying levels of ingredient specified, the remaining ingredients were included at optimum levels (superscribed 'd') arrived at after a series of preliminary trials for each ingredient; [d] Optimum level.

Fig.1. Initial baking of one side of the *nan* for 1 min on inner surface of the covering lid of gas *tandoor*.

consisted of 1 min baking on the inner side of the covering lid and 0.5 min for baking the other side on the wire mesh of the *tandoor*. Of the different baking temperatures (300-390°C) tried, the desired temperature range was 350-365°C.

Survey: The data and inferences based on the responses to the questionnaire on *nan* are as follows:

The frequency of consumption was occasional and daily in 12 and 88% cases, respectively. The number of *nans* prepared varied from 50 to 400 per day in the hotels and *'Dhabas'*. For obvious reasons, no specific quantitative information was revealed about the recipe and processing conditions used by almost all the respondents. Besides the main ingredient *maida*, other ingredients used invariably were *vanaspati* (hydrogenated fat)/ oil, salt, curd and baking soda. Egg, sugar and milk were also used by about 40% respondents. Only one respondent each, informed the use of 10, 4 and 1% of fat, salt and yeast, respectively. Only a few of the respondents used occasionally, spices like *Kalongi*, or *Somf*. Resting/fermentation period ranged from 15 min to 14 h (overnight). Baking was carried out for 1-10 min. in firebrick or coal-fired *tandoor*, without recording inner temperature. The desired texture mentioned was spongy with a 'typical' chewy bite.

Laboratory method developed for the preparation of nan: Based on the results of above studies, the optimum levels of ingredients and the desired processing conditions were arrived at for the preparation of dough of desired consistency and a *nan* of good overall quality. Ingredients (g): maida 100, curd (pH 4.8) 12, milk 6, salt 1, egg 3, fat 4, sugar 2, baking soda 0.5 and quantity of water equivalent to NWA (RWAM extrusion time range: 65-76 sec) were mixed for 3 min in a Hobart mixer. The dough obtained was rested for a 4 h fermentation period. About 80 g of the dough was rolled to a thickness of 2.5 mm and baked in gas *tandoor*, set at maximum flame for 1 min on the inner side of the covering lid and the other side for 0.5 min. on the wiremesh of *tandoor* directly. *Nan* prepared, thus, was soft to touch, spongy to handfeel, somewhat firm to tear, a little chewy to bite without sticking to teeth and had a characteristic fermented flavour and a good overall acceptability.

Acknowledgement

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Effect of Pre-treatment and Drying Air Temperature on Quality of Peas Dehydrated in Fluidized Bed Dryer

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Data on pretreatments (pricking and blanching) and drying air temperatures (60-90°C) on rehydration ratio and sensory characteristics of peas (Variety:'Arkel') dehydrated in fluidized bed dryers showed that the effect of pricking was more prominent than blanching. Temperature also affected texture and flavour. Drying air temperatures of 70-80°C with prickir.g and blanching were found to be the optimum treatments for pea dehydration in fluidized bed.

Keywords : Pricking, Blanching, Fluidization, Sensory evaluation, Drying, Peas.

Pea (*Pisum sativum*) is an important legume which is consumed in several forms. Fresh peas as such are highly perishable and also the availability is seasonal. The dehydrated peas are gaining popularity because they offer the advantages of greater shelf-life, palatability and convenience during transport and handling. (Kuppuswamy and Gururaj Rao 1970). To obtain a dehydrated product of high quality, the drying process should be such that it allows effective retention of colour, texture, flavour, taste and nutritive value, comparable to fresh peas. The conventional air drying has failed to produce dehydrated peas of high shelf-life (Hand et al. 1955). The drying in fluidized bed dryer at 70-75°C was found optimum as drying below this temperature affected the texture, while that above this temperature affected the colour and rehydration characteristics (Gangopadhyay and Choudhari 1979). Pricking of peas enhanced the drying rate, also colour and texture was better for pricked peas (Takte and Singh 1986; Prabhakar Bhat et al. 1974). The present study was, therefore, undertaken to evaluate the effect of pretreatments (pricking and blanching) and drying air temperature on rehydration ratio and sensory characteristics of peas dehydrated in fluidized bed dryer.

Materials and Methods

Preparation and drying of peas : The study was conducted on 'Arkel' variety as it is the most commonly grown in the Tarai region and is also suitable for making as dehydrated product (Khurdiya et al. 1972). The green peas were procured from Haldwani market. The pea pods were shelled manually, graded to 9.2 - 10 mm size in Carter-Day cylindrical grader, pricked once in hand-operated pricking machine and blanched in a pan containing hot water at 96°C for 2 min. The blanched peas were immediately cooled using cold water and spread on a cotton cloth for removal of surface moisture. Four levels of drying air temperatures (60, 70, 80 and 90°C), all at 3.1 min/sec air velocity (minimum velocity required for fluidization) were used in fluidized bed dryer. The selection of the air velocity was governed by the fact that the drying air velocity had no effect on drying rate (Uckon and Ulku 1966). In each case, 500 g sample was dried in a laboratory fluidized bed dryer and the sample was weighed at an interval of 10 min, till the weight became more or less constant. The dried sample was cooled and packed immediately in polythene bag.

Analytical methods : Moisture content of fresh peas was determined by two stage air oven method recommended by American Association of Cereal Chemists (AACC, 1962). Residual peroxidase activity after blanching was measured by peroxidase test, while rehydration ratio (RR) was evaluated according to Indian Standards (BIS 1968).

Sensory evaluation : Sensory evaluation was carried out by a panel of ten judges of different age groups, having different eating habits. The judges were selected from the staff in the Post Harvest Process and Food Engineering Department of the University. Different attributes viz. colour, texture, flavour and overall acceptability were rated on the basis of a 9-point Hedonic scale (BIS 1972), ranging from 1 (most undesirable) to 9 (most desirable). Data were subjected to statistical analysis (Snedecor and Cochran 1968).

Results and Discussion

Effect on rehydration ratio (RR) : Unpricked samples (both unblanched and blanched) had RR values less than 3.0 (Table 1) and did not meet

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TABLE 1. MEAN VALUES AND CRITICAL DIFFERENCES OF QUALITY ATTRIBUTES OF DEHYDRATED PEAS

Pre-treatments	Dry air temperature (°C)	Rehydration ratio	Sensory score			
			Colour	Texture	Flavour	Overall acceptability
Unpricked-Unblanched	60	2.61	3.0	1.8	2.7	3.4
	70	2.84	1.8	5.3	2.9	5.0
	80	2.87	1.6	6.0	4.3	5.3
	90	2.84	1.4	1.5	2.6	2.3
Pricked-Unblanched	60	3.18	7.1	2.2	4.8	4.8
	70	3.36	8.0	4.9	6.1	7.1
	80	3.38	6.1	7.8	8.1	6.4
	90	3.32	4.4	5.2	1.6	4.3
Unpricked-Blanched	60	2.72	5.1	1.9	5.9	4.3
	70	2.88	4.9	5.7	4.9	5.5
	80	2.90	3.5	5.2	5.3	6.2
	90	2.86	2.6	4.8	3.7	4.1
Pricked-Blanched	60	3.19	8.3*	2.6	4.9	5.0
	70	3.36	7.6	8.0	8.3*	7.2
	80	3.43*	7.6	8.1*	7.7	7.7*
	90	3.34	5.1	2.6	1.8	3.0
Residual sum of squares		3.42	7.67	7.28	7.53	6.60
C D (5%)		0.0051	0.6213	0.8151	0.7691	1.0983
Acceptable value/score		3.2	7.5	7.5	7.5	7.5
Individual effects of pretreatments						
Unpricked		2.82	2.9	4.0	4.0	4.5
Pricked		3.32	6.8	5.2	5.4	5.7
C D (5%)		0.0010	0.2197	0.2889	0.2711	0.3880
Unblanched		3.05	4.2	4.3	4.1	4.8
Blanched		3.09	5.6	4.8	5.3	5.4
C D (5%)		0.0018	0.2197	0.2382	0.2719	0.3883
Dried at 60°C		2.93	5.9	2.1	4.5	4.4
70°C		3.11	5.6	6.0	5.5	6.2
80°C		3.15	4.7	6.8	6.3	6.4
90°C		3.09	3.4	3.5	2.4	3.4
C D (5%)		0.0025	0.3107	0.4075	0.3845	0.5491

* Best mean in the respective quality attribute.

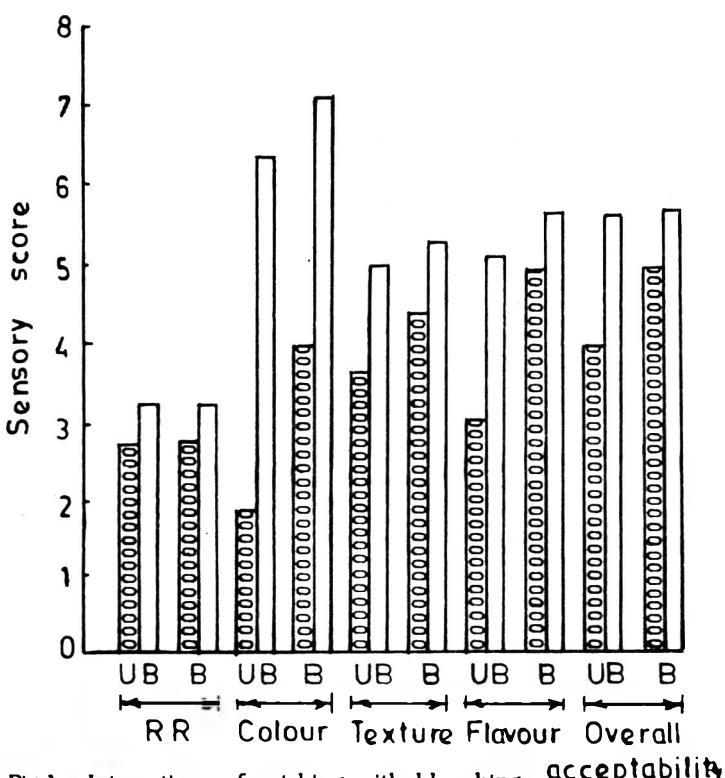

Fig.1. Interactions of pricking with blanching
▨ Unpricked; □ Pricked
UB- Unblanched; B - Blanched

the quality requirements with respect to the reconstitutability of the dehydrated peas. Amongst the pricked samples, the RR values were greater than 3.2 except for the samples dried at 60°C (both unblanched and blanched). The data revealed that RR values increased significantly for both pricking and blanching. However, the influence of pricking was more prominent than blanching. Increase in drying air temperature from 60 to 80°C also significantly improved the RR values. But, further increase in temperature to 90°C decreased the RR values significantly. The overall effect of temperature on RR was, however, significant.

The effects of interactions of pricking and blanching (Fig.1); pricking and drying air temperature; and blanching and drying air temperature (Fig.2) were significant with respect to RR.

Effect on colour, texture, flavour and overall acceptability: Pricking and blanching increased colour, texture, flavour and overall acceptability scores. Increase in drying air temperature from 60 to 90°C significantly decreased colour score. The scores for texture, flavour and overall acceptability

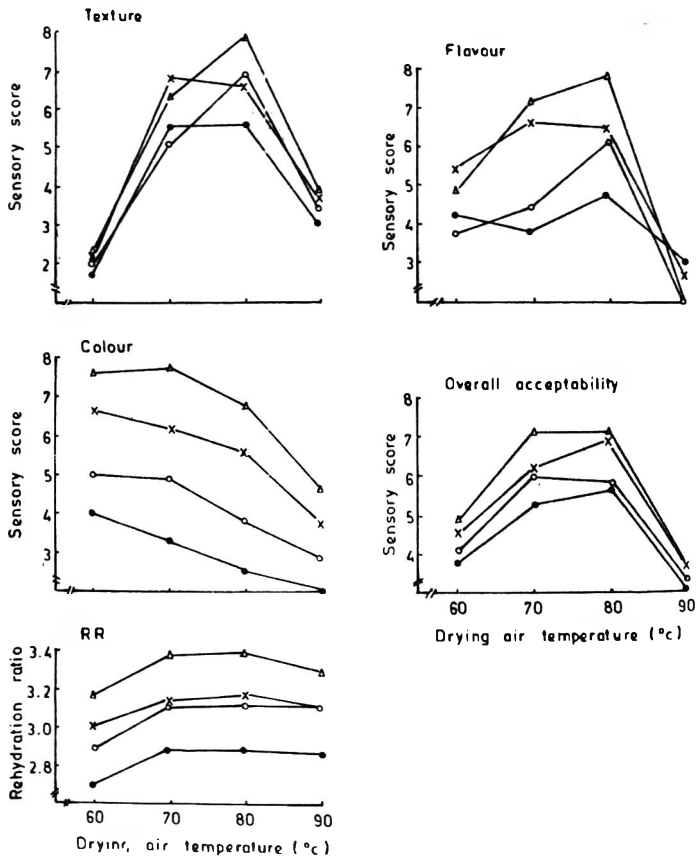

Fig.2. Interactions of pricking and blanching with drying air temperature

O——O Unblanched ●——● Unpricked
X——X Blanched Δ——Δ Pricked

increased significantly with increase in drying air temperature from 60 to 80°C, but further increase in temperature to 90°C lowered the scores (Table 1). Interactions of pricking and blanching were significant for colour, flavour and overall acceptability (Fig.1). Interactions of pricking and drying air temperature were significant for colour, texture and flavour, while those of blanching and drying air temperature were significant for texture and flavour (Fig.2).

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Improvement of Sensory and Nutritional Qualities of Sorghum-based *Kisra'* by Supplementation with Groundnut

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Studies were conducted to assess the feasibility of supplementation of sorghum flour with groundnut flour for *kisra* preparation. Flour samples of four sorghum cultivars were supplemented with 0, 10, 15, 20, 25 and 30% of defatted groundnut flour, and *kisra* prepared was studied for sensory and nutritional qualities. The quality of sorghum flour *kisra* with groundnut flour upto 30% was found to be satisfactory and acceptable as judged by sensory evaluation. Protein and lysine contents of *kisra* increased by 73% as a result of supplementation of sorghum with 30% groundnut flour. At this level of supplementation, the ratios of leucine to isoleucine and leucine to lysine were significantly decreased and *in vitro* protein digestibility of *kisra* increased. The results are of importance in improving the nutritional status of the diets of people in semi-arid tropical Africa.

Keywords : *Kisra*, Groundnut flour, Sorghum-based fermented food, Sensory quality, Nutritional aspects, Amino acid composition.

Sorghum (*Sorghum bicolor* L. Moench) is a staple food in the semi-arid tropic (SAT) regions of Africa. *Kisra*, a fermented thin pancake-like leavened bread made from whole sorghum flour, is the predominant staple diet in the sorghum-growing regions of Sudan (Gebisa 1982). *Kisra* is usually served with stews, sauces or even just water and condiments. Sorghum grain contains low amounts of proteins and is also deficient in lysine, which affects the nutritional quality of sorghum proteins (Deosthale et al. 1972). Protein calorie malnutrition (PCM) is still the primary nutritional problem in many developing countries, particularly in Africa. To combat this problem, supplementation of cereals with grain legumes in the daily diets of the people has been emphasized. Among grain legumes, groundnut (*Arachis hypogaea* L.) is a good source of protein (Srinivasan et al. 1979; Nagaraj and Subramanian 1973). It was reported that the protein content of defatted groundnut meal of three varieties ranged between 40.9 and 44.5% (Mir and Hill 1979). Grits containing 60% protein were used to fortify corn and oat-based foods (Ayres and Davenport 1977). Further, these workers used groundnut flour in baking studies to replace milk and egg and prepared excellent breads and dough formulation with no significant flavour or appearance differences. According to Okeiyi and Futreli (1983), the protein efficiency ratio (PER) of sorghum and wheat flours plus groundnut butter and soya flour (SWPSoy) diet was not different from casein diet. Supplementary value of peanut protein to rice when fed to weanling rats has been studied (Yayathi and Brinkman 1975). Further, the incorporation of 10% groundnut flour increased the protein content of wheat *chapati* by 22% and available lysine by 27% (Bhat and Vivian 1980; Pereira et al. 1968). *Gari*, a low protein food prepared from cassava, was supplemented with groundnut grits containing 60% protein and it was found that the addition of 10% groundnut grits enhanced the sensory properties of *Gari* (Edwards et al. 1978). Also, the potential application of groundnut flour as a supplement for selected food products of wheat such as bread, muffins and biscuits has been reported (Ory and Conkerton, 1983). As a source of protein, the uses of groundnut in cereal-based diets to improve their nutritional quality have been emphasized recently (Singh 1984). Negligible information is available on the supplementation of sorghum food products with high protein groundnut flour. Therefore, the present study was undertaken 1) to assess the feasibility of supplementation of sorghum flour with defatted groundnut flour for acceptable *kisra* quality and 2) to determine the effect of supplementation on the nutritional quality of the product.

Materials and Methods

Seed samples of six grain sorghum cultivars ['A-Tx623xCS3541', 'A-155x120', '77CS5', 'A-155xTAN430', 'Ax155x(77CS1xTx430') and 'A-160x77 CS1'] were obtained from Texas Agricultural Experiment Sorghum Nursery in 1986.

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'Dabar', a commonly grown cultivar in SAT Africa, was obtained from Sudan in 1986. Defatted groundnut flour was obtained from Flavoured Nuts Company, North Carolina Division, Seabrook Blanching Corporation. The starter yeast culture, for fermentation was obtained from Sudan in a powder form (sun-dried) and was typical of that normally used in Sudan for *kisra* making.

Measurement of grain hardness : The grain hardness values for sorghum cultivars were determined by milling 50 g sorghum grain for two min in a Strong-Scott laboratory barley pearler (Strong-Scott, Chicago, Illinois, USA). The milled grain was sieved through a US-12 screen on the rotor (Tyler Ro-tap) for 3 minutes. Hardness was expressed as the percentage of flour sample that could not pass through the sieve (Maxon et al. 1972).

Preparation of Kisra : *Kisra* was prepared in a traditional way as employed commonly by the households in Sudan. Sorghum flour (90 g) was mixed with 120 ml water in a stainless steel beaker and 30 g of the starter yeast culture was added. The contents were thoroughly mixed and incubated at 27°C for 18 h as the pH reached 3.9-4.0. After fermentation, 60 ml water was added and dough prepared. The dough was baked in the form of a thin sheet on a hot plate at 160°C for 1.5 min. For sorghum groundnut composite flour *kisra*, sorghum flour was supplemented with 0, 10, 20, 25 and 30% of the groundnut flour separately and *kisra* was prepared as described above.

Baking-ease and sensory evaluation : The baking-ease was determined by weighing the residues remaining on the hot plate after *kisra* preparation. Weight, of residue left over was measured and expressed as baking-ease. The lesser the residue weight, the better was the baking-ease. Such organoleptic characteristics as baking ease, colour, texture, taste, general acceptability and keeping quality were determined by a panel of eight members consisting of Sudanese and Ethiopians who were familiar with *kisra* quality. These characteristics were rated on a Hedonic scale of 1-5 (where 1=very poor, 2=poor, 3=good, 4=very good and 5=excellent). Data for individual parameters were reported as means of eight observations. A general quality evaluation for each *kisra* sample was made by summing up the means for all parameters.

Chemical analysis : For chemical analysis, the representative samples of *kisra* were cut into small pieces and freeze-dried. Moisture contents of the individual flour samples including composite flours were determined by drying the samples in an air-oven at 103°C as per Method 44-15A (AACC, 1983). Crude protein (Method 46-08), ash (Method 08-16), and crude fiber (Method 32-10) were also determined according to AACC (1983).

Amino acid analysis : One hundred mg of each defatted sample was hydrolyzed in 5 ml of 6 N HCl at 110°C for 18 h. After hydrolysis, the pH was adjusted to 2.2 with concentrated NaOH solution. Citrate buffer (pH 2.2) was added to make up the volume to 40 ml and centrifuged to obtain a clear supernatant for analysis. Amino acid analysis was carried out using amino acid analyzer (Model-119CL, Beckman, Palo Alto, California, USA).

In vitro *protein digestibility :* A sample containing 400 mg nitrogen was suspended in 100 ml of 0.1 N HCl and shaken at 37°C for 30 min. The pH was adjusted to 1.9 with 1.0 N NaOH and 20 ml pepsin enzyme solution (5mg/ml) in 0.1 N NaOH was added. The digestion was carried out for 30 min and stopped by raising the pH with 5 ml of 1.0 N NaOH. Further, pancreatin digestion was performed by adjusting the pepsin digest to pH 8.0 with 0.1 M phosphate buffer by dialysis at 37°C. Then, 20 ml of pancreatin solution (5 mg/ml) was added and digestion carried out at 37°C for 5 h. The nitrogen content in the dialysate was taken as a measure of IVPD.

Statistical analysis : Statistical analysis were performed using the statistical analysis stem on the IBM mainframe computer at the Alabama A & M University. Data were analyzed using the general linear model procedure and significant differences were determined by the Duncan's Multiple Range Test.

Results and Discussion

Results of the evaluation of grain characteristics and *kisra* quality of seven sorghum cultivars are summarized in Table 1. The grain studied involved the comparison of the quality of *kisra* made by using six sorghum cultivars developed and grown in the United States with that of a sorghum cultivar, 'Dabar', commonly used for *kisra* preparation in Sudan. The 100-grain weight of these

TABLE 1. GRAIN CHARACTERISTICS AND *KISRA* QUALITY OF SORGHUM CULTIVARS

Cultivar	100 grain weight, g[a]	Grain hardness, %[a]	Flour viscosity, BU[a]	Baking-ease residue weight, g[a]	*Kisra* quality[b]			
					Taste	Colour	Texture	Keeping quality[c]
'Dabar'	3.0	46.2	800	2.6	3.6	4.3	3.8	3.3
'A-155x(77CSIxTx430)'	2.6	50.3	520	4.0	3.2	3.9	3.3	2.9
'A-155x(120x700)x700'	2.9	52.2	500	3.5	3.3	4.1	3.4	2.8
'A-155xTAN 430'	3.3	52.2	600	3.4	3.3	4.1	3.6	3.1
'A-Tx623xCS3541'	3.0	51.1	780	3.1	3.6	4.3	3.7	3.2
'77CS5'	2.9	52.7	330	3.5	3.1	3.4	3.4	2.6
'A-160x77CSI'	2.7	62.5	540	2.8	3.8	4.3	3.5	3.2

a. Means of 3 replicates, BU=Brabender units as amylograph peak.
b. All sensory parameters were rated on a Hedonic scale of 1-5, where 5 = excellent and 1 = poor, by eight panel members
c. Measured after 24 h storage at room temperature.

cultivars ranged between 2.6 and 3.3 g, thereby showing variations. Grain hardness was much lower than reported by other workers (Reichert et al. 1982), but this might have been due to the fact that all the cultivars scaled as intermediate floury endosperm grains which show small variation in grain hardness (Rooney and Miller 1982). On the other hand, a large variability in flour viscosity of these cultivars was observed (Table 1).

The colour and texture of *kisra* are considered as the most important criteria determining acceptability of the product. A good quality *kisra* must be white in colour, soft, moist and supple in texture (Gebisa 1982). Considerable differences in taste, colour, texture and keeping quality of *kisra* made by using these cultivars were observed (Table 1). However, the *kisra* quality in terms of these characteristics of five cultivars grown in the United States was comparable with that of 'Dabar' (Table 1). Results indicated that cultivar "77CS5' was significantly ($P \leq 0.05$) different from the other six cultivars including 'Dabar' and produced unacceptable, intensely greenish-black coloured *kisra*. Since all the cultivars were of the type of intermediate floury endosperm grains, there were no significant differences in texture of *kisra* made from these cultivars. Interestingly, flour viscosity and baking-ease were positively and significantly correlated ($P \leq 0.05$) with colour, texture, and taste of *kisra* (Table 2). On the other hand, 100-grain weight and grain hardness of cultivars did not show any significant correlation with *kisra* properties as judged by panelists and this might have been due to a small variability in 100-grain weight and grain

TABLE 2. CORRELATION COEFFICIENTS OF SORGHUM GRAIN CHARACTERISTICS AND *KISRA* QUALITY

	Taste	Texture	Colour	Baking-ease	Viscosity	Hardness
100 seed weight	−0.158*	−0.342**	−0.013	+0.099	−0.420**	+0.089
Hardness	−0.187*	−0.193	+0.322*	+0.306**	+0.035	
Viscosity	+0.624**	+0.542**	+0.681**	−0.137*		
Baking-ease	+0.641**	+0.636**	+0.849**			
Colour	+0.011	+0.344**				
Texture	+0.254**					

* Significantly different at (P = 0.05) level
** Significantly different at (P = 0.01) level

hardness of cultivars tested. However, these characteristics were more positively and significantly correlated ($P \leq 0.05$) with baking-ease (Table 2). The results are in agreement with those reported by

TABLE 3. BAKING-EASE AND SENSORY EVALUATION OF SORGHUM *KISRA* SUPPLEMENTED WITH GROUNDNUT FLOUR

Characteristics	Supplementation level, % defatted groundnut flour					
	0	10	15	20	25	30
Baking-ease[a]	4.1	4.1	3.9	3.8	3.7	3.6
Colour[b]	4.2	4.3	4.3	4.3	4.3	4.4
Texture[b]	3.6	3.7	3.7	3.8	3.7	3.7
Taste[b]	3.6	3.5	3.6	3.5	3.6	3.6
Keeping quality[bc]	3.2	3.2	3.0	2.8	2.7	2.6

a. Expressed as residue weight (g), values are means of three determinations
b. Means of eight sensory panel members as rated on Hedonic scale of 1-5 where 5=excellent and 1=very poor
c. Keeping quality was determined after 24 h storage at room temperature.

TABLE 4. MOISTURE, ASH, PROTEIN AND FIBRE CONTENTS OF SORGHUM *KISRA* SUPPLEMENTED WITH GROUNDNUT FLOUR[a]

Constituent,%	Supplementation, % defatted groundnut flour					
	0	10	15	20	25	30
Moisture	2.6	7.4	4.9	8.4	9.1	7.5
Ash[b]	1.3	1.4	1.4	1.5	1.5	1.5
Protein[b]	12.2	13.3	15.9	17.3	19.9	21.1
Crude fibre[b]	3.6	3.6	3.7	3.6	3.7	3.7

a. All values are averages of three replicates.
b. Data expressed on dry weight basis.

Gebisa (1982) who observed that cultivars with highly vitreous grains were consistently rated as below average for baking-ease, while those with less vitreous or opaque endosperm were rated as above average for baking-ease.

The effects of supplementation of sorghum flour with groundnut flour on *kisra* quality are presented in Table 3. Even though the supplementation studies were conducted on three U.S. cultivars ('A-155xTAN 430', 'A-Tx623xCS3541' and 'A-160x77CSI') and a 'Dabar' cultivar from Sudan, only the results on 'Dabar' cultivar are reported here. This is because the results of all these four cultivars were more or less similar. Although baking-ease and keeping quality of *kisra* decreased slightly with increasing the level of supplementation, the differences in these characteristics were not large among different levels of supplementation. More importantly, colour, texture and taste of sorghum *kisra* showed no noticeable differences when it was supplemented with 0, 10, 15, 20, 25 and 30% flour. However, the panelists observed that supplementation with more than 30% groundnut flour, produced unacceptable *kisra* and hence, further supplementation levels were not studied. Based on the results of this study, it appears that sorghum *kisra* quality would not be adversely affected when sorghum flour is supplemented with groundnut flour upto 30%.

In order to study the effect of supplementation on the nutritional quality of *kisra*, various chemical constituents including amino acids and *in vitro* protein digestibility of *kisra*, supplemented with 0, 10, 15, 20, 25 and 30% groundnut flour, were determined. Moisture and ash contents of sorghum *kisra* increased with an increase in groundnut flour concentration, whereas no large differences in crude fibre content of the *kisra* were observed as shown in Table 4. Protein content of *kisra* increased remarkably as the levels of groundnut flour increased. Protein content increased by 73% as a result of supplementation of sorghum flour with 30% groundnut flour. Also, there was a remarkable increase in lysine content of *kisra* as a result of supplementation (Table 5). Increases in protein and lysine due to supplementations in the present study are comparable to those reported by other workers for supplemented cereal-based foods. Protein content of corn and oats-based food was considerably increased with the addition of 17.5% flour (Ayres and Davenport 1977). Similarly, incorporation of 10% groundnut flour increased the protein and available lysine contents of wheat *chapati* by 22%

TABLE 5. AMINO ACID COMPOSITION OF SORGHUM *KISRA* SUPPLEMENTED WITH GROUNDNUT FLOUR[a]

Amino acid g/100 g protein	Sorghum flour	Supplementation level, % defatted ground flour					
		0	10	15	20	25	30
Aspartic acid	7.4	6.7	8.2	7.1	6.7	6.3	7.0
Threonine	2.7	2.6	2.4	3.0	3.9	3.0	3.2
Serine	5.3	4.6	4.1	4.0	4.3	3.2	4.1
Glutamic acid	21.7	19.3	20.1	17.3	17.0	16.1	15.8
Proline	8.9	7.4	7.5	6.7	6.7	5.9	5.0
Glycine	3.6	3.5	3.3	3.1	2.8	2.5	2.7
Alanine	10.0	8.4	7.3	6.6	6.2	5.7	5.2
Methionine	1.1	1.0	0.8	1.1	1.1	1.1	1.0
Isoleucine	2.5	2.2	2.2	2.3	2.9	2.6	3.2
Leucine	12.4	11.2	11.0	9.5	9.2	8.2	8.5
Tyrosine	3.1	3.0	2.6	2.5	2.4	2.1	2.0
Histidine	2.2	1.9	1.8	2.3	2.2	2.4	2.3
Lysine	2.0	1.8	1.7	2.5	2.8	2.9	3.1
Valine	4.6	4.9	5.1	3.5	3.4	3.5	3.9
Phenylalanine	3.7	4.4	4.2	4.0	3.7	3.3	3.2
Arginine	2.6	2.9	2.9	2.5	2.4	2.3	2.2

a. Data expressed on dry weight basis. Each value is a mean of two determinations.

and 27%, respectively (Bhat and Vivian 1980). In addition to lysine, threonine and histidine were the other essential amino acids which increased as a result of supplementation (Table 5).

From a nutrition point of view, it may be noted that the ratios of leucine to lysine and leucine to isoleucine of *kisra* dropped to lower values due to sorghum supplementation with groundnut flour. To be nutritionally sound, food uses of sorghum must provide an adequate and correct balance between essential and non-essential amino acids. A high leucine to isoleucine ratio in sorghum has been reported to be responsible for the pellagra disease in the sorghum-eating population in India (Srikantia 1978). Earlier workers also suggested that the leucine to lysine ratios lower than 4.6 in sorghum are not effective in preventing pellagra (Deosthale et al. 1972). From the results obtained in this study, it appears that supplementation of sorghum flour with peanut flour would correct the imbalances between amino acids of *kisra* which otherwise would cause nutritional disorders.

TABLE 6. RATIOS OF AMINO ACIDS AS QUALITY INDICES AND *IN VITRO* PROTEIN DIGESTIBILITY OF KISRA OF SORGHUM AND GROUNDNUT SUPPLEMENTED FLOURS[a]

Constituent	Supplementation level, % defatted groundnut flour					
	0	10	15	20	25	30
Leucine/Isoleucine	5.7	5.1	4.3	3.1	3.1	2.7
Leucine/Lysine	6.2	6.5	3.9	3.3	2.8	2.7
E/T	2.7	2.5	2.5	2.4	2.2	2.1
In vitro protein digestibility, %	66.0	66.7	67.5	68.9	68.9	69.7

a. All values are means of three determinations
E/T= Ratio of essential amino acids (E) to total amino acids (T)

The *in vitro* protein digestibility (IVPD) increased from 66.0% for sorghum *kisra* to 69.7% for sorghum *kisra* with 30% groundnut flour (Table 6). A slight improvement in IVPD values was also noticed at lowers levels of supplementation (Table 6). The major problem with sorghum appears to be one of low protein digestibility (Maclean et al. 1982). However, the IVPD values of the sorghum *kisra* are slightly higher than those reported by earlier workers (Axtell et al. 1982). The importance of the interaction of digestibility and the concentrations of protein and lysine to improve the nutritional quality of sorghum has been emphasized (Maclean et al. 1982). Improved levels of protein, lysine and IVPD were the beneficial effects of supplementations.

In conclusion, the nutritional quality of *kisra*, an important food item prepared mostly by using whole sorghum flour in several African countries, can be improved by supplementation of sorghum flour with groundnut flour upto 30%. The results also indicate that nutritional parameters like protein, amino acids balance and *in vitro* protein digestibility (IVPD), of *kisra* of supplemented flour are better than those of the unsupplemented flour. The introduction of such new nutritionally improved products, particularly in the less developed countries of Africa, Asia and Latin America, would play an important role in alleviating the protein calorie-malnutrition (PCM) problem. Such efforts would also result in enhanced utilization of grain legumes.

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Microbiological Analysis of Environmental Sources of Contamination in Deonar Abattoir

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Investigation was carried out to analyse microbiological hazards and to determine the critical control points in the buffalo slaughterline. Nine different points in the slaughterhouse were selected and samples were analysed for total viable counts and the numbers of faecal coliforms, Enterobacteriaceae, *Bacillus* spp., *Staphylococcus* spp. and *Clostridium* spp.. Highly significant differences among different points were observed. The maximum levels of contamination amongst slaughterhouse points were noted for floors, platforms and walls with a mean total viable count of 4.11±0.50 $\log_{10}$ CFU/sq cm. The floors, platforms, walls, knives, axe, saw-blade, hooks and handswabs were considered as critical points in the slaughterhouse and monitoring of these points would lead to the development of HACCP in slaughterhouse.

Keywords : Microbiological hazards, HACCP concept, Slaughterhouse, Slaughterline operations.

In its demand for animal proteins, humanity is exposed to foodborne infections and intoxications. Most of the reported outbreaks of food poisonings are associated with food service operations and food processing plants. Economic losses are enormous due to microbiological food spoilage, affecting the primary production. The ante-mortem and post-mortem examinations are not sufficiently adequate to arrive at a firm diagnosis on the origin of microbial problems associated with animal foods (Skovgaard 1989; Gupta et al. 1987). Traditional quality inspections and microbiological testing of end products have shown little evidence of their effectiveness in epidemiology. A need to reduce costs of safety and quality assurance has led to the development of a rational approach based on the hazard analysis and critical control point (HACCP) system. The application of HACCP shifts emphasis to raw materials and process control, thus taking away the control out of the laboratory into the manufacturing environment (Kaufmann and Schaffner 1974; Bobeng and David 1977; Bryan and McKinley 1979; Zottola and Wolf 1980).

In India, the practices of hygiene and sanitation prevailing in the food processing plants, aided by ecological conditions, encourage access to microbial contamination, their survival and growth in the foods. With this background, the present study was undertaken to assess the potential sources of microbiological hazards associated with slaughterline operations and the surrounding environment.

Materials and Methods

Selection of points and sample collections : Seven batches of nine different points in the slaughterhouse viz., knife, axe, saw-blade, hooks, floor, wall, platform, handswab and water were selected. All the samples were collected during slaughtering operations by swabbing, except those of the water. About 10 ml of tap-water used in slaughterhouse was collected in a sterile test tube. Sterile cotton swab (3 cm long and 1 cm in dia) was moistened with 0.1% peptone and rubbed on the surface for 30 sec. The swab was transferred to a screw-capped sterile test tube containing 10 ml of maintenance medium (0.85% saline and 0.1% peptone). Samples were brought to the laboratory in iced thermos flask and processed immediately.

Enumeration of bacteria : Appropriate dilutions of the samples were made in sterile normal saline for enumeration of total viable counts (TVC), counts of faecal coliforms, enterobacteriaceae, staphylococci, *Bacillus* spp. and *Clostridium* spp., using plate count agar. The media used include violet red bile agar, MacConkey's agar, Baird-Parker's agar, egg yolk agar and sodium polymixin sulphadiazine agar, respectively (Speck 1984).

Identification of bacteria : Typical characteristic colonies of each bacteria developed on the isolation media were noted. Randomly selected colonies were subjected to purification, characterization and identification (Cowan and Steel 1970; Cheesbrough 1985; Sneath et al. 1986).

Statistical analysis: The difference between the slaughterhouse points for TVC and for counts of different bacterial groups were analysed by using completely randomized design and the means were compared by critical difference test (Snedecor and Cochran 1968).

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Results and Discussion

TVC and the counts of different bacterial groups in the slaughterhouse points are presented in Table 1. Of nine points studied, floors showed a maximum TVC of 6.70 $\log_{10}$ CFU/sq cm, while water sample showed a minimum count of 2.07 $\log_{10}$ CFU/ml. The overall average for all the points was 4.11±0.50 $\log_{10}$CFU/sq cm. Statistical analysis of the microbial counts revealed that the bacterial counts differed significantly among the various slaughterhouse points to high extent. The highest counts were observed for floor, platforms and walls, thereby resulting in maximum number of the bacterial isolates (Table 2). Newton et al. (1978) reported high microbial population for structural surfaces in dressing areas, particularly the floors and designated them to be the potential sources

TABLE 1. BACTERIAL COUNTS ENUMERATED AT DIFFERENT POINTS IN A SLAUGHTERHOUSE

Sample points	Bacterial counts ($\log_{10}$ CFU/sq cm)					
	Total viable count	Entero-bacteri-aceae	Faecal coli-forms	*Bacillus* spp.	*Staphy-lococcus* spp.	*Clostri-dium* spp.
Knives	3.2	5.9	5.7	5.5	4.9	2.1
Axe	3.8	5.6	5.9	5.4	4.9	2.4
Saw-blade	3.1	4.7	5.5	5.8	4.8	2.8
Hooks	4.2	5.6	5.6	5.7	4.6	2.3
Floor	6.7	6.9	7.3	6.9	5.9	4.1
Wall	5.3	6.2	6.6	6.4	5.2	3.5
Platform	5.6	6.5	6.8	6.7	5.4	3.9
Hand swabs	2.9	5.4	5.5	4.6	4.2	1.3
Water*	2.1	4.4	4.5	3.9	3.4	0.0

* Counts expressed as $\log_{10}$ Cfu/ml.

TABLE 2. BACTERIAL CULTURES ISOLATED FROM DIFFERENT POINTS IN A SLAUGHTERHOUSE

Organisms	Source							
	Knives	Axe	Saw-blades	Hooks	Floor	Walls	Platforms	Hand swabs
	Samples Positive							
*Bacillus cereus**	3	3	4	5	6	6	5	0
*Bacillus subtilis***	4	2	5	4	7	6	6	1
*Bacillus megaterium***	4	3	3	4	4	5	4	0
*Bacillus circulans***	3	3	4	4	6	5	6	2
*Bacillus coagulans***	5	4	6	5	5	7	6	1
Bacillus spp.**	5	4	6	6	7	7	7	3
*Staphylococcus aureus**	1	1	3	2	4	5	4	1
*Staphylococcus epidermidis***	2	3	4	4	7	5	6	3
*Micrococcus roseus***	4	2	5	4	5	6	7	2
*Micrococcus luteus***	3	5	4	5	3	5	5	1
Micrococcus spp.**	6	2	5	3	7	6	7	3
Streptococcus faecalis *	0	1	0	0	3	2	2	0
*Streptococcus mitis***	1	0	0	1	2	1	1	0
*Streptococcus faecium***	2	1	1	2	2	1	2	0
*Streptococcus bovis***	1	3	0	1	3	2	3	0
Streptococcus spp.**	2	1	2	1	5	5	6	2
Clostridium spp.*	4	3	3	4	7	7	7	0
*Escherichia coli**	5	6	5	3	7	7	2	2
Klebsiella spp.**	2	2	4	4	5	6	5	3
*Citrobacter freundei***	1	2	1	1	3	1	2	0
*Enterobacter aerogenes***	2	1	1	1	2	2	2	0
*Enterobacter cloacae***	1	0	0	0	2	1	1	0
*Pseudomonas aeruginosa**	2	0	0	1	3	2	3	1
Alcaligenes spp. **	0	0	0	0	1	1	1	0
Shigella spp.*	0	1	2	1	4	3	4	0
*Serratia marcescens***	2	1	0	0	2	2	3	0
*Proteus mirabilis**	0	0	0	1	5	5	6	0
*Proteus vulgaris***	2	1	1	1	6	4	6	1

* Pathogenic, ** Non-pathogenic spoilage micro organism. One *Micrococcus* sp. was isolated from a water sample

of contamination. Floors, platforms and walls, are probably contaminated by the microorganisms present on the animal bodies. The carcasses may also contaminate the walls and platforms through contact. The situation is further aggravated by the rigid surfaces of the platforms. Uneven surfaces, cracks and crevices on the floor and walls, where meat particles and moisture accumulate, may also lead to bacterial proliferation. Hence, floors, walls and platforms are identified as critical points in the slaughterhouse and must be effectively and regularly cleaned with sanitizing agents. Water at 65°C and with contact time of 30 sec may be used for complete removal of fat and protein material (Weise and Levetzow 1976).

In the present study, TVC and the numbers of different bacterial types on knives, axe, saw-blade and hooks were significantly high and compared closely with those reported by earlier workers (Guarino et al. 1974; Simard and Auclair 1981). The bacterial flora of knives, axe, saw-blade and hooks can be attributed to their direct contact with the carcasses and viscera. The prevalence of common types of bacteria on both carcasses and slaughterhouse equipments are well known (Mackey and Derrick 1979). The reason for such a higher bacterial load may be due to poor practices of hygiene and sanitation followed in the abattoir. These equipments come into direct contact with carcasses and thus, act as vectors. Hence, these points are also considered as potential sources of microbial hazards.

Total viable counts and counts of pathogens for handswabs were lower than those in other samples (Table 1) and resulted in the isolation of 26 cultures. Higher counts, even of one type of bacteria, cannot warrant for good hygienic practices (Kendereski 1970). Prevalence of the organisms, particularly on the worker's hands, could be due to the contact with carcasses and their own body parts during the operations and/or the unhygienic practices. Washing of hands can considerably reduce the number of transient bacteria (Wit and Kamplemacher 1983). The water used at Deonar Abattoir is from the municipal supply of potable water, which had a low bacterial profile and was free from pathogenic bacteria.

A total of 651 isolates were obtained in the present study and these included potential pathogenic organisms viz., *S. aureus*, *B. cereus*, *Clostridium* spp., *E.coli*, *Shigella* spp., and spoilage causing organisms (Table 2). The presence of these organisms at various sites and equipments indicate improper sanitary conditions and potential sources for food poisoning hazards. The HACCP approach would help in monitoring the whole system by frequent evaluation of the microbial types at various contaminating points, thereby minimising the public health hazards.

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Effect of Antimicrobial Agents and Packaging Materials on the Microbial Quality of *Khoa*

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The effectiveness of few selected antimicrobial agents and commonly available packaging materials on microbial quality of *khoa* during storage at 37 and 5°C showed a reduction in the counts of mesophilic aerobes, yeast and moulds with the incorporation of 0.30% potassium sorbate on product weight basis and upon packing in aluminium foil.

Keywords : *Khoa*, Packaging materials, Nisaplin, Potassium sorbate, Storage temperature.

In India, about 7% of total milk produced annually is converted into *khoa*, a popular indigenous heat dessicated milk product (Mathur 1991). This milk product has a low shelf-life due to microbial spoilage (Jha et al. 1977; Rajorhia and Srinivasan 1979). Generally, the micro-organisms occur as post-processing contaminants. As a means to improve the shelf-life of *khoa*, in the present study, an attempt was made to find out the effectiveness of a few selected antimicrobial agents on the microbial quality of *khoa* packed in commonly available packaging materials.

Khoa was prepared from fresh cow milk, obtained from dairy farm of Tamil Nadu Veterinary and Animal Science University (standardized to 4% fat) in a double jacketted kettle under controlled steam pressure according to the method described by Rajorhia et al (1990). Aqueous solution of the antimicrobial agents namely, nisaplin (Applin and Barret Ltd., England) at two concentrations of 0.01 and 0.02% and potassium sorbate at 0.15 and 0.30% levels, on product weight basis, were incorporated individually into *khoa* samples (100 g each) during the last stages of preparation. The samples were then packed in U.V. sterilized packaging materials like aluminium foil, polyethylene and parchment paper and stored at 37 and 5°C, respectively. Stored samples (five replicates) were enumerated for mesophilic aerobes and yeast and moulds (Speck 1984) at an interval of 3 days in case of 37°C and 15 days in case of 5°C storage. Results obtained were subjected to statistical analysis (Snedecor and Cochran 1967).

The effect of two different concentrations of antimicrobial agents and three packaging materials on the counts of mesophilic aerobes and yeast and moulds in *khoa* during storage at 37 and 5°C are presented in Figs.1 and 2 and the results of statistical analysis are given in Table 1.

With reference to the microbial changes in *khoa* stored at 37°C, aluminium foil as a packaging material proved to be effective and differed significantly ($P<0.05$) with polyethylene and parchment paper in checking growth of mesophilic aerobes, yeast and moulds. There was statistically significant difference ($P<0.01$) among the various levels of antimicrobial agents used with respect to the microbial counts. Potassium sorbate used at 0.30% level was able to bring about maximum reduction of microbial counts in *khoa*, but there

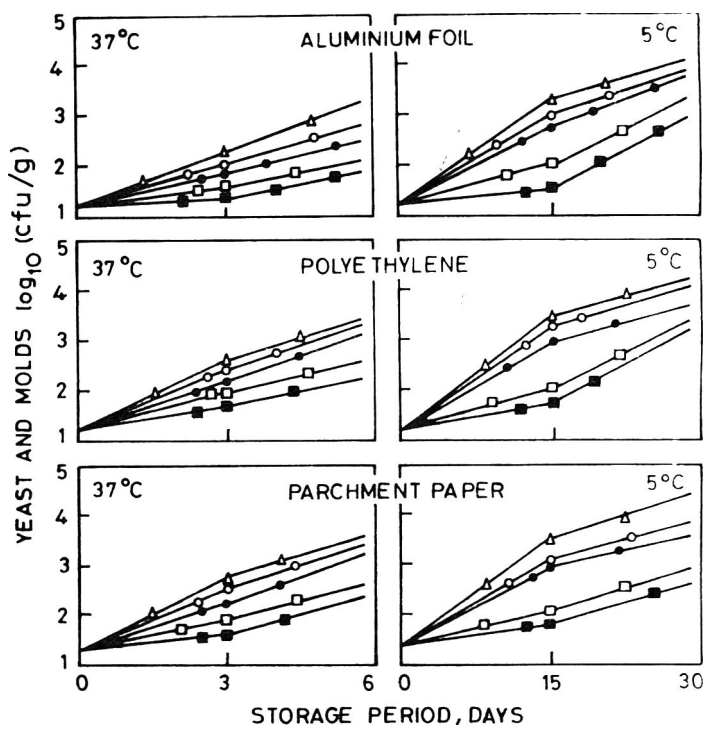

Fig.1. Effect of antimicrobial agents and packaging materials on the counts of mesophilic aerobes in *Khoa* during storage at 37 and 5°C.
Δ—Δ Control, O—O 0.01% nisaplin, ●—● 0.02% nisaplin, ❑—❑ 0.15% potassium sorbate, ■—■ 0.30% potassium sorbate

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TABLE 1. ANALYSIS OF VARIANCE OF VARIOUS MICROBIAL PARAMETERS (IN LOG UNITS) OF *KHOA* DURING STORAGE.

Source of variation	Degrees of freedom	Mean sum of squares			
		Mesophilic aerobes		Yeast and mould count	
		(37°C)	(5°C)	(37°C)	(5°C)
Among packages	2	0.0434*	0.1768**	0.2402**	0.0501^{NS}
Among preservatives	4	2.8530**	5.8774**	0.3447**	0.7822**
Interaction, packages X preservatives	8	0.0054^{NS}	0.0139^{NS}	0.0028^{NS}	0.0302^{NS}
Among intervals of storage	2	54.3876**	47.1453**	13.0174**	28.7157**
Interaction, packages X intervals	4	0.0115^{NS}	0.0483**	0.0905**	0.3703**
Interaction, preservatives X intervals	8	0.7183**	1.8874**	0.0827**	0.0139^{NS}
Error	16	0.0041	0.0058	0.0124	0.0189

* Significant at 5% level **Significant at 1% level.

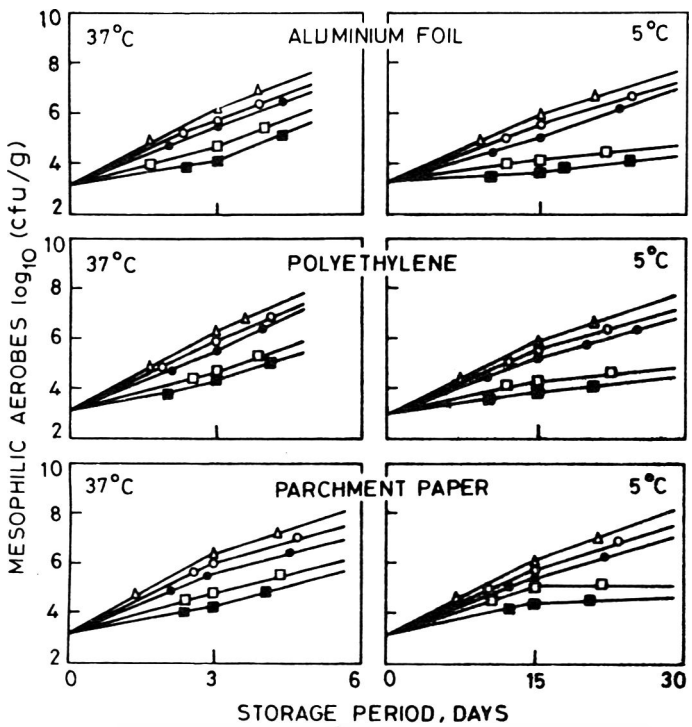

Fig.2. Effect of antimicrobial agents and packaging materials on the counts of yeast and molds in *Khoa* during storage at 37 and 5°C.
Δ—Δ Control, O—O 0.01% nisaplin, ●—● 0.02% nisaplin, ❑—❑ 0.15% potassium sorbate, ■—■ 0.30% potassium sorbate

was no significant difference between control samples and *khoa* with 0.01% level of nisaplin. Increase in the microbial counts was observed during storage of *khoa*. However, the magnitude of this increase declined with the increase in potassium sorbate concentration. A similar trend was observed with an increase in nisin concentration in *khoa* stored at room temperature (Grewal and Jain 1978).

Studies of *khoa* stored at 5°C revealed that various packaging materials differed significantly (P<0.01) with reference to the counts of mesophilic aerobes, the lowest being with aluminium foil. However, there was no significant effect of packaging materials on the counts of yeast and moulds. With regard to the antimicrobial agents, potassium sorbate and nisaplin differed significantly (P<0.01) in reducing the microbial counts. Potassium sorbate had more pronounced effect in reducing microbial counts as compared to nisaplin. These results are in accordance with an earlier study (Ghodekar et al. 1978), wherein incorporation of 0.20% potassium sorbate into *khoa* enhanced the shelf-life from 6 to 14 days at 7°C.

There was a significant improvement in the microbial quality of *khoa* with the incorporation of 0.30% potassium sorbate on product weight basis and packed in aluminium foil.

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Decontamination of Insecticide Residues on Mango by Washing and Peeling

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The insecticide residues on mango fruits, resulting from plant protection sprays, were reduced to 66-68% for dimethoate and fenthion as against 21-27% for fenvalerate and cypermethrin simply by washing treatment. The peeling-off the fruit pericarp was found to dislodge 100% residues in all the cases.

Keywords : Mango decontamination, Insecticide residues, Washing, Peeling, Plant protection sprays.

The cultivation of mango in peninsular India requires intensive plant protection measures at all stages, since the tree suffers heavily from new flush stage by a variety of insect pests. Heavy pesticide applications, thus, result in the build-up of the residues on or in the fruits particularly, if applied at fruit bearing stage (Saivaraj et al 1982; Awasthi 1988). Since mango fruits are consumed at all the stages of fruit growth in different preparations, it is desirable to decontaminate the fruit from the point of safety to human health. Various pesticide decontamination processes like; (a) washing the treated fruits/vegetables with water/dilute solutions of non-toxic chemicals, (b) peeling-off the fruit skin, etc., were reported to dislodge the residues to varying degrees depending on constitution of the fruit, chemical nature of the pesticide and environmental conditions (Nath et al 1975; Awasthi 1986). The present communication describes the effect of washing and peeling the pesticide-treated mango fruits on the extent of the reduction of the residues of dimethoate, fenthion, cypermethrin and fenvalerate insecticides prior to safe consumption of fruits.

Mango cv. 'Totapuri' trees in a 8 years old orchard of the institute were used in this study. Insecticide schedules involving two spray applications of dimethoate and fenthion each at 0.05%; cypermethrin and fenvalerate each at 0.01%, coinciding fruit development and stone-hardening stages were laid out. Fruit samples from treated trees were collected at periodic intervals after the second application for residue analysis. The treated fruit samples from each treatment at every sampling were divided into three sets. One set was used for residue analysis in whole fruit. The fruits from second set were washed by dipping in water for 10 min and then used for residue analysis, while the fruits from third set were peeled-off, washed and then used for residue analysis.

Pesticide residues were extracted from fruits by solvent extraction followed by clean up of residues from other co-extractives and quantitative estimation of the residues was done by gas liquid chromatography through therm ionic detector for dimethoate and fenthion (Awasthi and Ahuja 1991), electron capture detector for cypermethrin and fenvalerate (Awasthi 1985), using standardised parameters. The data were subjected to statistical analysis (Hoskins 1961) to find the rate of residue dissipation (Half-life) and waiting periods (T_{to1}), the period required to be lapsed between the last treatment and the harvest of the crop, based on the persistence pattern of residues and maximum residue limits (MRL) prescribed by FAO/WHO for different pesticides (Anon 1986).

The average initial deposits and persistence of insecticide residues on the fruit are detailed in Table 1. The effectiveness of washing the treated fruits in water and peeling-off the fruit skin in the decontamination of residue deposits at periodic intervals following spray treatment has been detailed in Table 2. The progressive residue decay on whole fruit took place at the half-life of 3.1, 3.7, 5.8 and 5.3 days for dimethoate, fenthion, cypermethrin and fenvalerate, respectively. (Table 1). Organophosphates dissipated faster than pyrethroids, but quantitatively higher residues were still persisted on whole fruits from the former, after 10 days of the treatment under normal conditions. The washing of the treated fruits effected the reduction of surface residues to the extent of 66-68% for dimethoate and fenthion as compared to 21-27% for pyrethroids at the initial stages of spray treatment. The effectiveness of washing was, however, reduced at later stages of all the insecticides

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TABLE 1. RESIDUES OF INSECTICIDES ON WHOLE MANGO FRUIT AND THE RATE OF RESIDUE DECAY AND THE WAITING PERIOD FOR INSECTICIDAL TREATMENT.

Insecticides	Average residues (mg kg^{-1}) after treatment, days						Half-life, days	MRL, ppm	Waiting periods, days
	0	3	7	10	15	20			
Dimethoate	1.35	0.67 (50.3)	0.36 (73.3)	0.12 91.1)	ND (100.0)	ND (100.0)	3.1 (4.7)	2.0	Nil (Nil)
Fenthion	1.27	0.72 (43.3)	0.40 (68.5)	0.16 (87.5)	ND (100.0)	ND (100.0)	3.7 (5.6)	2.0	Nil (Nil)
Cypermethrin	0.83	0.57 (31.3)	0.32 (61.4)	0.19 (77.1)	0.11 (86.8)	0.06 (92.7)	5.8 (5.9)	0.5	3.4 (1.9)
Fenvalerate	0.87	0.64 (26.4)	0.32 (63.2)	0.22 (74.7)	0.14 (83.9)	0.05 (94.2)	5.3 (5.3)	0.2	11.2 (10.9)

Values for average residues are for whole mango fruit. Figures in brackets under average residues are per cent reduction; in case of decay and waiting periods are for processed mango fruits. ND= Not detectable.

TABLE 2. DECONTAMINATION OF INSECTICIDE RESIDUES ON MANGO FRUITS BY WASHING AND PEELING

Days after treatment	Average residues (mg kg^{-1})			
	Dimethoate	Fenthion	Cypermethrin	Fenvalerate
0	0.45 (66.6)	0.40 (68.3)	0.60 (27.7)	0.68 (21.8)
3	0.40 (40.3)	0.44 (38.8)	0.45 (21.0)	0.52 (18.7)
7	0.24 (33.3)	0.27 (32.5)	0.30 (6.3)	0.30 (6.3)
10	0.10 (33.3)	0.12 (25.0)	0.18 (5.0)	0.22 (0.0)
15	ND (100.0)	ND (100.0)	0.11 (0.1)	0.14 (0.0)
20	ND (100.0)	ND (100.0)	0.06 (0.0)	0.05 (0.0)

Figures in brackets denote per cent loss of residues after decontamination by washing. Peeling showed 100% decontamination at 0 and all the days of treatment.

and more specifically on synthetic pyrethroids due to strong bonding between the insecticide molecules and waxy layer of fruit skin as also their non-systemic and non-translaminar movement characteristics (Elliot 1980; Briggs 1985).

The process of peeling-off the fruit skin was found to remove the residues absolutely at all the stages for all the insecticides after the treatment (Table 2). This reflected the accumulation of residues in the fruit pericarp only and no further movement to fruit pulp. Thus, the fruit pulp was free from any toxic residues at any stage of residue persistence after peeling-off the treated fruits. These observations concur the earlier reports (Nath et al 1975; Awasthi 1986), though the degree of dislodging the residues varied from substrate to substrate and types of insecticides.

The waiting periods worked out for unwashed and washed mango fruits (Table 1) were also reduced accordingly due to washing effect, thereby reducing the toxicity hazards due to toxic residues persistent on fruits.

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Iodine Content of Diets of the People of Different Regions Living in Bombay

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Total daily iodine intake of 100 women from ten different regions, living in Bombay, ranged from 211-301 mcg. Nearly 15.3-42.0% of iodine was contributed by the daily salt intake. Iodine losses during cooking ranged from 37.4-69.7%.

Keywords : Iodine, Diet, Foods, Salt, Cooking, Regions.

Iodine is an essential nutrient, crucial for proper growth, development and the normal functioning of the body (Pandav and Kochupillai, 1982). Average daily requirement of iodine is 150 mcg and dietary iodine intake below 50 mcg is associated with goitre (NIN, 1987). About 90% of the daily requirement of iodine is met by food, but the dietary sources supplying this element are not well-defined and the information on iodine content of Indian foods (raw/cooked) is also limited. Therefore, this study was undertaken to determine (a) the adequacy of daily iodine intake in various regional diets, (b) contribution of various foods and salt to the daily iodine intake and (c) to determine iodine losses during cooking by comparing the iodine content of raw and cooked diets.

Diets of 100 women, from 10 different regions, living in Bombay, were collected in duplicate in glass jars on 3 consecutive days (two week days and 1 day of weekend). Detailed information about raw materials involved in the preparation of the diets was also collected. The duplicate diet samples were pooled, homogenised and aliquots were taken (in triplicate) for estimation of iodine. The intakes of iodine from raw foods and cooked mixed diets were estimated by using the method standardized by NIN (1987). Salt intake was estimated by finding the amount of salt (teaspoon) used per day and dividing it by the number of consumption units. The iodine content of the salt was determined by iodometric titration (Tyabji, 1985). The total daily iodine intakes, calculated from raw foods and salt, were compared with the iodine intake from mixed cooked diets by using student's 't' test. Correlation coefficients between selected variables were computed.

It was observed that the mean iodine content of various regional diets ranged from 211 to 301 mcg daily (Table 1). These values are much higher than the Recommended Dietary Allowance of 150 mcg for adults. National Nutrition Monitoring Bureau (NNMB) and many other workers reported values of 174-365 and 224-302 mcg for iodine intakes by very low and low income groups, respectively (NNMB; 1984; Stanbury and Hetzel 1980; Park et al, 1981; Wenlock et al, 1982; Varo et al. 1982; Bester 1988). However, it may be noted that the reported values of the iodine content of diets by various workers were computed from the iodine

TABLE 1. IODINE INTAKE FROM VARIOUS FOOD GROUPS

Community	Total Iodine, meg	Cereals, %	Pulses, %	Vegetables, %	Milk and milk products, %	Flesh foods, %
Maharastrian	252	35.7	10.7	3.2	44.8	5.6
Sindhi	247	40.9	9.3	5.3	44.5	-
Gujarati	287	49.1	11.5	2.1	37.3	-
Marawadi	240	43.3	9.6	4.6	42.5	-
Christian (Goanese)	301	32.2	7.9	1.7	30.9	27.2
Tamilian	223	36.3	15.7	1.3	46.6	-
Uttar Pradesh	248	37.9	11.3	5.2	45.6	4.4
Punjabi	211	35.1	16.6	5.2	46.4	-
Muslim (Hyderabad)	250	32.8	13.2	2.0	38.8	13.2

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TABLE 2. CONTRIBUTION OF SALT TO IODINE INTAKE IN VARIOUS REGIONAL DIETS AND IODINE LOSSES DURING COOKING.

Community	Salt consumed per capita, g	Iodine content of salt, ppm	% of total iodine intake	Total iodine intake, mcg		
				raw foods salt, mcg	cooked mixed diet, mcg	loss %
Maharastrian	6.1 + 2.9	7.0 + 0.0	14.2	294.6	130.4	55.74
Sindhi	8.4 + 3.2	2.8 + 3.8	7.9	270.5	164.9	39.04
Gujarati	8.8 + 3.7	5.6 + 3.1	13.9	336.4	102.0	69.68
Marwadi	8.7 + 3.9	4.2 + 3.8	12.3	276.5	128.6	53.49
Christian (Goanese)	14.4 + 15.2	4.2 + 3.8	17.1	361.8	133.3	63.16
South Indian	10.7 + 4.8	5.6 + 3.1	20.8	282.9	151.6	46.41
Malayalee	7.1 + 1.8	7.0 + 0.0	15.6	316.7	136.0	57.02
Uttar Pradesh	7.4 + 1.3	5.6 + 3.1	14.2	289.4	131.1	54.69
Punjabi	9.0 + 4.6	7.0 + 0.0	22.9	274.0	117.9	56.97
Muslim (Hyderabad)	6.3 + 3.4	7.0 + 0.0	14.6	294.1	184.0	37.44

content of raw food and not from cooked mixed diets. The contribution of different food groups to the daily iodine intake indicated that the cereals contributed 32.2-49.1% of the dietary iodine intake. This figure is much lower than the value of 75% reported by NNMB (1984). The major dietary contributors (30-46.6%) to the daily iodine were milk and milk products (Varo 1982). This was also observed by Bester (1988). Park et al (1981) have reported that the dairy products were the major contributors to dietary iodine. The contribution of vegetables and fruits to the daily dietary iodine intake was very low (1.3-5.3%). Flesh foods are the other important dietary sources of iodine. Depending upon the amount eaten, they contribute 4.4-27.2% of the daily iodine intake. The total amount of salt consumed per capita per day was found to range from 6.1-14.4 g. (Table 2). The values observed are almost similar to those reported by NNMB (1984). It is interesting to note that none of the salts contained iodine levels of 15 ppm as specified for iodised salt (NGCP 1987). The mean iodine contents of the salts ranged from 2.8-7.0 ppm which correspond to 7.9-22.9% of the daily iodine intake.

A positive correlation between the dietary iodine intake of cooked diet and iodine content of salt was observed (r=0.30). Table 2 shows that the iodine intake from mixed cooked diets was low (102.0-184.0 mcg) and iodine losses during cooking ranged from 37.4-69.7%. This was not surprising as iodine is an unstable and volatile compound. This may mean that the iodine values calculated from raw foods can give a wrong impression with regard to iodine intake. This could be the reason why the prevalence of goitre in India is so high even though NNMB data (1984) show higher than RDA of 150 mcg iodine intake even in very low income groups.

In this study, 7 out of 10 regional diets showed a iodine content lower than 150 mcg, when iodine was estimated in the cooked mixed diet. The correlation between the iodine content of the raw and cooked diets appears to be non-significant (r=0.12) even though it was positive.

The results of the present study suggest that iodine content computed from intake of raw foods is significantly higher than that of mixed cooked diet. The iodine losses during cooking are appreciable. This should be taken into account in the National Goitre Control Programme. The minimum level of 15 ppm of iodine in salt at the consumer level may not be adequate enough to provide extra iodine needed to meet the daily dietary requirements. As cereals and pulses together contribute less than half of the daily dietary iodine, the lower socio-economic groups are specially vulnerable to iodine deficiency. Their diets are predominantly cereal-based and intake of milk and other flesh food is low. More realistic guidelines for iodised salt are, therefore, vital.

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Glucosinolate and Lipid Composition of Newer Indian Varieties of Mustard and Rapeseed

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Mustard varieties contain 64.4 and 89.5 μ moles gluconapin/g dry meal in contrast to 104.2 and 123.3 μ moles/g dry meal in rapeseed varieties. Sinigrin was present only in mustard and amounted to 7.6 and 10.3 μ moles/g dry meal. Erucic acid was found to be rich in all the varieties. Iodine values were higher in mustard varieties than in four varieties of rapeseed.

Keywords : Glucosinolate, Gluconapin, Sinigrin, Erucic acid, Mustard, Rapeseed.

India is a leading producer of mustard (*Brassica juncea*) and rapeseed (*Brassica campestris*) in the world, the production being 4.4 million tonnes (Anon 1990). However, the yield per hectare is low and a number of new varieties are being developed to improve the yields. The oils of mustard and rapeseed are characterised by the presence of erucic acid, $C_{22:1}$ which is reported to cause myocardial fibrosis (Beari et al. 1972). The seed meal contains the bitter and thyrotoxic glucosinolates (Belzile et al. 1963). Besides, varieties with low glucosinolates contents have also been reported (Uppal et al. 1984). Therefore attention needs to be focussed on the quality of oil and meal arising from these newer varieties.

Two varieties each of mustard ('RLM-198' and 'Prakash') and rapeseed ('R_1Y' and 'P_{10}') were analysed for glucosinolates. The seeds were flaked, defatted using hexane and residual solvent in the meal was removed by exposure to sunlight. Total glucosinolates, extracted with boiling water, were separated and estimated as desulpho-permethyl silyl ether (Heany and Fenwick 1980) by gas-liquid chromatography. Varian gas chromatograph, fitted with a glass column of 3% OV-7 on chromosorb WAW-HMDS (80-100), was used with nitrogen as carrier gas at 40 ml/min. Glucotropeolin/sinigrin was used as an internal standard.

The oils from 3 varieties of mustard ('Durgamani', 'Varuna' and 'RLM-198') and 4 varieties of rapeseed ('T-42', 'T-9', 'TS-72' and 'BSH-1') were subjected to physico-chemical characterisation with respect to iodine value, free fatty acids, saponification value, unsaponifiable matter, butyro refractometer reading (BRR), refractive index (RI), Bellier turbidity temperature (BTT), according to the AOCS procedure (AOCS 1975). The methyl esters (Christie 1975) of fatty acids were separated and determined by gas-liquid chromatography. Dual column CIC gas-chromatograph fitted with 12.5% diethylene glycol succinate on chromosorb-w (80-100 mesh) was used. The separation was done at isothermal temperature of 183°C. The peak area was calculated for quantitation.

TABLE 1. GLUCOSINOLATES OF MUSTARD AND RAPESEED VARIETIES.

Varieties	Gluconapin (μ moles/g dry meal)	Sinigrin
'RLM 198'	89.5	10.3
'Prakash'	64.4	7.6
'P_{10}' (Brown seeds)	123.3	Tr.
'R_1Y' (Yellow seeds)	104.2	Tr.

Tr. = Traces

The results in Table 1 indicate that gluconapin (3-butenyl glucosinolate) was predominant in mustard and rapeseed varieties. This is in contrast to the earlier report (Kjaer 1953) which showed sinigrin as the major glucosinolate in *B. juncea*. In the present study, sinigrin was observed as a minor constituent (7.6 to 10.3 μ moles/g dry meal) of glucosinolate in *B. juncea* as against its presence in traces in *B. campestris*.

The physico-chemical characteristics of the oil (Table 2) showed some differences in iodine values, all the mustard varieties being higher in iodine values than all the varieties of rapeseed. This was reflected in the fatty acid composition namely $C_{18:1}$, $C_{18:2}$ and $C_{18:3}$ (Table 3). The results agree with the reports published earlier in case of rapeseed. (Krishnamurthy et al. 1983). There were no appreciable differences in BTT and BRR values. Saponification values varied from 164.2 to 190.0. Erucic acid level in 'RLM 198' mustard variety was higher than the amounts present in other 2 varieties of mustard i.e., 'Varuna' and 'Durgamani'.

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TABLE 2. THE PHYSICO-CHEMICAL CHARACTERISTICS OF MUSTARD AND RAPESEED

Varieties	BRR 40°C	RI	BTT (°C)	Iodine value	Sap. value	Unsap. matter (%)	F.F.A.(% oleic acid)
'Durgamani'	59.2	1.47	25	103.1	138.7	0.9	0.7
'Varuna'	59.0	1.47	26	102.9	109.7	0.9	0.7
'RLM-198'	57.8	1.46	26	92.3	139.7	1.2	1.7
'T-42'	58.5	1.46	27	79.8	176.1	0.8	2.1
'T-9'	57.4	1.46	26	83.6	139.9	0.8	1.8
'TS-72'	59.0	1.47	29	88.6	175.5	0.9	2.3
'BSH-1'	59.0	1.47	27	91.1	174.5	0.8	1.0

BRR = Butyro Refractometer Reading, RI = Refractive Index, BTT = Bellier Turbidity Temperature, FFA = Free Fatty Acid.

TABLE 3. FATTY ACID COMPOSITION OF LIPIDS OF MUSTARD AND RAPESEED VARIETIES.

Varieties	$C_{16:0}$	$C_{16:1}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:1}$	$C_{20:2}$	$C_{22:1}$
				(Relative percentage)					
'Varuna'	3.5	Tr.	0.5	11.1	16.3	12.8	8.4	1.4	46.0
'Durgamani'	3.2	Tr.	0.9	10.1	17.9	10.2	8.0	1.3	48.3
'RLM-198'	2.1	0.8	0.5	8.3	13.1	8.1	5.8	1.1	60.3
'T-42'	2.0	0.5	1.3	8.1	14.8	8.7	5.1	1.0	58.5
'T-9'	1.2	0.3	0.4	11.4	10.4	6.6	6.0	2.1	61.6
'TS-72'	2.4	0.4	0.3	15.0	15.0	12.6	7.8	1.5	48.5
'BSH-1'	4.3	0.4	0.7	14.0	9.7	9.0	7.7	2.6	51.6

$C_{14:0}$ was in traces in all the varieties.

These latter varieties contained higher proportions of $C_{18:1}$, $C_{18:2}$ and $C_{18:3}$.

Data indicated that all the 7 new varieties of mustard and rapeseed are rich in erucic acid. However, glucosinolates of rapeseed varieties contain only gluconapin, whereas mustard varieties have a small amount of sinigrin and major portion of gluconapin.

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Composition and Quality of Nectar Prepared from Blended Pulps of *Amrapali* and *Totapuri* Mangoes

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Nectar prepared from the pulps of *Totapuri* and *Amrapali* at the ratio of 50:50, was superior in objective colour, carotenoid contents, viscosity and sensory quality, to the nectars prepared from either *Totapuri* pulp alone or the blend with *Amrapali* in the ratio of 75:25.

Keywords : Mango, Pulp, Nectar, Quality, Blends, Composition, *Amrapali*, *Totapuri*

Mango is a popular fruit of the tropics. About 67% of the world output (amounting to 9.33 million tonnes) is produced in India (Anon 1980a), where mango occupies a total area of 1.963 million hectares, i.e. 40% of the area under fruit crops (Anon 1987). Mango is processed into several products in Indian homes as well as at commercial level. Mango nectar, which contains 20% fruit pulp, can provide good colour, flavour and body to the beverage without any additives. Several mango cultivars have been described to produce good nectars (Rao et al. 1968; Saini et al 1982; Mahadeviah et al. 1969, 1974). A combination of *Dashehari* and *Langra* mangoes in equal proportions gave best nectar (Roy et al. 1972). *Amrapali (Dashehari x Neelum)*, rich in carotenoid contents, deep orange-red flesh and fibreless, was reported to be an excellent mango for juice and beverage production (Anon 1980b; Khurdiya and Roy 1988). *Totapuri* cultivar is usually employed in the commercial production of mango juice and beverages for local consumption and export. The present investigation was conducted to improve *Totapuri* mango nectar by blending with *Amrapali*.

Totapuri mangoes were obtained from local market, while *Amrapali* cultivar was from the experimental orchard of the Institute. The fruits were allowed to ripen fully in the laboratory at ambient temperature (35-36°C), washed thoroughly with water, pulped in a stainless steel pulper using 1/32 inch mesh sieve, the pulp was heat-processed upto 90°C and bottled after reducing the pH to less than 4.0 by citric acid. The bottled pulp was stored at 3°C until required. *Amrapali* and *Totapuri* pulps were mixed in a Waring blender at different ratios, converted into nectar and preserved by heat processing (90°C) as per specification of FPO (Lal et al. 1986). Both the pulp and the nectars were analysed for the various quality parameters:

Total soluble solids (°Brix) were determined with refractometer and the readings were corrected to 20°C. Acidity and pH were determined by the standard methods (AOAC 1960). Total carotenoids were estimated by the method described by Roy (1973). The colour was measured with a Gardner colour guard system 1000 colorimeter, using Hunter L, a, b scale and total colour, hue and chroma were also calculated (Ranganna 1986). The density of the nectar was estimated as the proportion of a mass to volume. Viscosity of the nectar was measured in a Digital Brookfield Synchro-electric viscometer at 20°C with spindle No.1 at 60 rpm and expressed in centipoise units (Ranganna 1986). Sensory evaluation was carried out by a panel of seven judges using a 9-point Hedonic scale (Amerine et al. 1965).

It is evident from the data (Table 1) that the pulps of both the *Amrapali* and *Totapuri* mangoes showed significant variations in all the parameters of physico-chemical characteristics. *Amrapali* pulp was superior to that of *Totapuri* with respect to total carotenoids and colour. The °Brix, acidity and pH were higher in the *Amrapali* pulp than *Totapuri*. The total carotenoid contents of the *Amrapali* were 5.8 times greater than *Totapuri* pulp. The carotenoids were responsible to lend orange-red colour and 2.8 times higher value of +a. The +b value of *Amrapali* pulp was also higher by 6.6% than that of *Totapuri*. Total colour and chromacity were 12.1 and 26.2% higher in *Amrapali* than *Totapuri* pulp, respectively. The hue (dominant wave length) of *Amrapali* pulp was 2.7 times greater than *Totapuri* pulp.

The nectars (20% pulp, 15 °Brix and 0.3% acidity) from blended pulps showed that *Amrapali* had greatly influenced the quality of *Totapuri* mango nectar in respect of carotenoid contents, viscosity, Hunter colour values and sensory quality (Table 1). The *Amrapali* nectar (AT-1) possessed highest

TABLE 1. PHYSICO-CHEMICAL COMPOSITION AND QUALITY OF BLENDED MANGO PULPS AND NECTARS FROM CULTIVARS *AMRAPALI* AND *TOTAPURI*.

Parameters	Proportions of *'Amrapali'* and *Totapuri* pulp (respectively in blends) 100:0 (AT-1)	75:25 (AT-2)	50:50 (AT-3)	25:75 (AT-4)	0:100 (AT-5)
Pulp					
°Brix	21	20	19	18	17
Acidity (%)	0.58	0.57	0.57	0.54	0.55
pH	3.7	3.7	3.7	3.7	3.7
Total carotenoids (mg/100g)	5.2	3.5	3.3	2.1	0.9
Hunter Scale					
L	41.7	42.2	42.4	39.9	39.5
+ a	19.0	17.3	16.7	11.8	6.7
+ b	26.9	27.6	27.8	25.9	25.2
Total colour	53.1	53.4	53.4	49.0	47.4
Hue	0.71	0.63	0.60	0.45	0.27
Chroma	32.9	32.6	32.5	28.4	26.1
Nectars					
Total carotenoids (mg/100g)	1.14	0.75	0.33	0.15	0.09
Density (g/ml)	1.053	1.052	1.048	1.041	1.036
Viscosity (CP)	11.0	12.6	17.5	28.8	39.3
Hunter scale					
L	47.8	44.2	43.4	42.3	39.0
+ a	12.9	10.4	7.7	5.3	1.9
+ b	29.3	28.0	27.8	27.0	24.7
Total colour	57.6	53.5	52.1	50.5	46.2
Hue	0.44	0.37	0.28	0.20	0.08
Chroma	32.8	29.9	28.9	27.5	24.8
Sensory quality score					
Colour	8.7	8.4	7.8	6.6	5.2
Flavour	7.2	7.6	7.2	6.4	5.6
Texture	7.4	7.6	6.9	6.2	5.5
Overall	23.3	23.6	21.9	19.2	16.2

CD - (5%); Colour - 0.78; Flavour -1.00; Texture - 0.97 and Overall - 2.64.

carotenoids which were 12.7 times greater than those of *Totapuri* nectar. The *Amrapali* nectar was highest in density, but lowest in viscosity, in comparison to *Totapuri* nectar. The density decreased, while viscosity increased with increasing proportion of *Totapuri* in the mango nectar. *Totapuri* nectar was 3.6 times viscous than *Amrapali* nectar, thereby affecting the textural score.

The *Amrapali* nectar possessed 1.22, 6.79 and 1.19 times higher values of L, +a and +b than those of *Totapuri*, respectively. This shows that the colour of the *Amrapali* nectar was orange-red, while that of *Totapuri* was pale yellow and it improved as the proportion of *Amrapali* was increased. The total colour, hue and chroma of the nectars have similar pattern as shown in the case of blended pulp.

As far as the sensory quality scores were concerned, all the samples except *Totapuri* nectar (AT-5) were acceptable to the taste panel members. The *Totapuri* nectar scored very low for colour, flavour and texture. There were no statistically significant differences in sensory quality among the first three treatments (AT-1, AT-2 and AT-3). Hence all these can be considered as equally good. Therefore, blending *Amrapali* and *Totapuri* mango pulps at the ratio of 50:50 and the nectar produced from it, could be nearly as good as the nectar prepared from *Amrapali* pulp (AT-1). It was also found superior to the nectars prepared from the pulps of other two treatments (AT-4 and AT-5). This will enable effective utilization of *Totapuri* pulp without affecting the quality in the preparation of mango nectar.

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Incidence of Aerobic Spore Formers in *Lassi*

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Analysis of 75 market samples of *lassi* revealed higher incidence of aerobic spore formers in samples from local vendors, followed by private manufacturers and organised dairies. The occurrence of *B.subtilis* was high and the isolated *B. cereus* were non-toxigenic in nature.

Keywords : *Lassi*, Aerobic spore formers, *B. subtilis*, *B. cereus*, Total viable counts.

Aerobic spore formers are of considerable importance in food industry because of their ability to produce enzymes and the resultant undesirable textural and flavour defects. *Bacillus cereus*, the toxin producing species of aerobic spore formers, has been implicated in many food poisoning cases (Johnson 1984; Rajakowski and Mikolajcik 1987; Wong et al. 1988; Ramaraju and Kirankumar 1988; Eapen et al. 1983). As the information on the incidence of aerobic spore formers and toxigenic activity of *B.cereus* from *lassi* is scanty, the present study was undertaken.

A total number of 75 market samples of *lassi* (sweetened curd), 25 from each of the following sources viz. local vendors, private manufacturers and organised dairies, were collected aseptically. The samples were enumerated for total viable counts and aerobic spore formers (Speck 1984) immediately after collection. The protocol described, in Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons 1974) was followed for identification of aerobic spore formers. Enterotoxigenic activity of *B.cereus* was determined by Rabbit illeal loop induced fluid accumulation technique (Spira and Goepfert 1972). Results obtained were subjected to statistical analysis (Snedecor and Cochran 1967).

The total viable counts, aerobic spore counts and percentage of aerobic spore formers in *lassi* are presented in Table 1. The total viable counts and aerobic spore counts were significantly ($P<0.01$) higher in *lassi* samples from local vendors, while no significant differences were observed between the samples from private manufacturers and organised dairies. This incidence of aerobic spore formers is high as compared with 0.07% in the *lassi* prepared under laboratory conditions (unpublished data). The higher incidence in local vendors can be attributed to unhygienic practices during handling of the product.

TABLE 1. MEAN TOTAL VIABLE COUNTS, AEROBIC COUNTS AND PERCENTAGE OF AEROBIC SPORE FORMERS IN *LASSI* FROM DIFFERENT SOURCES (MEAN OF 25 SAMPLES ± S.E.)

Source	Total counts (cfu/g)**	Aerobic spore counts (cfu/g)**	Percentage of aerobic spore formers
Local vendors	$3.86\times10^{7}\pm0.29^{b}$	$3.26\times10^{5}\pm1.02^{b}$	0.8
Private manufactures	$2.17\times10^{6}\pm1.89^{a}$	$9.11\times10^{3}\pm1.68^{a}$	0.4
Organised dairies	$4.68\times10^{5}\pm2.58^{a}$	$1.63\times10^{3}\pm3.01^{a}$	0.3
Overall mean	$1.37\times10^{7}\pm5.02$	$1.12\times10^{5}\pm8.04$	

Means with similar superscripts do not differ significantly ** ($P<0.01$).

TABLE 2. DISTRIBUTION OF *BACILLUS* SPECIES IN *LASSI* SAMPLES.

Bacillus species	Source		
	Local vendors	Private manufacturers	Organised dairies
Bacillus subtilis	12	6	8
Bacillus megatherium	8	8	4
Bacillus cereus	4	2	3
Bacillus licheniformis	5	3	4
Bacillus coagulans	6	4	3
Bacillus pumilus	3	3	2
Bacillus sphaericus	2	2	-

Among various species of aerobic spore formers (Table 2), occurrence of *B. subtilis* was higher (28.2%) followed by *B. megatherium* (21.7%) in *lassi* samples. The isolates of *B.cereus* from *lassi* were non-enterotoxigenic strains as the response to rabbit illeal loop induced fluid accumulation technique was found to be negative.

The study revealed higher incidence of aerobic spore formers in market samples of *lassi*, thus necessitating to follow strict hygienic regulations in preparation and marketing of this product.

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Incorporation of Chicken Byproducts in Mutton Nuggets

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Emulsion-based mutton nuggets, incorporating chicken byproducts i.e. skin, gizzard and heart (SGH) from spent hens, were evaluated for yield and quality. Three formulations containing 15% mutton fat, 15 and 25% SGH were compared. Emulsion stability, cooking loss and composition were nearly similar, but flavour scores were significantly higher for 15% SGH. Incorporation of SGH resulted in better acceptability of mutton nuggets as compared to those with mutton fat.

Keywords : Skin, Gizzard, Heart, Spent hens, Mutton nuggets, Emulsion stability, Sensory evaluation.

Several workers attempted to develop ground or emulsion type products for efficient utilisation of tough meat from spent animals (Baker et al. 1972; Baliga and Madaiah 1971; Seideman et al. 1982). For realizing higher returns from spent hens, byproducts such as skin, gizzard and heart (SGH) have to be utilised. Composition and functional properties of these byproducts have been reported (Kondaiah and Panda 1987) and their incorporation in chicken sausages has been suggested (Kondaiah and Panda 1989). Mutton fat was reported to pose dispersion problems in emulsion products and results in unacceptable mouth coating (Carpenter et al. 1966; Chattoraj et al. 1979). Combination of meats to compliment each other in preparation of meat products has been reported (Bushway et al. 1988; Mir Salahuddin et al. 1988; Anjaneyulu et al. 1990). In the present study, the incorporation of chicken byproducts at different levels in emulsion-based mutton nuggets for replacing mutton fat has been evaluated.

Mutton was obtained within 3 h of slaughter from 5 year old sheep and frozen at -10°C. Chicken byproducts, SGH, were obtained from slaughtered spent hens and frozen. The frozen samples were tempered at 5°C for 12 h before utilisation in the trials. Three formulations of 2.5 kg each were developed. Formulations 1 and 2 contained mutton + mutton fat and mutton + SGH at 85:15 proportions, respectively, while formulation 3 contained mutton and SGH at 75:25 proportions. In addition, each formulation contained 2% salt, 0.5% polyphosphate, 1.5% spices, 5% condiments and 10% ice flakes. Skin, gizzard and heart were used in natural proportions of 77.7, 17.6 and 4.5%, respectively. Meat was coarse-minced, while fat and byproducts were finely minced and emulsions were made using Hobart model bowl chopper. Nuggets were made by forming blocks, cutting into cubes and subjected to evaluation by 11 experienced members (Kondaiah et al. 1990). Emulsion stability was recorded. Two trials were conducted and analysed statistically (Snedecor and Cochran, 1968).

Processing quality of nuggets was similar under the three formulations (Table 1). No significant differences were observed in emulsion stability, cooking loss and composition. Emulsion stability values and cooking loss were below 5%, thereby indicating good quality emulsions and product. Incorporation of SGH at 15% level resulted in better sensory scores than the other formulations (Table 1). As expected, relatively lower scores were observed with 15% mutton fat incorporation. Mutton fat, being a saturated hard fat with high solidification point, did not get properly dispersed in the cold environment (<10°C) of emulsion and resulted in undesirable mouth coating (Carpenter et al. 1966; Chattoraj et al. 1979; Kondaiah et al. 1987). This

TABLE 1. EFFECT OF INCORPORATION OF MUTTON FAT AND CHICKEN BYPRODUCTS (SGH) ON THE QUALITY OF MUTTON NUGGETS

Parameters	Formulation		
	1	2	3
Emulsion stability, %	4.4±0.5	3.9±0.5	3.4±0.4
Cooking loss, %	4.0±0.3	3.8±0.1	3.4±0.4
Moisture, %	65.6±0.8	66.5±0.4	65.5±0.2
Protein, %	17.6±1.0	17.1±0.6	17.4±1.0
Fat, %	13.3±1.0	12.3±0.7	14.0±0.8
Appearance	6.6±0.1	6.7±0.1	6.8±0.1
Flavour	5.7±0.2[a]	6.4±0.1[b]	6.0±0.1[ab]
Juiciness	6.1±0.2	6.2±0.2	6.1±0.2
Texture	6.2±0.2	6.6±0.1	6.3±0.2
Mouth coating	6.3±0.2	6.6±0.2	6.6±0.2
Overall palatability	6.1±0.2	6.4±0.2	6.2±0.2

Means with the same superscript do not differ significantly (P<0.05)

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was reflected in the lower scores as compared to that with 15% SGH. At 25% level of SGH, the flavour scores were lower than those at 15% SGH, but higher than at 15% mutton fat. While the lower scores at 15% mutton fat could be attributed to the disadvantages of hard fat, lower scores at higher level of chicken byproducts could be due to the lower meat content. Lower sensory scores were reported in frankfurters containing higher fat levels of mutton and beef, due to a waxy or tallowy taste (Carpenter et al. 1966). This has been reflected in the overall palatability scores also. The study has indicated that chicken byproducts such as skin, gizzard and heart could be beneficially incorporated upto 25% level in emulsion-based mutton products with dual advantage of utilising the low value byproducts and producing a mutton product of better acceptability.

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Carbohydrates and Pigment Assays in Forty One Genotypes of Carrot (*Daucus carota* L)

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Considerable variation has been observed in total solids, edible part, moisture, total sugars, reducing sugars, non-reducing sugars, total fructose, total carotenoids, anthocyanins, xanthophyll and lycopene contents in 41 carrot genotypes.

Keywords : Carrot, Pigment, Carbohydrates, Genotypes, Total solids, Edible parts

Carrot (*Daucus carota* L.) is grown all over India, both for forage and human consumption and also for the preparation of strained baby foods (Mrudula Kalpalathika et al. 1988). Carbohydrates and pigments are important quality attributes in its marketing. The growth and chemical composition of carrots are known to be influenced by the time of sowing and harvest (Nilsson 1987). The present study reports variability in carbohydrate and pigment levels in 41 carrot genotypes.

Carrot genotypes, namely 'Indian Gold', 'Temperate type', 'Sel 1-4-2', 'Hisar local collection', 'Sel 1-5-1', 'Hisar local Sel-1', 'Hisar local Sel-2', 'Sel 1-9-2', 'HS 5-1-1', 'Sel 1-9-3', 'Sel 1-5-2', 'Sonepat selection', 'HS 2-2-1', 'Sel 1-6-1', 'Pusa Kesar 2-1', Pusa Kesar 1-1', 'Sel 1-7-2', 'Sel 1-7-1', 'Sel 1-8-4', 'Sel 1-10-2', 'Sel 1-8-3', 'HS 1', Sel 1-5-3', 'Sel 1-8-2', 'Gurgaon Selection', 'Sel 1-10-1', 'Pusa Kesar 1-2', 'Sel 1-4-1', 'Sel 1-6-2', 'HS-3', 'Sonepat selection 3-1-1', 'Sel 1-1-2', 'HS 5-2-1', 'Sel 1-1-1', 'Sel 1-3-1', 'HS 2-2-2', 'Sel 1-2-2', 'Sahbad selection-1', 'Pusa Kesar 3-1', 'Sel 1-3-2' and 'Indian Long Red' were procured from the research farm at marketable stage during February, 1986. Recommended package of practices was followed to raise the crop under Hisar conditions (HAU 1981). Twenty roots, randomly sampled from a large population, were reduced to cookable size (0.25 to 1.00 cm^2), after discarding the non-edible part, and dried at 60°C to a constant weight, before grinding to pass through 80 mesh sieve. Water soluble carbohydrates were extracted by autoclaving (McKee 1985), clarified and hydrolysed by the method of Srinivasan and Bhatia (1953). Reducing sugars were determined volumetrically (Hulme and Narain 1931) and non-reducing sugars by difference. Total fructose was assayed by the method of Roe (1934). Total carotenoids, anthocyanins, lycopene and xanthophyll were estimated by the method of Roy (1973), Siegelman and Hendricks (1957), Ranganna (1977) and Middendrof et al. (1960), respectively.

TABLE 1. VARIATIONS IN WATER SOLUBLE CARBOHYDRATES AND PIGMENTS IN CARROT GENOTYPES

Quality indices, %	Range	Mean	S.D.
Edible part	79.8-96.1	88.1	3.4
Moisture	87.4-97.9	92.2	2.8
Total solids	2.1-12.6	7.8	2.8
Total sugars			
OASB	0.2-6.0	2.3	1.8
ODMB	5.9-52.0	25.3	13.9
Reducing sugars			
OASB	0.1-4.8	1.4	1.3
ODMB	4.2-39.7	14.4	11.0
Non-reducing sugars			
OASB	0.0-2.4	0.9	0.6
ODMB	0.9-19.9	10.9	5.2
Total fructose			
OASB	0.1-4.0	1.3	1.0
ODMB	1.8-35.7	14.0	8.5
Total carotenoids			
OASB	23.3-143.8	61.4	26.0
ODMB	0.4-2.4	0.9	0.4
Lycopene			
OASB+	0.3-2.8	1.3	0.6
ODMB+	5.4-41.5	15.8	7.1
Anthocyanins			
OASB+	0.40-11.2	6.1	3.3
ODMB+	21.2-123.5	62.3	27.5
Xanthophylls			
OASB+	0.7-89.9	45.5	19.3
ODMS	0.3-1.5	0.6	0.3

Each value is an average of two determinations
+ : mg/100 g;

The data on the variations in moisture; edible part; total, reducing and non-reducing sugars; and total fructose are presented in Table 1. Variations in moisture and edible parts have been reported in the literature (Chandel and Rattan 1988). In

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general, the values for total fructose were at par with reducing sugars. The average values on dry matter basis (ODMB) for all carbohydrates fractions were 11.19 times greater than as such basis (OASB). Chandel and Rattan (1988) reported large variations in total sugars ranging from 3.8 to 8.8% in the carrots. Total carotenoids, lycopene, anthocyanins and xanthophyll values varied widely among genotypes (Table 1). The variation in colour in carrot has been shown to be mainly due to genotypes (Bajaj et al. 1980; Heinonen 1990).

The formation of anthocyanins has been shown to be associated with accumulation of sugars in plant tissues (Goodwin 1976) and this corroborates well with the present findings (Table 2). The correlation between various chemical components is illustrated in Table 2. Total carotenoids were found to be significantly correlated with total solids and negatively with edible part on OASB. Edible part, lycopene and xanthophyll showed significant association with total carotenoids, but total sugars, reducing sugars, fructose, total solids and anthocyanins were negatively associated with total carotenoids on ODMB. Highly significant correlations of greater than 0.90 have been observed between xanthophyll and non-reducing sugars as well as between total sugars and total fructose (Table 1). Lycopene has significant relationship with total sugars, xanthophyll and total solids, but negatively with reducing sugars. All fractions of carbohydrates showed significant positive correlations with anthocyanins. Total solids and anthocyanins showed significant negative relationship on ODMB. Except for reducing sugars on ODMB, all fractions of carbohydrates showed significant negative association with xanthophyll, whereas moisture and xanthophyll produced negative significant correlation (-0.765**) on ODMB. All carbohydrate fractions also have highly significant correlation among themselves.

Considerable variations in pigments and carbohydrates among the genotypes suggest a possible scope for depending on the screening of further genotypes of carrot with a view to select a specific genotype with improved quality.

TABLE 2. CORRELATION BETWEEN VARIOUS CHEMICAL CHARACTERS IN CARROT

	Total sugars	Reducing sugars	Non-reducing sugars	Total fructose	Edible part	Total solids	Xantho-phyll	Antho-cyanins	Lyco-pene
Total carotenoids									
OASB	+0.30	+0.28	+0.28	+0.25	-0.68**	+0.56**	+0.03	+0.11	+0.46**
ODMB	-0.54**	-0.42**	+0.03	-0.52**	+0.53**	-0.53**	+0.75**	-0.85**	+0.71**
Lycopene									
OASB	+0.40**	-0.31*	+0.39*	+0.07	-0.12	+0.43**	+0.60**	+0.28	-
ODMB	+0.35*	-0.51**	-0.19	-0.29	+0.28	-0.17	+0.81**	+0.002	-
Anthocyanins									
OASB	+0.59**	+0.52**	+0.59**	+0.60**	+0.11	+0.66**	+0.38*	-	-
ODMB	+0.40**	+0.35*	+0.32*	+0.42**	+0.09	-0.45**	-0.09	-	-
Xanthophyll									
OASB	+0.39**	0.33*	+0.95**	+0.28	-0.14	-0.03	-	-	-
ODMB	-0.42**	+0.64**	-0.37*	-0.47**	+0.06	+0.01	-	-	-
Total solids									
OASB	+0.87**	+0.31*	+0.67**	+0.83**	+0.21	-	-	-	-
ODMB	+0.79**	+0.75**	+0.57**	+0.75**	-	-	-	-	-
Total fructose									
OASB	+0.95**	+0.94**	+0.73**	-	-	-	-	-	-
ODMB	+0.90**	+0.74**	+0.50**	-	-	-	-	-	-
Non-reducing sugars									
OASB	+0.82**	+0.47**	-	-	-	-	-	-	-
ODMB	+0.32*	+0.37*	-	-	-	-	-	-	-
Reducing sugars									
OASB	+0.96**	-	-	-	-	-	-	-	-
ODMB	+0.94**	-	-	-	-	-	-	-	-

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

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Handbook of Food Engineering, Edited by Dennis. R. Heldman and Daryl B. Lund, Marcel Dekkar, Inc, 270, Madison Avenue, New York, 1992, pp:768, price ($195.00; $65.00 on orders of five or more copies for class room use only)

There is a long felt need for practising engineers, and research students for a handbook of food engineering and the present book fulfils such a need. The handbook is sub-divided into 14 chapters, generally organised by traditional unit operations and written by experts in the field.

Chapter one deals with rheological properties of foods including accurate steady rheological data necessary for the design of continuous flow processes, heating rates during concentration, aseptic processing and residence-time distribution in extrusion. In addition, details regarding the progress made on the measurement and simulation of visco-elastic semi-solid foods and their biopolymeric components were presented. The next chapter on kinetics of food systems has received a great deal of attention to optimize or at least maximize the quality of food products during processing and storage. Details of reaction kinetics have been provided to give a better idea of how to formulate or fortify food products to preserve the existing nutrients or to minimise the appearance of undesirable breakdown products. Various order of reactions and implications are extensively dealt with. Detailed tables indicating kinetic parameters for vitamin destruction and pigment losses during thermal processing or storage of various fruit and vegetable products have been enumerated. Changes in the physical state of all materials are discussed along with transformations in food systems. Food materials, exhibiting both equilibrium and non-equilibrium states in a number of compounds within a complex structure which makes their phase behaviour complicated and close to those of polymers, have been extensively dealt with. Because of the biological and fragile nature of foods and the ever-present threat of attack by insects and microorganisms, the design of transportation and storage systems poses special challenges and the problems associated with these are brought out with clarity.

Many desirable changes as well as undesirable reactions occur in foods, when heated or cooled. When the food material is heated or cooled, an initial period of unsteady state is observed and after the lapse of certain time, the rate of heat transfer reaches a steady state. In the chapter on heating and cooling processes for foods, mathematical description of both steady and unsteady states of heat transfer as also important thermal properties of foods on mathematical models, have been presented. In the chapter on food freezing, thermodynamics of food freezing, procedure for determination of frozen food properties needed for refrigeration requirements, methods for computation of freezing time currently used for freezing systems and design calculations for refrigeration requirements are discussed. In the chapter on mass transfer in food, the author has brought out the principles and theory of diffusion, sorption isotherms, basic theories of drying, liquid-solid extraction, whereas in evaporation and freeze concentration and concentration of liquid foods by reverse osmosis, the authors have discussed: various types of evaporators used in food industry, like multiple effect evaporation, mechanical vapour recompression, freeze concentration, principles of reverse osmosis, ultra-filtration, microfiltration and the economics of each one of the system, their comparative advantages and applications. The chapter on food dehydration deals with all aspects like purpose of drying of food products and fundamentals, water sorption isotherms, prediction of drying rates, moisture diffusivities in foods, dryer designs for conventional dryers and supercritical fluid extraction and its application to drying as well as figures and solutions with typical examples. Four chapters fall distinctly away from classical unit operations, viz., thermal process calculation, extrusion processes, food packaging, cleaning and sanitation.

The authors have discussed thermal inactivation kinetics of bacterial spores, heat transfer in canned foods, process calculations, commercial sterilization systems. aseptic processing and low acid canned food regulations. In the extrusion process, the main emphasis of the chapter was to provide to the food engineer a quantitative understanding of the performance of various extrusion devices and not a routine way to provide the reader as to how to produce various extrusion products. Presently, the scientific and engineering principles are coming more and more into their own in the field of packaging in general, and food packaging in particular. Protection, through packaging, is thoroughly presented in the chapter on food packaging. In the last chapter on cleaning and

sanitation, hygiene which is of utmost importance in the food manufacturing process, is discussed to provide the reader the basic understanding of mass and heat transfer phenomena involved, outline design considerations and practical user advice.

The handbook is well written with figures, tables and design equations. It is in the direction similar to that of Chemical Engineers' Handbook. The book is recommended to practising chemical/ food engineers, technologists, R&D scientists and students. It is an excellent addition to libraries.

M.M. KRISHNAIAH
C.F.T.R.I., MYSORE

Drying of solids, Edited by Arun S. Mujumdar, Published by International Science Publishers (New York) and Oxford & IBH Publishing Co.Pt. Ltd., (New Delhi), 1992, pp. 529, Price not mentioned

This book is published to continue the tradition of earlier books on the same topic edited by Dr. Arun S. Mujumdar, who is widely known internationally for his extensive and innovative contributions to the fields of drying, heat and mass transfer. He is currently Professor of Chemical Engineering at McGill University, Canada and is the founder of the International Drying Symposium Series (IDSS).

Drying by thermal processes has wide applications in agricultural, chemical, food, paper, pharmaceuticals, wood and polymer industries. A proper insight of the physical, physico-chemical and thermo-chemical changes occurring during drying of the materials, as well as knowledge of flow behaviour involving heat and mass transfer and hydrodynamics is important in designing an industrial dryer. Selection of appropriate drying technology and equipment, needs information on conventional and novel drying processes available. With the tremendous growth in the number of published research articles in the last few years, a book like this serves as a ready reference and a technological update on drying of solids. The book is divided into 6 sections, namely; review, drying of wood and paper, simulation of drying and dryers, drying of food products, miscellaneous topics and bibliographies.

Section one includes six reviews, contributed by experts around the world. The first review gives the overview of advances in industrial drying technologies and their potential application areas. Subsequent three review articles are of particular interest to food technologists, since these cover advances in osmotic dehydration, drying of starch and gluten and drying of food products in fluidized vibration bed. Review on hydrodynamics, heat transfer and drying of spouted bed and analogy of heat-moisture transfer will be useful for food and chemical engineers engaged in designing of dryers.

Section two includes five papers by authors devoted to drying of wood and paper. An overview of drying of wood is contributed on the basis of research carried out at Moscow Forest Research Institute. Novel drying techniques, like infra-red thermal radiation and super-heated steam drying, are discussed as separate papers. A few articles on the theoretical aspects like heat and mass transfer are also included. Section three on simulation of drying and dryers, covers mathematical modelling. There are four papers and the first one proposes a model for convective drying of non-porous shrinking spheres. This system has relevance to drying of liquid and solid foods, biological products, polymer solutions and colloidal materials. The next paper is on optimization of drying of yeasts.

Section four is on drying of food products and has six papers, covering drying technologies in potato processing, influence of drying on colour of plant products, osmo-convective drying of fruits and vegetables, solar-assisted osmotic dehydration, solar drying of vegetables and sorption isotherms of foods. All the articles are useful to food technologists and food scientists. The paper on potato drying is an overview of the current state-of-the-art and provides guidelines for selection of conventional as well as new dryers. All the articles have good theoretical background and yet are very much 'application-oriented', since energy requirement is considered as key parameter, while developing the new drying technology. Section five covers some miscellaneous topics like modelling of drying of fibrous materials. The last, i.e. sixth section gives three bibliographies on di-electric drying, drying and de-watering and on sorption isotherms in foods. These include extensive, yet

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selective up-to-date literature on specific topics.

To sum up, this book contains selected research contributions from around the world to cater to the needs of practising engineers, applied scientists, academicians and researchers working in the rapidly emerging field of thermal drying.

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UDCT, BOMBAY

Handbook of Applied Mycology, Vol. 3: *Foods and Feeds*, Edited by Dilip K. Arora, K.G. Mukherji and E.H. Marth, Published by Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016, U.S.A., 1991; 640 p.; Price: US $ 150.00 (U.S. and Canada), US$ 172.00 (all other countries) - Prices subject to change without notice.

This excellent book is the third in a series of 5 volumes published under the series editorship of Dilip K. Arora, the well known authority on mycology and microbiology from the Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi. His co-editors for this volume are also the well known experts and include K.G. Mukherji of Botany Department, University of Delhi, Delhi and Elmer H. Marth of Food Research Institute, University of Wisconsin, Madison, USA. This combination of editors from East and West has managed to enlist the support of over 25 international experts for successfully presenting the much-needed reference book to illustrate the benefits and problems resulting from moulds in foods and feeds. The tradition of Marcel Dekker, Inc is also maintained in using acid-free paper for printing of the book. Even a casual glance at the content pages of the book illustrates that the book is a store-house of vitally important information to scientific community; the efforts of Marcel Dekker in this aspect are well recognised throughout the world. All the chapters give extensive literature and the whole book is endowed with 2100 literature citations.

The chapter by Samson et al. on taxonomy of filamentous fungi in foods and feeds gives necessary inputs on conventional methods for identification of these fungi with emphasis on new approaches such as immunological and molecular methods as well as computer-assisted keying. The section of nomenclature also gives vital information on the changing nomenclature of fungi. The ecology, spoilage and mycotoxin production by filamentous fungi in foods and feeds, as presented by Frisvad and Samson, deals with the environmental factors of storage fungi, microbial competition, spoilage, processing factors and mycotoxin production. These deliberations provide the potential routes for control of these fungi in foods and feeds. The chapter on xerophilic fungi in intermediate and low moisture foods by Hocking gives an insight on the fungal spoilage of these foods/food products and the importance of the role of water activity. Keys for identification of xerophilic fungi, along with their brief description, are also provided. The chapter on fungi and seed quality by Christensen deals with techniques for studying fungi in seeds, field and storage fungi, fungal effects on seed quality and the danger of mycotoxins in the seeds. The deterioration of seeds by storage fungi is aptly illustrated with photographs.

Lacey et al. have contributed an excellent chapter on grain fungi with emphasis on fungal colonization of grains, the relationship between fungal colonization of grains and different grain storage methods, fungal/arthropod interactions, water-temperature-gas relationships of grain fungi, fungal interactions on mycotoxin formation, kinetics of fungal growth in stored grains and the extent of devastating effects on grain quality. The chapter on importance of fungi in vegetables by Burgarelli and Brackett is of immense value to the vegetable scientists/technologists and opens up the possibility of scientific methods for preservation or shelf-life extension of these highly perishable foods. It also includes sections on post-harvest handling/ processing and fermentation of vegetables. Splittstoesser has critically reviewed the literature on fungi of importance in processed fruits, with specific reference to the prevention of the growth of fungi in the thermally processed fruits, low water activity fruits and frozen fruits. The role of preservatives and the mycological considerations in alcoholic fermentation of fruits is also discussed. The chapters on cultivated mushrooms by Chang and on biological utilization of edible fruiting fungi by Rajarathnam and Zakia Bano provide comprehensive, but concise information of immense value on these topics. Various avenues for gainful utilization of spent substrate form an aspect worth mentioning in the chapter by Rajarathnam and Zakia Bano.

The importance of koji moulds in the manufacture of non-proteinaceous fermented foods

and beverages as well as proteinaceous foods and condiments is excellently brought out by Yokotsuka. I must mention the right choice made by editors for preparing these two chapters. The information presented by Yokotsuka in these chapters is of immense value and gives an insight in this unique method of preservation/upgradation of foods, the art and science of which is perfected in the Oriental countries. The chapter on fungi and dairy products by Marth and Yousef is yet another masterpiece and a vast storehouse of information. It critically reviews the useful applications of fungi in cheeses, fermented milks and the management of dairy by-products. The section on fungus-related problems in the dairy products has utility value to the industry. The chapters on fungal metabolites in food processing and fungal enzymes in food processing by Bigelis are indispensable to anyone involved/interested in food processing. The account presented in these chapters illustrates as to how the food biotechnology is a classical food technology wedded to new techniques/approaches. It also defines the mycological perspectives amply. Food fermentation, canning, bottling and packaging form some of the many food processing aspects described in the later chapter. The role of genetic and protein engineering is also analyzed.

The chapter on single-cell protein from moulds and higher fungi by Kahlon analyzes the subject matter critically for giving insight in this important aspect. A short chapter of 12 pages on anti-fungal food additives by Liewen gives the gist of the problems of food spoilage by fungi and the additives which can control this devastating phenomena of food spoilage by fungi. The information can serve as a ready-reckoner to the food industry and technologists. It even gives the information on the interactions between various additives. The last chapter on products and uses of yeasts and yeast-like fungi by Nagodawithana deals with production of Baker's yeast, distiller's yeast, wine yeasts, nutritional yeast, mineral yeast, single-cell yeast protein, yeast products of industrial importance, colorants from yeasts, enzymes from yeasts, products of pharmaceutical/cosmetic value and genetically-engineered products from yeasts. It is baffling as to why this chapter was included in the book on Mycology. The chapter, however, is an excellent source of information on the topic.

On the whole, the book is an excellent and up-to-date master-piece of information/reference source for all the food biotechnologists as well as technologists from diverse fields such as microbiology, biotechnology, plant pathology, botany, agricultural production and biochemistry. It is indispensable to all those dealing with production, processing and storage of foods and food products. Even those mycologists with an interest in foods will find this book highly informative and immensely useful. The book will prove to be a vital asset to all those R&D institutions, universities and other organizations with interest in foods, feeds and mycology. Students learning the science, technology and engineering of foods/food products should not miss reading this book.

B.K. LONSANE
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Toxicological Evaluation of Certain Food Additives and Contaminants : WHO FOOD ADDITIVE SERIES : 28 WHO, Geneva, 1991.Prepared by the thirty-seventh meeting of the Joint FAO/ WHO Expert Committee on Food Additives (JECFA) 437 pp Price: Sw.fr.35.-

JECFA has been disseminating useful information on the toxicological studies on the safety of food additives, since 1959. Many food additives have been evaluated and Acceptable Daily Intakes (ADI) have been suggested for preservatives, anti-microbials, emulsifiers, food colours, anti-oxidants, maturing agents, anti-caking agents, thickening agents, food flavourings, contaminants etc. The current monograph is the 94th in the series and gives safety data and ADI values on a number of food additives, including anti-oxidants, enzyme preparations, food flavours, non-nutritive sweetening agents, miscellaneous food additives and food contaminants. The anti-oxidant BHT, although it has been given a temporary ADI of 0-0.125 mg/kg body wt, needs further toxicological testing, pending a future detailed report in 1994. Erythorbic acid ADI is "not specified" as it is poorly absorbed and retained in the body. It is less anti-scorbutic than ascorbic acid and it interferes with the latter's uptake only, if present in large amounts. However, in ascorbic acid depleted states, a level of erythorbic intake of 600 mg/capita has no adverse effects.

Of the four alpha-amylases and three chymosin preparations obtained from micro-organisms, some of them genetically modified, the committee feels that since enzymes are used in foods in low

concentrations, their ADI is "not specified". Allyl esters, particularly allyl hexanoate is present naturally in pineapples, but other allyl esters have no counterpart in nature. The committee allocates an ADI of 0-0.05 mg/kg b.w. as allyl alcohol equivalent for allyl heptanoate, allyl hexanoate and allyl isovalerate. For trans anethole, a temporary ADI of 0-0.06 mg/kg b.w. has been extended till 1992 and an ADI of 0-1 mg/kg b.w was established for (+) carvone. However, (–) carvone requires further toxicological data for arriving at an acceptable ADI.

Two non-nutritive sweeteners, acesulfame-K and trichloro galactosucrose (TGS) have both been assigned an ADI of 0-15 mg/kg b.w. Dimethyl dicarbamate (DMDC) is used as a cold sterilisation agent in fruit-based beverages, soft drinks and wines and this has been recommended for such use in accordance with Good Manufacturing Practices upto a maximum level of 25 mg/l. Dioctyl sodium sulfosuccinate (DSS) is used as a detergent in the food and pharmaceutical industry, for cleaning and peeling of fruits and vegetables, and cleaning of packaging. Pending further evaluation in 1995, a temporary ADI of 0-0.25 mg/kg b.w. has been allocated.

Gellan gum is obtained by fermentation using the aerobic G-negative bacterium *Pseudomonas elodea*. Gellan is a trisaccharide repeating unit (2-Glucose-1-Glucuronic acid-1-Rhamnose) and is used as a stabiliser and thickener in foods. The ADI is "not specified" but higher doses have a laxative effect.

Coal-fired or wood-fired roasters or driers and smoked meats and fish tend to build residues of Benzo(a) Pyrene [B(a)P] as a food contaminant. Apart from these, man-related food processes B(a)P and Polycyclic Aromatic Hydro-carbons (PAHs) are also environmental contaminants as products of pyrolysis of organic matter like forest fires, car exhausts etc. It is, therefore, very difficult to arrive at ADI values. The committee, however, recommends processes to minimise B(a)P exposure, washing of fruits and vegetables and trimming surface fat in meats. Use of indirect heating to replace coal and wood, fired roasters, driers and barbecue heaters will minimise this contaminant in foods. Ochratoxin A (OA) is a mycotoxin produced in grains by *Aspergillus ochraceus* as well as by other moulds, notably *Penicillium viridicatum*. OA is a dihydroisocoumarin moiety linked through its carboxyl group by an amide bond to one molecule of L-beta-phenylalanine. ADI values are very hard to establish, as it is extremely difficult to estimate total dietary exposure to OA for the general population. Worst intakes of 1-15 ng/kg b.w./day shows no evidence of neuropathy. Better storage conditions of grain and grain products are recommended with constant monitoring of OA levels.

This monograph, and those that have preceded it, are very useful to government and regulatory officers and those who produce and use food additives. The vast amount of toxicological data collected by the committee in the monograph is phenomenal and will serve as an eye-opener to those involved in toxicological testing of pesticide residues and other compounds.

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Evaluation of Certain Food Additives and Contaminants-789: WHO, Geneva; 1990; pp:48, Price : Sw. fr. 6.

The book entitled "Evaluation of Certain Food Additives and Contaminants" contains a report on the toxicological evaluation of various food additives and contaminants along with their recommended Acceptable Daily Intake (ADI) for humans. Various chapters of the book consist of (1) Principles governing the toxicological evaluation of food additives and contaminants (2) Principles governing the establishment and revision of specifications and (3) Methodology for analysing chemical contaminants in food. Toxicological data on various emulsifiers, enzymes, flavouring agents, food colours, thickening agents etc. are also given in the report. One of the main objectives of the present report is the evaluation of the effects of various food additives and contaminants on human health. Based on those results, recommendation for ADI is prepared.

Monographs containing summaries of relevant data and toxicological evaluation provide valuable information to trade and uniform and comprehensive recommendations to governments. This publication embraces the major observational comments and recommendations on the safety assessment of food additives and contaminants. It reaffirms the validity of recommendations that are still appropriate and points out the problems.associated with those that are no longer valid in the light of modern technical

advances. To attain a better health that will permit all the citizens of the world to lead a socially and economically productive life needs international standards for comprehensive compilation of specification for the identity and purity of food additives.

Prof. INDIA CHAKRAVARTY
ALL INDIA INSTITUTE OF HYGIENE AND PUBLIC HEALTH, CALCUTTA.

Evaluation of Certain Veterinary Drug Residues in Food : Joint FAO/WHO Expert Committee on Food Additives, WHO Technical Report Series, 815, Geneva, 1991; pp 64; Price : Sw Fr. 6.30.

Animal foods have been traditionally consumed by man since pre-historic times and their role for health and well-being needs no emphasis. In order to improve animal production and their productivity, enormous efforts are being made, including the use of drugs like anti-microbials, anti-helminthics, tranquillizers, growth promoters etc., at different stages of production and growth. These, in turn, pose serious threat to consumer through consumption of such contaminated foods. The situation may become more serious because of lack of liaison between livestock production and food hygiene practices in most of the developing countries. It is, therefore, essential that consumers, in general, and public health authorities, in particular, become aware and alert about the possible health hazards of such food contamination. It is in this context that the book "Evaluation of Certain Veterinary Drug Residues in Food" is a timely effort in the right direction.

The book constitutes the 38th Report of the Joint FAO/WHO Expert Committee on Food Additives and contains the collective views of an International group of experts. The specific tasks before the committee were (i) to elaborate principles for evaluating the safety of residues of veterinary drugs in foods for determining acceptable and safe levels for such residues; (ii) to evaluate the residues of certain veterinary drugs and (iii) to discuss the deliberations of the Codex Alimentaries Commission's 5th session of the Codex Committee on Residues of Veterinary Drugs in Foods.

The book gives detailed comments on residues of specific veterinary drugs i.e. β-adrenoceptor-blocking agent (Carazolol), three anti-helminthics (Febantel, fenbendazole, oxfendazole), three anti-microbial agents (spiramycin, sufladimidine, tylosin), and three tranquillizers (azaperone, chlorpromazine, propionylpromazine). Each drug has been dealt at length and the critical evaluation has been given based on the available data including those on toxicology/microbiology, metabolism, residues, analytical methods etc. The committee has given its recommendations on these compounds including Acceptable Daily Intakes and Maximum Residue Limits except for tylosine and tranquillizers, along with the guidelines for further work. The requirements of additional information has been highlighted. Printing, presentation of tables and get up of the book are good.

The book is a valuable asset and a source of information on veterinary drug residues in foods and will be of practical use to food researchers, veterinary professionals and the public health personnel. It will be a valuable addition to any library.

N. SHARMA
I.V.R.I., IZATNAGAR.

Fruit juices, with reference to citrus and tropical fruit juices: A study of the world market. International Trade Centre UNCTAD/GATT, Geneva, 1991, XVI, 282 pages, Price: Supplied free to developing countries (printed in English, French, Spanish).

The fruit juice industry has become one of the world's major agri-businesses. Since 1980, the world trade in fruit juices has increased three-fold and reached 5,000 million dollars in the year 1990. The importance of fruit juice industry for developing countries is emphasized by the fact that these countries account for roughly half of world's exports. Brazil, a developing country, occupies a first place in the export of fruit and vegetable juices. Many other developing countries including India are also exporting fruit juices and pulps, while several others have potential to do so. Research information has shown that world demand is expected to increase greatly in the future and the developing countries are the main beneficiaries.

In response to the many requests from the developing countries and also from FAO and UNIDO, the above mentioned book was published with up-to-date information by the International Trade Centre in 1991. As mentioned in the title, the market study deals particularly with citrus and

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tropical fruit juices. Other fruit juices including those from temperate zones such as apple, pear and berry juice are covered to a limited extent. Also, the study makes only occasional passing references to the vegetable juices. The main purpose of this study is to promote better utilization of developing countries' fruit resources and help them increase and diversify their exports. The information provided is intended to enable developing countries to adapt their production and marketing activities to the requirements of the world market.

The book begins with introduction and general summary which covers background, product description, scope and objectives of the study and market opportunities for developing countries. The book contains 12 chapters. Chapter 1 deals with world market for fruit juices which covers supply and demand, market characteristics (industrial end users, consumer habits and product preferences, packaging, sales promotion and advertising and importers' requirements), competition and prices, distribution channels and market access.

Chapters 2 to 12 present greater details for individual countries (each chapter dealing one country)- Belgium, Luxembourg, France, Germany, Italy, The Netherlands, Sweden, Switzerland, the United Kingdom, Canada, the United States and Japan, on aspects mentioned in Chapter 1 and also on prospects for specific sectors or products and selected addresses of brokers, agents, importers, manufacturers of speciality products, Government offices, Chambers of Commerce, etc. The book also contains appendix giving information on EEC customs duties and regulations. Finally, the book provides a useful bibliography.

This comprehensive book is useful to the Government agencies involved in processed fruit development programmes, specially in their formulation of production and export policies, processors and exporters of fruit juices and pulps, International Organizations and Development Banks, Trade Associations and Organizations conducting training courses and seminars.

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