ANNUAL REPORT

2009-2010

भाकृ अनुप
ICAR

CENTRAL INSTITUTE OF POST HARVEST ENGINEERING & TECHNOLOGY
P.O. PAU, Ludhiana - 141 004 (Punjab), India

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PREFACE

The institute made good progress in research and extension activities during the period 2009-2010. Research and extension activities were accelerated through in-house and externally funded projects. The research projects covered the areas value addition of food grains, oilseeds, spices, fruits and vegetables, storage of fruits and vegetables, environment control of cattle and poultry houses, development of tools and equipments for banana and other crops, non-destructive techniques for quality determination diversified value added products from meat, and micro-encapsulation of micro-organisms. Transfer of technologies was done through licensing of technologies, publication, presentations and training of entrepreneurs and farmers.

The research outputs were blade tenderizer, seed splitter, microencapsulator, CIPHET banana comb cutter, fruit fly trap, cereal-soy tempeh, milk, curd and paneer prepared from peanuts, ready to constitute makhana kheer mix, extruded products from pearl millet, barley and rice and β-carotene rich defatted soy flour fortified biscuit.

The packaging systems for carrot, minimally processed beans, guava, mango and kinnow were standardized. The effects of fruits by-products such as peel and rind were studied on tenderization of goat and chicken meat. Animal feed pellets prepared from unmarketable 10-12 % potato chips, barley and maize were observed to be nutritionally rich as per requirements of BIS. Mixed ber fruit and jamun fruit leather were prepared.

The physicochemical and microbiological quality of nine varieties of fresh & stored mangoes was evaluated for nondestructive study of quality of mango. A common maturity index was formulated for prediction of maturity of mangoes. One hundred and twenty three bacterial and 95 fungal strains were isolated from mango surfaces. The fan-fogger and fan-pad cooling systems installed in the shelters for cows and laying pullets was found to be effective for the production of milk and eggs respectively.

For effective communication of agricultural technologies to the end users the media and scientists interacted on a common platform. News clippings, television and radio programs and documentaries of agricultural technologies were prepared, published, broadcasted. An exhibition on showcasing of technologies of CIPHET, other institutes and SHGs and a media meet to unveil technologies of CIPHET was held.

Taking a unique initiative, an agro processing training program for jail inmates was started by CIPHET for Ludhiana Central jail inmates. The training on production of peanut milk, RTS beverage from guava and processing of tomatoes was given to inmates for creating self employment opportunities after completion of their sentences.Various training programs sponsored by ATMA and other government agencies were conducted for the farmers and officials from different states in the areas of post harvest technologies and establishment of APCs in rural catchments. The AICRPon post harvest technology and application of plastics in agriculture have also developed many useful technologies.

We thankfully acknowledge constant encouragement of Dr. Mangala Rai, Former Secretary DARE and DG (ICAR), Dr. S Ayyappan, Secretary DARE and DG, ICAR,, Sh A.K. Upadhyay, Former Special Secretary DARE and Secretary ICAR and Sh Rajiv Mehrishi, Additional Secretary DARE and Secretary ICAR for the cause of post harvest management and value addition. I acknowledge with thanks the support and cooperation extended by Dr. M. M. Pandey, DDG (Engg), Dr. Pitam Chandra the then ADG(PE), Dr. N. P. S. Sirohi, ADG (Engg), Dr. K. K. Singh, ADG(PE), Dr. S. Ganesan, Principal Scientist (Engg.), ICAR New Delhi. The help rendered by Drs. S. K. Nanda, PC(PHT), P. R. Bhatnagar, PC(APA), R. K. Gupta, S. N. Jha, D.R. Rai, D. Dhingra, Sangeeta Chopra, Sh. Tej Ram, Sh. Manilal, Sh. J. S. Paul, and all scientific, administrative, technical and supporting staff at CIPHET Ludhiana and Abohar in institute activities and preparation of this report is highly appreciated.

R T Patil
Director, CIPHET

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CIVIL WORKS

I. Completed

Sewerage system *(One set completed)*

Pilot Plant Building, CIPHET, Abohar

Renovation of Guest House at CIPHET, Ludhiana

II. Under Progress

Agro-processing cluster building, Ludhiana.

Chilli processing plant, Ludhiana.

Quarters (Type V) 2 Nos. at CIPHET, Ludhiana

Quarter (Type V) 01 No. at CIPHET, Abohar

Quarter (Type IV) 6 Nos. at CIPHET, Ludhiana

III. New works awarded for construction

Renovation of ARIS Cell, internal roads and over head tank at CIPHET, Ludhiana.

Conversion of KVK Building into Guest House at CIPHET, Abohar

STAFF POSITION (AS ON 31.03.2010)

Details of personnel	Sanctioned strength	Posts in position at		Total posts in position
		Ludhiana	Abohar	
Scientific	77*	30	06	36
Administrative	22#	18#	03	21
Technical	30	21	07	28
Supporting	05	03	01	04
Total	134	71	19	90

* including Director

Including Administrative Officer

AICRP on Post Harvest Technology, CIPHET, Ludhiana

Details of Personnel	Sanctioned Posts	Posts in Position
Scientific	3*	2
Technical	4	0
Administrative	2	1
Supporting	1	0
Total No. of posts	10	3

* Including PC (PHT)

AICRP on Application of Plastics in Agriculture, CIPHET, Ludhiana

Details of Personnel	Sanctioned Posts	Posts in Position
Scientific	2	1
Technical	2	2
Administrative	3	1
Supporting	2	0
Total No. of posts	9	4

STATEMENT OF BUDGET ESTIMATES AND EXPENDITURE

PLAN

(Rs. in lakhs)

S.No.	**Head of Account**	**Revised Budget Estimates**	**Expenditure up to 31.03.2010**
1.	Establishment Charges (TS/OTA)	-	-
2.	Travelling Allowance	12.00	11.99
3.	Other charges including equipment	271.65	271.32
4.	Revenue Resources	-	-
5.	Works (Major)	25.00	25.00
	a. Office building	-	-
	b. Residential building	-	-
6.	Information Technology	8.00	7.99
7.	Other items (HRD)	4.00	3.98
	Total	**320.65**	**320.28**

NON - PLAN

(Rs. in lakhs)

S.No.	**Head of Account**	**Revised Budget Estimates**	**Expenditure**
1.	Establishment Charges (TS/OTA)	464.92	462.86
2.	Travelling Allowance	1.47	1.46
3.	Other charges including equipment	41.29	41.28
4.	Revenue Resources	-	-
5.	Works		
	a. Office building	-	-
	b. Residential building	0.20	0.16
6.	Other items (HRD)	-	-
	Total	**507.88**	**505.76**

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RESEARCH ACHIEVEMENTS

AGRICULTURE STRUCTURES AND ENVIRONMENTAL CONTROL

Development of non-destructive systems for evaluation of microbial and physico-chemical quality parameters of mango

S N Jha, K Narsaiah, Pranita Jaisawal, Ramesh Kumar

A simple and common maturity index for all nine varieties based on biochemical properties of mangoes has been formulated in the following form:

$$I_m = n\frac{A \ x \ B}{C}$$

where; *Im*, is maturity index in fraction, A, B, C are biochemical properties such as total soluble solids, titratable acidity, dry matter content and *n* is a varietal factor. Level of maturity of each variety now can be thus computed quantitatively. 1522 NIR spectra of mangoes were acquired and analysed for nondestructive prediction of maturity (Fig.1).

Design and fabrication of a universal sample holder for all sizes and varieties of mangoes was completed. (Fig 2)

Development of shelf life extending compounds from fruits and vegetable by-products for use in meat and meat products

Suresh K Devatkal, and K.Narasaiah

Experiment I: Evaluation of antioxidant effect of kinnow rind powder, pomegranate rind and seed powders in goat meat.

Effect of salt and fruit by-products on colour and oxidative stability of goat meat stored at 4 ± 1 ^{0}C was evaluated. Five treatments used include : Control (meat), MS (meat +2% salt), KRP (meat+2%

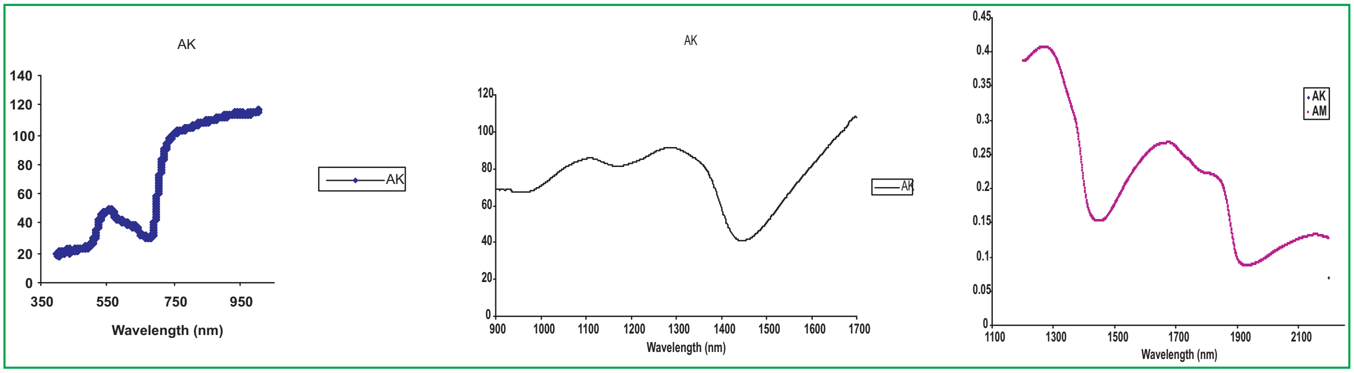


Fig. 1. NIR spectra of mango cultivars between the different wavelength range of 400-1000 nm, 900-1700 nm, 1200-2200 nm

One hundred twenty three bacterial and 95 fungal strains were isolated from the mango surfaces and all the bacterial isolates were biochemically characterized. Among total bacterial isolates common genera were: Bacillus, Lactobacillus, Serratia (responsible for spoilage), Mycobacterium, and E. coli. (possibly toxigenic bacteria) Aeromonas, Pseudomonas, Citrobacter. Besides, three most frequently occurring fungal strains were identified as Aspergilus niger, A. fumigatus, A. flavus responsible for spoilage.

Fig.2. Fibre optic spectrometer in operation for spectra acquisition using developed sample holder

salt+2% kinnow rind powder), PRP (meat + 2% salt + 2% pomegranate rind powder and PSP (meat + 2% salt + 2% pomegranate seed powder). Salt resulted in reduction of colour values ($P<0.05$). Lightness increased in control and remained almost same in others. Redness declined and yellowness showed inconsistent changes. Overall Thiobarbituric Acid Reating Substances (TBARS) values were higher ($P<0.05$) in MS followed by Control. PSP treated sample showed lowest TBARS values than other samples. Percent reduction of TBARS values was highest in PSP (443%) followed by PRP (227%) and KRP (123%). Salt accelerated the TBARS formation and fruit powders counteracted this effect. The overall antioxidant effect was in the order of PSP> PRP > KRP.

Further, an investigation was carried out to evaluate the antioxidant effect of extracts of fruit by-products viz., kinnow rind powder (KRP), pomegranate rind powder (PRP) and pomegranate seed powder (PSP) in goat meat patties. Total phenolics content, 2,2 diphenyl-1-picrylhydrazl (DPPH) radical scavenging activity and effect of these powders on instrumental color, sensory attributes and TBARS values during storage ($4 \pm 1\ ^0$C) of goat meat patties were evaluated. Results showed that extracts of these powders are rich sources of phenolic compounds having free radical scavenging activity. Hunter Lab L value significantly ($P<0.05$) lowered in PRP followed by PSP and KRP patties. Sensory evaluation indicated no significant differences among patties. Further, a significant ($P<0.5$) reduction in TBARS values (lipid oxidation) during storage of goat meat patties was observed in PRP, PSP and KRP as compared to control patties. Average TBARS values (mg/kg) during refrigerated storage ($4 \pm 1\ ^0$C) were significantly lower in PRP, followed by PSP and KRP as compared to control. The overall antioxidant effect was in the order of PRP> PSP > KRP. It was concluded that extracts of above fruits by-product powders have potential to be used as natural antioxidants in meat products.

Experiment II: Evaluation of antioxidant effect of kinnow rind powder, pomegranate rind and seed powders in chicken meat.

Use of extracts of kinnow and pomegranate by-products as source of natural antioxidant in salted chicken meat during refrigerated storage was evaluated. Five treatments viz., Control (meat), MS (meat + 2% salt), KRP (meat + 2% salt + 2% kinnow-rind-powder extract), PRP (meat + 2 % salt + 2% pomegranate-rind-powder extract), and PSP (meat + 2% salt + 2% pomegranate seed powder extract) were investigated. Results showed that salt significantly ($P<0.05$) reduced lightness and yellowness but increased chroma and TBARS values. The average increase in TBARS was significantly ($P<.05$) higher in MS (114%) and Control (108%) but lower in KRP (90%), PRP (81%) and PSP (73%). Lipid oxidation in salted meat during the storage was significantly reduced ($P<0.05$) by KRP (39%), PRP (43%) and PSP (68%). Thus it was observed that addition of 2 % salt accelerated the TBARS formation but inclusion of extracts of pomegranate and kinnow fruit by-products effectively counteracted this effect. The overall antioxidant effect was in the order of PSP>PRP>KRP. Further a significant negative correlation between total phenolic contents and TBARS values was also observed. Therefore, it was concluded that extracts of these fruit by-products have potential to be used as natural antioxidants to minimize the oxidative problems in poultry meat products.

Development of microencapsulator for immobilization of microorganisms and enzymes

K.Narsaiah and H.S. Oberoi

The small alginate microcapsule production can be done in a controllable manner by use of air jets to break the liquid jet. The basic principle is the use of high pressure air stream/stream impinge upon the matrix of fluid jet emerging from inner nozzle and break let them into small droplets in such a way that they fall in the gelling bath. Control of air pressure, air flow rate, flow rate of matrix fluid are critical for

Fig. 3. Microencapsulator

getting uniform size microcapsules. With proper instrumentation such as pressure regulator and controlled flow of matrix fluid with variable flow rate peristaltic pump, the production of microcapsules of desired size can be achieved. The microencapsulator is shown in Fig. 3.

Optimization of microcapsule production

Capsules were produced with the air pressure of 0.2, 0.5 and 1.0 kgf/cm^2 and flow rate of alginate was regulated at 111.5, 232.6, 363.63, 491.8 and 645.16 ml/min. Capsules were produced and hardened. They were classified into categories of different sizes by allowing to settle for different times. 10 g of capsules were taken and suspended in 1 litre water and stirred. This mixture was transferred to 1 litre measuring cylinder and the contents were allowed to settle for 30 sec. The supernatant was decanted and the residue was filtered with coarse filter paper. The supernatant was again made up to volume of 1 litre and again stirred. This mixture was transferred to 1 litre measuring cylinder and the contents were allowed to settle for 1 min. These steps were repeated for 2 min and 3 min. The weights of each fraction were noted. At pressure 0.2 kg/cm^2, almost 50% of the capsules had sizes 1.28, 1.10, 1.06, 0.94, 0.91 mm and 1.8, 1.6, 1.5, 1.3, 1.1 mm for 1mm and 2 mm size of the air nozzle at 111.5, 232.6, 363.63, 491.8 and 645.16 ml/min respectively. Similar results were observed at higher pressures 0.5 and 1.0 kg/cm^2.

The results indicated that as the flow rate increases at a fixed pressure, the size of capsule decreases (Fig. 4). The comparison of three charts reveals that with increase in air pressure at fixed flow rate, the size of capsule decreases. In both cases, the impact of the jets increases which results in droplets of smaller size.

Encapsulation of ascorbic acid:

For increasing the retention of small molecules such as vitamins and for controlled release, starch is generally added to alginate. It also increases mechanical strength of capsule. Results showed that with 2% alginate on increasing the starch content, the efficiency also increased, but by 3% alginate the increase of starch content (i.e., 0.5 to 1) no further increase in efficiency was observed. 3% alginate and 3% starch was the optimum concentration of polymer for maximum encapsulation efficiency.

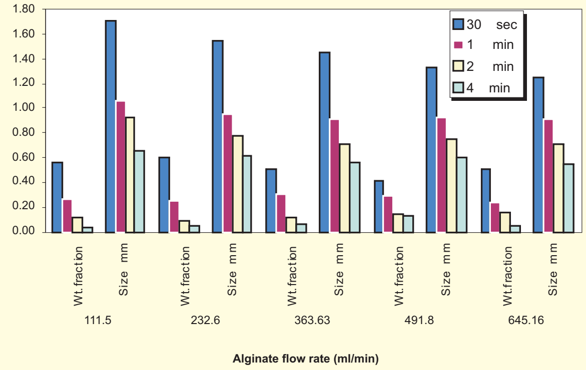
Ascorbic acid release characteristics:

Capsules made with different concentrations tested for their slow release of ascorbic acid with time. The ascorbic acid content in the capsules decreased slowly with time. It was noted that at a particular concentration of starch, there was a decrease in the release of ascorbic acid (Table 1).

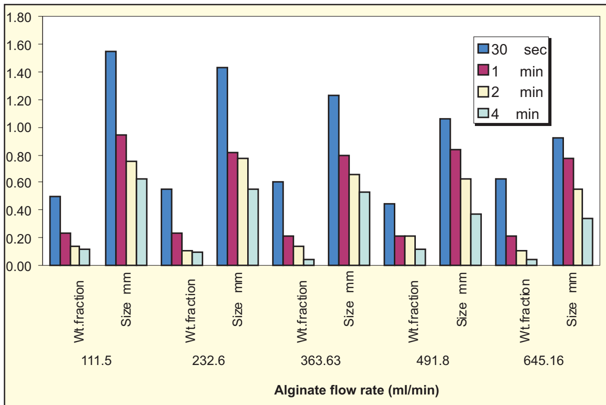
Encapsulation of enzymes (Urease)

Urease was encapsulated in alginate and assay of soluble urease and immobilized urease was done. The encapsulation efficiency was found to be 31.39% (Table 2).

The activity of urease immobilized in microcapsules showed almost no loss in activity for 15 days and slow decrease of activity thereafter (Fig 5) .



Figue 2.5 Variation in size and weight fraction (0.2 kg/cm2 g)



Figue 2.6 Variation in size and weight fraction (0.5 kg/cm2 g)

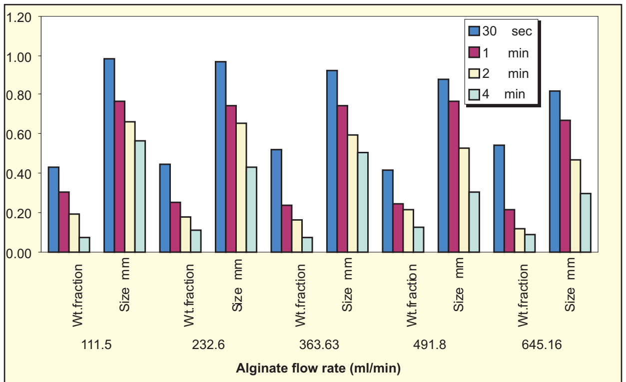


Figure 2.7 Variation in size and weight fraction (1.0 kg/cm^{2}g)

Fig. 4. Variation in size and weight fraction of capsles

The efficiency of yeast encapsulated bead was found to be 95% (Table 3). The results showed that almost all cells are retained after encapsulation. The reason for this is that yeast cells are bigger in the size than the ascorbic acid molecules. The fermentation performance of both immobilized and free yeast were of same magnitude (Table 4).

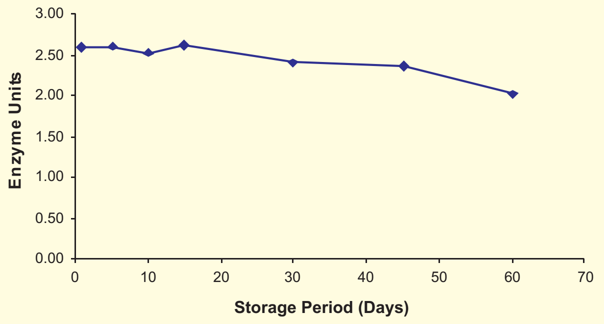


Fig. 5. Storage stability of immobilised urease

Herbal extracts were encapsulated using the microencapsulator developed (Table 5). The capsule were dried and used in hot beverages for sweetening and flavouring.

Development of microorganisms based ripening/anti-ripening agent for mango and banana

Pranita Jaiswal and S.N. Jha

Fresh banana hands were collected from banana orchard in Punjab Agriculture University, Ludhiana, for isolation and enumeration of microflora from banana surface. Ten bacterial and eight molds isolates were purified from banana surface. Near Infrared (NIR) spectra of these collected samples were also acquired with simultaneous analyses of physicochemical parameters (e.g total soluble solids (TSS), titratable acidity, dry matter content, total sugar, reducing sugar, colour) and texture properties. Besides microflora have also been isolated from spoiled fruits/vegetables (e.g potato, carrot, cauliflower).

Optimization of parameters for utilization of paddy straw, kinnow pulp and pea pods for production of cellulases, ethanol and feed supplements

H S Oberoi, VK Bhargav and Pranita Jaiswal

Aspergillus strain producing β-glucosidase in the range of 70-80 IU/ml from a mixture of rice straw and wheat bran was isolated from decaying organic matter. *Saccharomyces cerevisiae* strain has been developed through regular recycling on a galactose medium. It produced about 30% more ethanol from

Table 1: Release of ascorbic acid with different interval of time

Alginate concentration (%)	Starch concentration (%)	Ascorbic acid content in the sample beads. (mg)			
		0 h	After 24 h	After 48 h	After 72 h
3	1	0.3724	0.2979	0.2612	0.2304
3	1.5	0.3773	0.3301	0.2829	0.25
3	2	0.374	0.335	0.2984	0.2688

Table 2: Encapsulation efficiency of enzyme

Soluble urease activity (enzyme units)	Immobilized urease activity (enzyme units)	Encapsulation efficiency (%)
7.90	2.48	31.39

Encapsulation of yeast (*Saccharomyces cerevisiae)*

Table 3: Encapsulation efficiency of yeast

Concentration of alginate solution	No: of cells encapsulated	No: of cells obtained after encapsulation	Efficiency
3%	2 X 10^7	1.9 X 10^7	95%

Table 4: Comparison of fermentation free vs. immobilized yeast

Serial No.	Time hours	Alcohol Produced (%) (Immobilized yeast)	Alcohol Produced (%) (Free yeast)
1	6	0	0.05208
2	18	0.05540	0.07292
3	24	0.21875	0.29514
4	36	0.47917	0.55208
5	48	0.680556	0.70833

Table 5: Encapsulation of Herbal extracts (Pressure 0.2 kg/cm^{2}g, Alginate flow rate 24 ml/min

Serial No.	Herbal extract : Sodium alginate	Avg. size of capsules (mm)
1	ginger extract (1:2)	1.67
2	tulsi extract (1:2)	1.52
3	Stevia extract (1:2)	1.63
4	ginger extract (1:3)	2.80
5	tulsi extract (1:3)	2.26
6	Stevia extract (1:3)	2.50

kinnow waste through (Statistical optimization of simultaneous saccharification and fermentation) SSF, compared to the conventional *S. cerevisiae* strain.

SSF process using cellulase at 5FPU/g, pectinase at 60 IU/g, galactose adapted *S. cerevisiae* cells and temperature of 37 ºC resulted in ethanol concentration and volumetric productivity of 43g/l and 2.86g/l/h, respectively, from kinnow waste which showed potential for up scaling.

Adaptation of *Candida tropicalis* to rice straw hydrolysate obtained with dilute acid pre-treatment helped in enhanced ethanol production from rice straw. The adapted strain produced 20.32 g/l ethanol using SSF process.

Enzymatic hydrolysis of 1% alkali treated rice straw with 20 FPU/g cellulase, 45 IU/g β-glucosidase and 15 IU/g pectinase resulted in overall saccharification efficiency of 87% with conversion efficiency of glucan to glucose as 92%.

Ethanol concentration of 26 g/l was obtained in 36 h from fermentation of hydrolysate obtained with the use of cellulolytic enzymes from alkali pre-treated rice straw.

Novel biotechnological processes for production of high value products from rice straw and bagasse

H S Oberoi, VK Bhargav, K Narsaiah and RT Patil

Cellulose, hemicellulose and lignin content of three different rice varieties varied between 38.93-41.88%, 25.38-26.8% and 12.1-14.5%, respectively. Ash content in the three varieties varied between 13.69-15.76%. Pretreatment of rice straw using 1% alkali with sterilization hydro-thermal treatment resulted in appreciable delignification (50%).

Hydrolysis of alkali treated rice straw using cellulase at 18 FPU/g-ds, β- glucosidase at 40 IU/g-ds and pectinase at 15 IU/g-ds with 10% substrate concentration, resulted in 90% hydrolysis in 24 h. Hydrolysis of oxalic acid treated rice straw using cellulase at 25 FPU/g-ds, β- glucosidase at 45 IU/g-ds and pectinase at 15 IU/g-ds with 10% substrate concentration, resulted in about 75% hydrolysis in 24 h. Significant difference in the glucose and reducing sugar yield was observed when wet and dried pretreated rice straw was used for hydrolysis.

Development of technologies for pelletization, delignification and saccharification of cellulosic biomass such as rice straw, cotton stalk, sweet sorghum, switchgrass, *Prosopis julifera* and *Lantana camara* (DBT project)

H S Oberoi, VK Bhargav, K Narsaiah and RT Patil

Alkali pre-treatment of cotton stalks with 1 % alkali at 121 ºC for 30 min, after pre-conditioning for 1-h at 40 ºC resulted in 40 % delignification. Enzymatic hydrolysis of alkali pre-treated cotton stalks resulted in overall hydrolysis efficiency of 50 % at 10 % substrate loading.

Pre-treatment of switchgrass with ozone at 0.25 lpm and 45 mg/l, flow rate and concentration, respectively, resulted in about 55% delignification. Hydrolysis of ozone pre-treated switchgrass using cellulase and β-glucosidase at 15 FPU and 60 IU/ g-ds, respectively, resulted in 55 % hydrolysis in terms of glucan conversion to glucose. Increasing flow rate of ozone did not improve the hydrolysis efficiency, although lignin reduction was about 59%.

Optimization of fermentation parameters for bioethanol production using whey and vegetable wastes using different microbial strains in a batch type fermenter

H S Oberoi, VK Bhargav and D Dhingra

The process using whey (15% reducing sugars, w/v) with 15% cauliflower waste and 15% pea pods, separately in a 30 l batch fermenter, resulted in an ethanol concentration of 6.95 and 7.78% (v/v), respectively. Process using a mixture of whey and pea pods also showed a higher ethanol volumetric productivity which is important for commercial adoption of the process.

Production of amylases, proteases and pectinases using agricultural and horticultural residues as supplements

H S Oberoi, K Narsaiah and D Dhingra

Pretreatment of rapeseed mustard oilseeds with crude filtrate extract obtained from mixed-culture solid state fermentation of kinnow waste and wheat bran using mixed cultures of *Trichoderma reesei* RC-30 and *Aspergillus niger* BSC, helped in enhancing the oil recovery by 11%, when compared with control where no enzymatic pretreatment was given (Table 6). There was either an improvement or no change in quality attributes for oil extracted through enzymatic pretreatment (Table 7).

Table 6: Effect of enzymatic pretreatment on oil recovery from mustard seeds

Treatment	Oil recovery (%)
Control	$30.72^{c} \pm 0.87$
Crude extract of *A. niger*	$32.96^{b} \pm 0.55$
Crude extract of *T. reesei*	$33.87^{a} \pm 0.49$
Mixed extracts of *A. niger* + *T. reesei*	$34.32^{a} \pm 0.98$
ANOVA (P< 0.05)	0.002
LSD (0.05)	0.84

Values represented are mean ± SD, n= 3.
Means with the same superscript are
not significantly different

Table 7: Effect of enzymatic pretreatment on quality attributes of rapeseed mustard oil

Treatment	Saponification value	TBA value	Iodine value	Acid value
Control	$173.68\ ^{a} \pm 2.08$	$0.98^{a} \pm 0.00$	$103.66\ ^{b} \pm 2.31$	$1.10\ ^{a} \pm 0.01$
Crude extract of *A. niger*	$171.66\ ^{a} \pm 1.52$	$0.90^{b} \pm 0.00$	$124.33^{a} \pm 2.51$	$1.05^{b} \pm 0.00$
Crude extract of *T. reesei*	$169.66\ ^{a} \pm 1.52$	$0.89^{b} \pm 0.00$	$123.66^{a} \pm 3.05$	$1.03^{b,c} \pm 0.00$
Mixed extracts of *A. niger* + *T. reesei*	$163.55^{b} \pm 5.50$	$0.88^{c} \pm 0.00$	$125.66^{a} \pm 2.08$	$1.01^{c} \pm 0.03$
ANOVA, ($P< 0.05$)	0.022	< 0.0001	< 0.0001	0.002
Turkey LSD (0.05)	5.90	0.01	4.831	0.03

Control: Oil extracted without any enzymatic pretreatment
Values represented are mean $\pm$ SD, n= 3. Means with the same superscript are not significantly different.

Post harvest management and value addition of coriander

V K Bhargav and R K Vishwarkarma

The seed of coriander (Coriandrum sativum L.) is required to be splitted into two halves before sowing for good seed germination. It is spilted manually and lot of drudgery is involved in this labour intensive operation beside post harvest losses in terms of seed damage. The mechanized operation will reduce the drudgery and the post harvest losses.

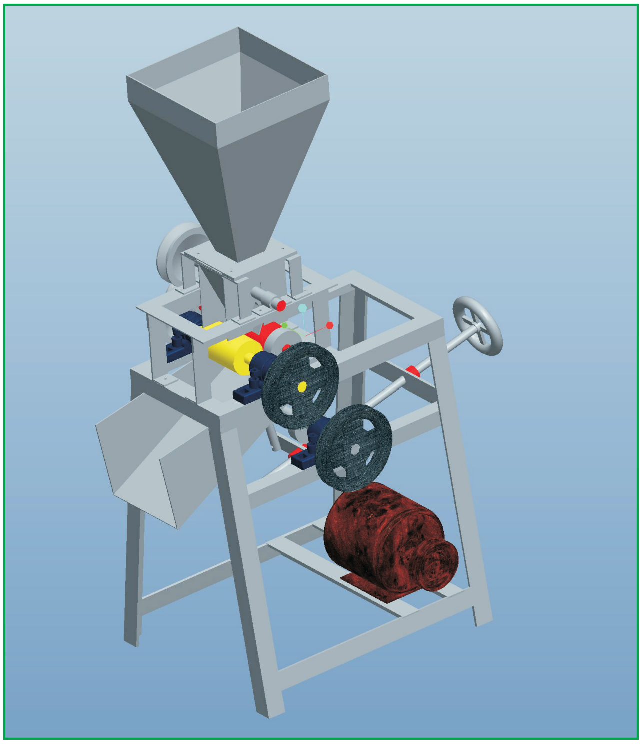


Fig. 6. Machine designed to split coriander seed

A power operated seed splitter of 20kg/h capacity was developed for this purpose. The machine is equipped with two rollers of 6.5 cm dia and 10cm long. The differential speed is provided to two rollers so that coriander would break in two halves. The gear type metering device was provided in the splitter. The machine (Fig. 6) was able to split the coriander at moisture content up 14.2%.

Tenderization of goat meat using pomegranate rind and seed powder, blade tenderizer and papain

K.Narsaiah , S.N. Jha , S.K. Devatkal, D.B. Singh and J. Sahoo

Tenderization with pomegranate seed powder:

Marination with (PSP) significantly ($P<0.05$) decreased cooking yield but no significant difference was noticed between different treatments of PSP. Similarly pH also significantly ($P<0.05$) decreased in treated samples as compared to control. Shear force value was significantly ($P<0.05$) lower in 4 % PSP treated sample followed by 2%, 6% and control (Fig. 7). Overall, PSP reduced the shear force values and improved tenderness of goat meat as compared to control. Sensory evaluation results indicated significantly higher ($P<0.05$) colour values in control and there was no significant difference between other treatments. Tenderness scores were significantly higher for PSP samples than control. In raw samples, lightness 'L' values were significantly ($P<0.05$) lower in 6% PSP sample and no significant

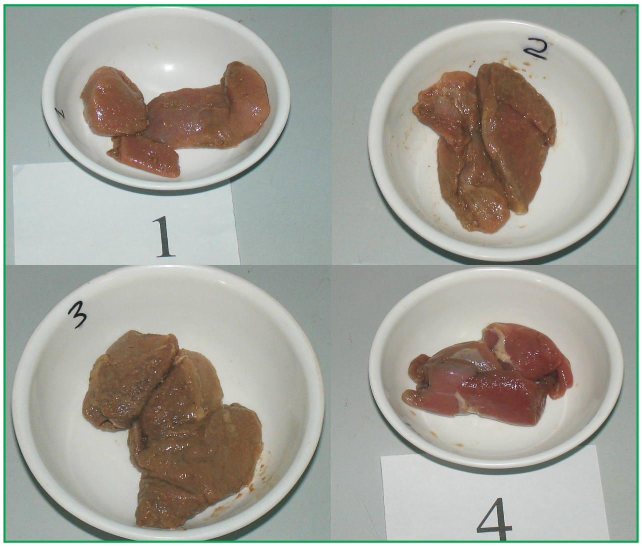


Fig. 7. Effect of treatment with pomegranate seed powder

difference was noticed for 2% and 4% PSP samples as compared to control. Increase in level of PSP significantly (P<0.05) increased redness 'a' values and yellowness 'b' values. In cooked samples L values were significantly (P<0.05) higher in control, and significantly lower in 4% PSP sample. Based on colour and texture properties 4% PSP was considered as the optimum level for tenderization.

Tenderization with pomegranate rind powder (PRP)

Marination with PRP caused a minor decrease in cooking yield. Treatment with PRP reduced pH significantly (P<0.05) as compared to control. Treatment with 2, 4 and 6% PRP significantly (P<0.05) reduced the shear force indicating improved tenderness of goat meat. Overall, PRP reduced the shear force values and improved tenderness of goat meat as compared to control. Results of instrumental colour evaluation of PRP marinated meat chunks revealed, decreased L (lightness) value, increased a (redness) value and b (yellow) value of goat meat chunks. Use of pomegranate rind powder darkened the colour. Since PRP is deep dark brown in colour, the same colour properties are reflected in the raw goat meat chunks. There was adverse effect on taste of treated meat; other sensory properties, flavor, juiciness and overall acceptability were not so significant. Due to the darkening of colour and strong bitter taste, PRP was not recommended for tenderization.

Tenderization with knurled rollers

Cooking yield of roller treated sample decreased with increasing passes. Control sample was having highest cooking yield followed by 8, 12 and 16 passes. Lower cooking yield resulted due to rupture of cellular structure and release of moisture. Roller treatment did not have any effect on pH of different samples. Passing the meat through rollers improved the tenderness of goat meat chunks. It was observed that treatment with 12 and16 passes gave lowest shear force value as compared to control and 8 pass treated sample. Mechanical breakdown of connective tissue and muscle fibres might be the reason for decreased shear force value. Flavour and juiciness had been found to be significant for 12 pass treatments with knurled rollers. Sensory scores indicated higher score in 8 pass treated samples as compared to others with higher tenderness. Higher no of passes did not show any further impact in tenderness as compared to 8 pass and thus 8 pass had been found to be optimum for goat meat tenderization.

Tenderization with blade tenderizer:

A blade tenderizer (Fig. 8) was developed with surgical blades welded to tenderizer. The surgical blades were fixed to these holders and the number of blades were adjusted depending on the size of animal or muscle. Incising the goat meat with a blade tenderizer significantly decreased the cooking yield as compared to control. Loss of water content during

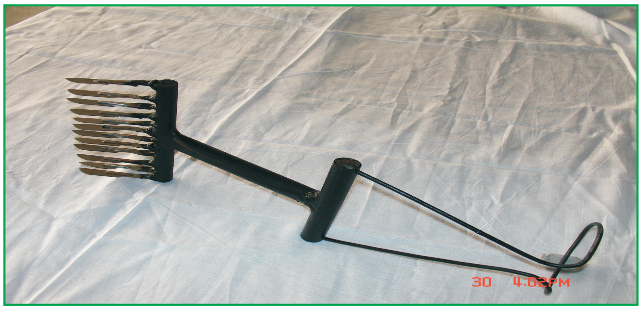


Fig. 8. Blade Tenderiser

incision and due to rupture of muscles during cooking might have caused the decreased yield. Blade incision caused no significant change in pH. Sensory scores improved slightly due to incision treatment. Overall results of shear force value and sensory score indicated that blade tenderization may be useful for tenderization of goat meat.

Effect of different treatments on tenderization of meat

Yield was significantly higher in control followed by PSP, blade incision and significantly ($P<0.05$) lower in papain treated meat sample. The pH was significantly lower in 4% PSP treated meat than others. Shear force value was significantly ($P<0.05$) lower in papain followed by PSP and blade incision than control sample. All the treatments improved the tenderness of goat meat as there was reduction in shear force values. Sensory evaluation results indicated significantly lower ($P<0.05$) colour values in PSP and higher flavour scores in papain (Fig. 9). Tenderness scores were significantly higher in papain followed by PSP and blade incised sample than control.

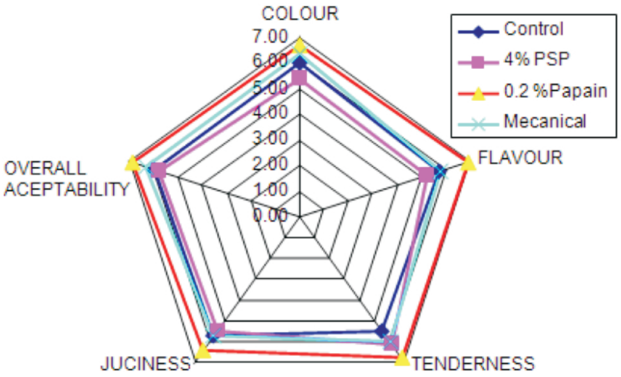


Fig. 9. Effect of combined treatment on sensory characteristics

The experiment showed that the cooked samples treated with papain and blade incisions scored better sensory scores and required lesser shear force compared to 4% PSP and control. Overall results of shear force value, texture and sensory score indicated that blade tenderization may be useful for tenderization of goat meat.

Value chain on potato and potato products

D Dhingra

Animal feed pellets were prepared from unmarketable potato chips (10-22%) barley and maize. The proximate composition of unmarketable potato chips, barley and maize was analysed and is presented in Table 8.

Table 8 Proximate composition (%) of unmarketable potato chips, barley and maize.

Component	Barley	Maize	Potato chips
Moisture	14.1	12.2	4.64
Ash	2.79	1.48	3.95
Crude protein	14.36	10.02	9.82
Crude fat	3.96	5.71	32.73
Crude fiber	4.75	2.96	4.72
Carbohydrate	60.04	67.08	44

The proximate composition of the animal feed pellets (Fig. 10) prepared from barley, maize and potato chips was analysed and is presented in Table 9. It was observed that the moisture content of the pellets was slightly higher than the prescribed limits by Bureau of Indian Standards (11%). Thus pellets will require drying before packaging. The nutritional requirements however were as per BIS. The tensile

Fig. 10. Unmarketable potato chips utilized in Animal feed pellets

strength (which is an indication of the mechanical strength of the pellets under compression) was measured using Texture Analyser. The results of mechanical strength of feed pellets are presented in Table 10. The animal feed pellets containing potato chips > 15% can withstand mechancial stress during transportation.

Table 9 Proximate composition of the animal feed pellets prepared from barley, maize and potato chips

Samples	Moisture	Ash	Crude protein	Crude fat	Crude fiber	Carbohydrates
1	11.51	2.53	12.11	10.63	4.03	59.19
2	12	2.58	12.79	9.21	5.35	58.07
3	11.6	2.3	11.67	9.7	3.79	60.94
4	13.04	2.72	12.41	8.71	5.64	57.48
5	11.96	2.29	12	8.53	3.85	61.37
6	12.4	2.39	12.67	7.75	4.03	60.76
7	11.15	2.72	11.75	11.37	3.94	59.07
8	11.7	2.55	13.06	10.03	4.09	58.57
9	12.67	2.46	12.67	8.42	4.07	59.71
10	12.2	2.32	12.13	8	3.85	61.5
11	11.36	2.64	12.34	11.11	4.15	58.4
12	11.61	2.42	11.92	10.53	3.63	59.89
13	11.8	2.44	12.23	9.46	3.94	60.13
14	11.8	2.44	12.23	9.46	3.94	60.13
15	11.8	2.44	12.23	9.46	3.94	60.13

Fig. 11. Potato peel and the extracted dietary fiber

The process for the extraction of dietary fiber (Fig. 11) from potato peel was developed which involved treatment of peel with acid, enzyme and hydrogen peroxide. The process is outlined in flow-chart (Fig. 12).

Table 10 Mechanical strength of animal feed pellets

S.No	Levels of potato chips in %	Tensile stress (s) in MPa
1	20	1.31
2	15.78	1.16
3	15.78	1.23
4	13.04	1.09
5	12.50	1.01
6	10	1.05
7	22.22	1.44
8	18.18	1.12
9	12.50	1.05
10	10	0.99
11	22.22	1.47
12	18.18	1.13
13	15.78	1.36
14	15.78	1.36
15	15.78	1.36

10 g of sample (potato peel)
↓
Bleaching with H_2O_2 for 30 min at 60°C
↓
Acid treatment with boiling 0.255N H_2SO_4 for 30 min (Wt. 6.534g)
↓
Cool and filter, wash till it becomes acid free
↓
Protease enzyme treatment in phosphate buffer (pH 7.5 ± 0.2)
↓
Incubate for 30 min at 60°C
↓
Cool and filter
↓
Successive washing with appropriate amounts
of 78% ethyl alcohol, 95% ethyl alcohol and acetone
↓
Dry residue overnight in 70°C vacuum oven or 105°C air oven
↓
Cool in desiccator and weigh to nearest 0.1mg (5.734g)
↓
Potato Peel dietary fiber with TDF of 55.27%

Fig. 12. Flow-chart for extraction of dietary fiber from potato peel

Development of cooling systems for comfort and enhanced production of dairy cow

S Chopra, S. N. Jha, M. L. Mehra and P Malhotra

The effect of different cooling systems during hot dry season on thermal comfort and production performance of cows was studied. Two cooling systems i.e. fan-pad and fan-fogger systems were installed in the shelters. The cows were kept in loose housing system and the size of each shelter was 50 x 6 x 4.6 m with an open arena on one side and a feeding line on the other side. The fan-fogger system consisted of air circulator fans of size 36” mounted on the side walls of the shelters. These fans provided airflow of around 700 $m^3 min^{-1}$ and were tilted downward at an angle of 20-30 °. The fogger nozzles (0.5 mm size, 45 psi, 50 ° spray angle) were mounted on a copper ring and placed in front of the fan. A high pressure pipe connected the fogging ring to the water tank through a pump, through which the filtered water was pumped into the foggers. The on / off timings of the foggers was controlled by a timer. When switched on, the fogger created a fine mist which cooled the shelter by evaporation. During off time of the fogger, the fan was in running condition. The cycle of on time of 120 s and 60 s off time was repeated. The entrances to the shelter were covered by tarpaulins to preserve the microclimate in the shelter.

Table 11: Temperature and humidity conditions in shelters with cooling systems

	Shelter with fanpad system		Shelter with fan-fogger system		Shelter with fan (Control)	
	Temperature ©	Relative Humidity (%)	Temperature ©	Relative Humidity (%)	Temperature ©	Relative Humidity (%)
May	31	66	34	58	38	45
June	30	75	35	64	39	46
July	30	65	31	60	36	52

The fan-pad cooling system was fitted to another cattle shelter. Two coolers containing 36” / 700 rpm exhaust fans and cellulose pads were fitted to the side walls of the shelters. The pads made of cellulose paper were housed in a G.I casing with a water distributor through a P.V.C header. The intricately woven cellulose pads provided necessary water to air contact to achieve high efficiency in cooling. The feeding side and the entrance side were covered with net and tarpaulin respectively to prevent solar radiation input and the cold air from escaping the shelter. The shelter (control) consisted of only a fan system mounted on the wall.

Temperature and Humidity conditions in the shelters

The temperature and humidity conditions in the shelters were monitored through May – July and are presented in Table 11.

Effect on Productivity

The milk production of cows kept in the control shelter reduced by 35.8 % (Fig. 13) during the experimental period of 2 months due to heat stress. In the fan-pad and fan-fogger systems the milk

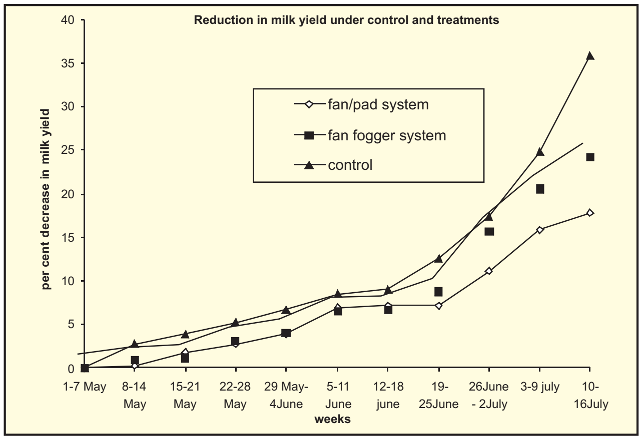


Fig. 13. Effect on milk productivity of the cooling systems

production reduced by 17.8 and 24.3 % respectively, as the animals were under lesser heat stress. The fan-pad and fan-fogger cooling systems lowered the temperature by 7-8 and 4 °C and increased the RH by 40 and 20 % in the shelters respectively as compared to the control. Among the three systems, fan-pad system was most effective for cows' comfort and for better production. There was least decline in milk production due to heat stress in fan-pad cooling system due to favorable micro climate created by it. This system was followed by fan fogger system.

Effect of cooling systems on thermal comfort and production of poultry birds

S Chopra, O.D. Wanjari, S.S Nagra, D.R. Rai and D Kaur

The effect of different cooling systems during hot dry season on thermal comfort and production performance of laying pullets was studied. Two cooling systems i.e. fan - pad and fan - fogger were used in layers kept in cages as well as under deep litter system (DLS). The poultry shelter was segregated into six experimental units, three for the cage system and three for the DLS. The fan -fogger system consisted of a blower with a copper ring placed in front of it. Fine foggers were placed on the ring, which was connected with a water tank through a high pressure pipe. The filtered water was pumped into the foggers. The foggers's on / off- timings were controlled through a timer. While switched on, the fogger created a fine mist which cooled the shelter. During off -time of the fogger, the fan was in running condition. 30 sec. on and 60 sec off cycle was repeated.

The fan - pad system consisted of cellulose pads placed at one end of the shelter and the exhaust fan fitted at the opposite end. The water was pumped to the pads to keep them wet. The crossing air in this system cooled the shelter. The cooling systems lowered the temperature by 6-7 °C and increased the RH by 20% than that in the control shelters (Fig. 14).

The egg production increased by 16 and 12 % during the experimental period of 2 months in the fan-pad and fan-fogger system, respectively, under DLS and by 17 and 20 % in cage system, respectively (Fig. 15). Both fan-pad and fan-fogger systems were effective for bird's comfort and for better production.

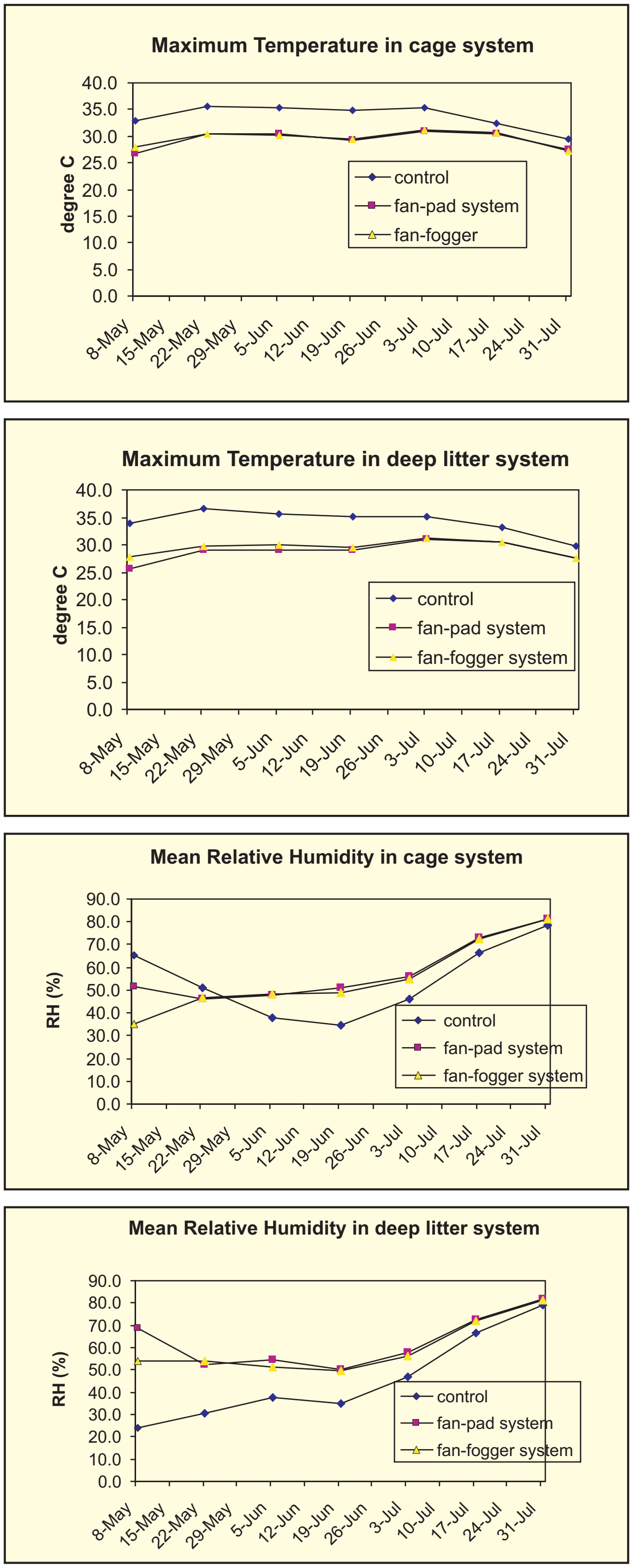


Fig. 14. Maximum temperature and mean relative humidity in the cooled and control shelters

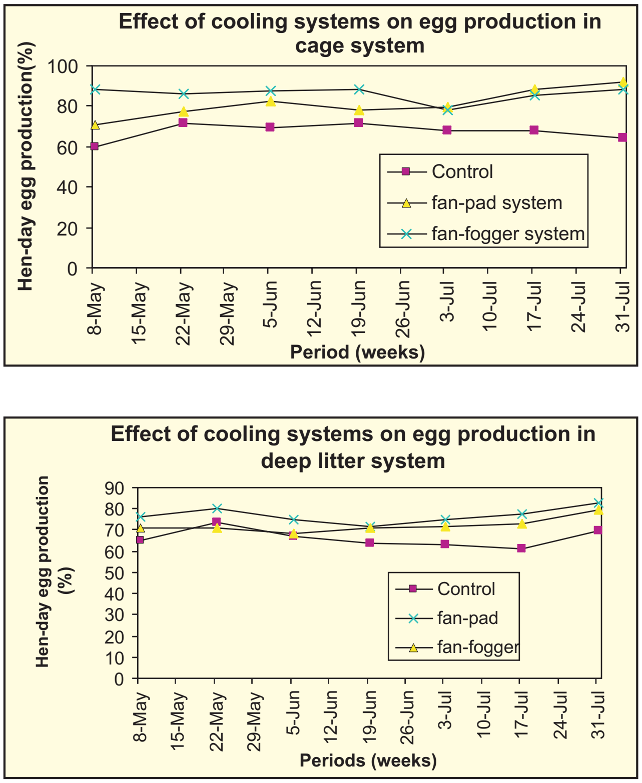


Fig. 15. Effect of cooling systems on egg production

Development of post-harvest processes and machinery for *makhana* processing & value addition

S. N. Jha and B. K. Jha

Ready to constitute *makhana kheer* mix was developed by incorporating different constituents with major parts of *makhana* (25 – 40 %) and other essential ingredients. Proportions of different compositions were standardized using sensory score at 7-8 on 9 point Hedonic scale. Proximate analysis of the developed mix was carried out and is presented in Table 12. Storability of the product (Fig. 16) in refrigerator and at room temperature in polyethylene bags was studied and shelf life was found to be about 4 months at % moisture content. As moisture content reduced reconstitution time of mix to become kheer increased.

Fig. 16. Ready to constitute *makhana kheer* mix in different packets

Table 12. Nutritional Composition of Ready to constitute makhana kheer mix

Constituents g/100 g	
Protein (g)	11.59
Fat (g)	7.64
Carbohydrate (g)	64.74
Calcium (g)	0.1626
Sodium (g)	0.1325
Potassium (g)	0.1111
Magnesium (g)	0.0321
Iron (g)	0.0065
Cholesterol (g)	0.02
Saturated fatty acid (g)	4.36
PUFA (g)	0.16
MUFA (g)	1.68
Trans fatty acid (g)	0.24

Performance of *makhana* popping machine

The following fabrication defects in *makhana* seeds roasting and popping machine (Fig. 17) were rectified by the local fabricator at Darbhanga:

(i) The clearance between screw edge and barrel of roaster was made uniform in order to avoid choking during heating.

(ii) Two outlet spouts as per drawing were rectified and roaster was provided with one spout going directly to popping unit and another perpendicular to barrel with a liver mechanism for deflecting the roasted seeds during conditioning.

Fig. 17. Developed makhana popping machine in exhibition

(iii) The direction of burner knobs changed towards operator side.

(iv) Possibility was explored for placing impeller in the centre of striking surface (Casing) of popping unit to make the alignment proper.

(v) Possibilities were explored in order to make the gap uniform between the impeller edge and striking surface (casing) of popping unit. Another casing of uniform size was placed.

After above rectifications series of runs to check the performance of machine were performed by RCM Darbhanga and with the help of farmers and local processors. The optimum level of moisture content and temperature of roasted *makhana* seeds was achieved by using grad uniform size seeds in a single batch. The conditioned dry nuts having moisture content of 20-25 % were roasted to get moisture content of 17-18 %. These seeds were tempered for about 30-48 h. The desired moisture ranged from 8.1 to 9.6 %. The barrel temperature was recorded in the range of 200-250 °C. The *makhana* seeds roasting and popping machine was tested at single designed speed for its performance. The popping and decortication efficiencies of machine were found to be up to 45 and 66 % respectively.

Application of modified atmosphere packaging and storage to fresh vegetables

D R Rai and S.N. Jha

Shelf-life extension of carrot through Modified atmosphere packaging (MAP)

Carrots *(Dancus Carota)* are particularly rich in carotene (pro-vitamin A). The carrots were gladed, sorted and cleaned with water. The carrots were then immersed in water containing 0.5% citric acid for 1 min to prevent growth of micro-organisms and again rinsed with plain water for 1 min. Carrots were packed in poly-propylene (PP) film packages (Fig. 18). The packed samples were taken out on 3rd, 6th, 9th and 17th day of storage for quality analysis.

Fig. 18. Carrots under modified atmosphere packaging

Headspace O_2 and CO_2 concentrations

As the storage progressed under 15° C, the headspace atmosphere continued to vary till its equilibration, on third day. In the perforated samples (2, 4, 6, perforations), O_2 level remained in the limit of 8-16%. The level of CO_2 remained within 5 -16%

for perforated samples. In non perforated samples oxygen level decreased at a faster rate and CO_2 levels had increasing pattern.

These gas conditions had different effects on physico-chemical constituents of stored carrot. The equilibrated levels of headspace O_2 and CO_2 under all the different packaging treatments at the storage temperatures were found to be statistically significant at 95% confidence level with $p\text{-values} < 0.05$ which indicated that variability in the quantum of package body perforations was largely responsible for variable diffusion across the film packages.

No significant loss in weight during the entire storage period was observed for perforated (2, 4 and 6 perforations) as well as for the non-perforated film packages, at the storage temperature of 15 ºC at 95 % confidence level However, at 15ºC, the higher weight loss was observed in the control samples and they lost about 11% of their initial weight at the end of storage mainly due to the influence of normal in-pack

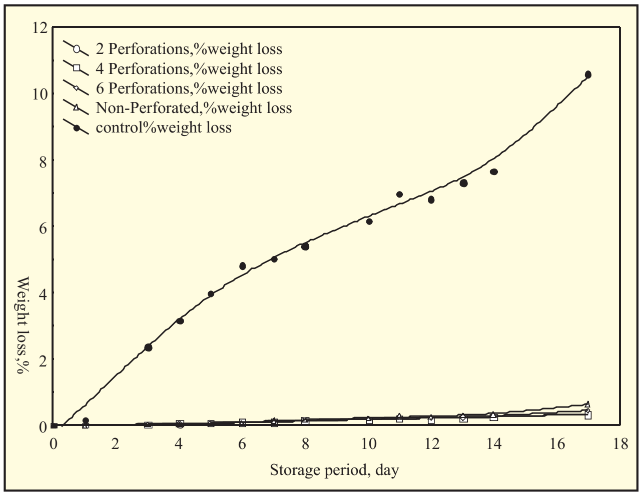


Fig. 19

Pigments

Chlorophyll is associated with retention of bright green surface colour of many fresh and fresh-cut vegetables. However, it degrades at a faster rate due to the vagaries of post-harvest handling, storage and transport. MAP resulted in a substantial increase in chlorophyll content of carrot. In perforated samples chlorophyll increased till 3rd day of storage due to re-greening of the produce in the storage except control. The chlorophyll levels increased for all the perforated film packages and were observed to be statistically significant at 95% confidence level with $p\text{-values} < 0.05$. The slightly higher increase of chlorophyll in perforated packages with 2 perforations indicated that chlorophyll retention largely depended upon the transient and steady state headspace O_2 and CO_2 concentrations.

However, for non-perforated packages, the increase in the chlorophyll content was observed to be smaller which was attributed to the presence of high headspace CO_2 and the associated anaerobic O_2 concentrations. Results indicated that in spite of anaerobic O_2 levels, high CO_2 concentrations alone played a predominant role in increase of chlorophyll, but the anaerobic levels of O_2 are undesirable as they lead to development of off-flavours inside the package. For control samples, after initial increase there was decrease in chlorophyll content.

Lycopene

Lycopene is associated with retention of bright red surface colour of many fresh and fresh cut fruits and vegetables. In non- perforated samples, lycopene was highest on 9th day and then a decrease was recorded till the end of storage period. In perforated samples, the decrease in lycopene was observed till 14th day of storage and then slight increase was recorded at the end of storage period, i.e. giving a stable value of lycopene in samples.

Identification & evaluation of appropriate packaging for minimal processing of selected fruits and vegetables

D R Rai and K. Narsaiah

a) Respiratory behavior and the effect of modified atmospheres generated by varying package weight on quality of fresh-cut green beans (*Phaseolus vulgaris L.)*

Green beans have intense respiration and the respiratory heat so produced, limits their post-harvest shelf-life. This can be partially attributed to the intense metabolic activity of immature seeds inside the pods. As the respiration proceeds senescence occurs leading to enhancement of degradation, hydrolysis of starch and consumption of soluble sugars by respiratory metabolism. Respiration of different fruits and vegetables can be controlled by storing them at low temperature along with appropriate packaging technologies viz. modified atmosphere packaging (MAP) or controlled atmosphere (CA).

Green beans were harvested from the research farm of the institute at Ludhiana. Bright green and firm bean pods (length: 60-90 mm), free from blemishes, insect, mechanical damage and visual defects were sorted out in the field itself and were then placed inside the field crates for further handling and pre-cooling. The bean pods were first hydro-cooled and later on, air-cooled for 2 h at 15°C in a cold room before the start of the experiment. The beans were again sorted to remove the remaining foreign matter and visibly damaged material (if anything left after first sorting), centrifuged at 400 rpm for 15 s to remove surface water by means of a basket centrifuge (CIPHET, India) and were cut manually into 10-12 mm size pieces using sharp edge stainless steel knives.

Respiratory behavior of minimally processed green beans

Three impermeable glass containers were taken and their void volume was evaluated. The fresh-cut green beans were filled in the containers, leaving certain sufficient headspace for gaseous measurements. Tightly sealed containers were then placed inside an environmental chamber maintained at 15°C and a relative humidity (RH) of 75%. The container headspace was continuously monitored for O_2 and CO_2 concentrations using a portable headspace gas analyzer. The respiration rates of fresh-cut green beans were calculated at any instant of time as per Eqs. (1) and (2):

$$R_{O_2} \quad \frac{V_v \quad y^i_{O_2} \quad y^f_{O_2}}{t^f \quad t^i \quad 100 \quad W_{gb}} \qquad (1)$$

$$R_{CO_2} \quad \frac{V_v \quad y^i_{CO_2} \quad y^f_{CO_2}}{t^f \quad t^i \quad 100 \quad W_{gb}} \qquad (2)$$

where, $y^i_{O_2}$, $y^f_{O_2}$, $y^i_{CO_2}$ and $y^f_{CO_2}$ are the initial and the final concentrations of O_2 and CO_2 inside the glass container, respectively; V_v is void volume of the container in ml; W_{gb} is the weight of green beans in glass container, in kg; t^i and t^f are the initial and the final times of observation, respectively, in h. The packaging requirements of green beans were decided taking into account their rates of respiration, physiological characteristics and apparent marketable quality. Macro-perforated MA packages (8 holes, 0.3 mm dia. each, bag area: 0.17 m^2) made from polypropylene (PP) film (Thickness: 35 m, Gas permeability coefficients: 1.49 x 10^{-5} ml.mm^{-2} h^{-1} kPa^{-1} for O_2 and 5.23 x 10^{-5} ml.mm^{-2} h^{-1} kPa^{-1} for CO_2 at 15 °C and 75% RH were selected for the storage studies.

Freshly harvested beans were pre-cooled and sorted as per the procedure described earlier. Pre-cooled beans were washed for 60 s in water containing citric acid (0.5%), centrifuged to remove surface water using a basket centrifuge (CIPHET, India) for removal of excess moisture to prevent water borne pathogens and micro-organisms and were again air-cooled for 2 h. The beans were then cut into 10-12 mm pieces using a sharp edge knife. In order to have differential headspace, different weights of fresh-cut beans such as 250, 500, 750, 1000 g were packed into macro-perforated PP film packages and were stored at 15 °C and 75% relative humidity (RH). Unsealed samples kept under similar conditions acted as control. Three packages from each type of treatments were analyzed on 1, 3, and 4th day of storage for weight loss, in-pack headspace concentration of O_2 and CO_2 as well as for the qualitative analysis (chlorophyll, -carotene, ascorbic acid, odour and water accumulation).

Weight loss and gas analysis

During the entire storage period, the weight loss was determined by weighing the individual package on the day of observation using a laboratory level weighing scale having 0.01 g accuracy. Samples from package headspace were drawn for 3 s through the probe and fed simultaneously to O_2 and CO_2 sensors. Sensor signals were converted to concentration values of O_2 and CO_2, which were directly read on the digital display panel of the instrument.

Total Chlorophyll and -Carotene Content

The pigments (chlorophyll and -carotene) were determined by homogenizing 1 g of green-beans with 10mL of acetone and n-hexane (4 : 6). The homogenized solution was allowed to stand for 1 min in an amber colored glass tube placed inside the flaked ice and was protected from direct exposure to the light by covering it from outside by aluminium foil. One ml of the supernatant was taken and was diluted with 9 ml of the extract solution. The resulting solution was analyzed spectrophotometrically with the help of an UV-Vis spectrophotometer The optical density of the solution was measured at different wavelengths namely, 663, 645, 505, and 453nm using acetone and n-hexane (4 : 6) as blank.

Ascorbic Acid

The ascorbic acid content of was determined quantitatively as per the modified 2,6-dichlorophenolindophenol (DIP) method. The extract was centrifuged at 3000g in a cold centrifuge at 3° C for 15 min. One ml of the supernatant was mixed with 9 ml of 0.05mM of DIP using a vortex shaker for 15 s and its absorbance was measured against the blank at 515nm with the help of a UV-Vis spectrophotometer.

Assessment of rates of respiration of fresh-cut green beans

Initially, R_{O_2} and R_{CO_2} were observed to be 302 $ml.kg^{-1}.h^{-1}$ and 89.00 $ml.kg^{-1}.h^{-1}$, respectively which meant that ruptured tissues were respiring excessively in response to the atmospheric levels of O_2 inside the experimental containers. However, as the headspace concentrations of O_2 and CO_2 varied from their standard atmospheric levels and then stabilized, R_{O_2} and R_{CO_2} values settled around 57.5 and 33.11 $ml.kg^{-1}.h^{-1}$, respectively.

Weight loss and headspace gaseous concentration

While the control samples lost about 7.0% of their initial weight towards the end of storage, it was observed to be non-significant among different MAP treatments at 95% confidence level which was clearly indicative of the advantage of packaging, as establishment of high R.H. through continuous respiration of fresh-cut green beans under MAP treatments inside the film packages, resulted in slower transpiration and hence lesser weight loss. As the storage progressed, the O_2 concentration decreased and CO_2 concentration increased under all the treatments. The gaseous compositions on 4th day of storage stabilized around 14.20, 12.70, 11.55 and 7.30% for O_2 (R^2: 0.90, 0.86, 0.92 and 0.91, respectively) and 3.70, 5.16, 5.60 and 8.10% for CO_2 (R^2: 0.90, 0.89, 0.92 and 0.86, respectively) in film packages containing 250, 500, 750 and 1000 g of green beans, respectively.

Pigments

Initially, the average chlorophyll content of freshly harvested green beans after minimal processing was observed to be 38.61 mg/100g of fresh weight (fw). These results led to the conclusion that the combinations of a range of gaseous atmospheres with hyper-normal CO_2 (5.16-8.10%) and sub-atmospheric O_2 (7.3-14.1%) levels could help maintaining the chlorophyll content and thus, the desired green colour during four days of storage under modified atmosphere conditions studied. β-carotene content of fresh sample of green-beans was observed to be 6.35 mg/100g. Later on, β-carotene was more or less maintained in all the samples except control and was recorded as 2.71, 4.43, 3.08 and 3.72 mg/100g fw in 250, 500, 750 and 1000 g samples, respectively, at the end 4th day. On the other hand, a rapid increase in β-carotene content was observed in control samples after 2nd day, largely due to the development of slight yellowness in these samples, as visible to naked eyes. Although, MAP of fresh-cut green bean could retain β-carotene up to certain extent, however, the quantity of in-pack material and thus, the variable headspace had insignificant effect on the β-carotene levels.

Ascorbic acid

In this study, the packages with limited head-space (750 and 1000 g packages) and thus higher CO_2 levels could retain the ascorbic acid content more efficiently, as higher CO_2 levels could prevent its oxidation

In conclusion, it could be surmised from this study that the rates of O_2 consumption and CO_2 evolution for minimally processed green-beans (Fig. 20) at 15 °C and 75% RH were 57.47 $ml.kg^{-1}.h^{-1}$ and 33.11 $ml.kg^{-1}.h^{-1}$, respectively. When the minimally processed green beans were stored for 4 days at 15°C, under differential modified atmospheres generated through variable in-pack weights of the produce, they could maintain most of the desirable quality characteristics (physiological loss in weight, pigments , ascorbic acid, etc.) to the acceptable limits. Package body perforations helped to restrict the accumulation of moisture and increased the gaseous diffusion across the packages; and hence prevented the fermentation. Results of the study suggested that taking into account all the qualitative parameters, 1000 g of minimally processed green beans could be successfully stored for 4 days under the modified atmosphere conditions in perforated PP film packages.

Fig. 20. Minimally processed green beans under MAP

Value Chain on Novelty Pork Products under organized Pig Farming System

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Survey of equipment available at pilot plants of IVRI, Bareilly, CARI, Bareilly, Assam Agricultural University, Khanapar and NRC meat, Hyderabad and small scale industries near Ludhiana was done to assess the requirements for design of bowl chopper, sausage filler, electric stunner and transport system. Bowl chopper, sausage filler and electric stunner were procured.

Conceptual designs of insulated/vacuum insulated transportation unit for pig carcass and pork products, bowl chopper and sausage filler were done. Local entrepreneurs are identified and contacted for fabrication of sausage filler, bowl chopper, electric stunner and transport vehicle.

A twin screw food extruder was used for extrusion cooking. Different extrudates were prepared with independent variables viz. feed rate (6.5, 9.5, 11.5 and 13.5kg/h) and screw speed (200,250,300 and 350 rpm). Response surface plots and polynomial equations were generated for optimizing the process variables and product quality attributes.

Instant *UPMA* dry mix

Pearl millet grains were oven dried for 4-6 hr (to obtain 8-10 % moisture) and then cleaned manually as well as in cyclone separator. The cleaned samples were ground in mini-grinder and sieved in sieve shaker. The grits passed through sieve size of ASTM 28, 48 & 65 (i.e., 480 & 650 micron) were selected for *upma* dry mix preparation. These samples of pearl millet particles were autoclaved (121 ^{0}C, 15 min) and surface moisture was removed by spreading over aluminum tray. The *upma* dry mix (Fig. 22) prepared were subjected to quality parameters analysis.

Fig. 22. Reconstituted UPMA preparation

Experiments were planned using CCRD with three variables i.e. vanaspati (40-50g/100g pearl millet *suji*), citric acid (0.15-0.25/100g pearl millet *suji*) and water for rehydration (220-260ml/100g dry mix).Different sensory responses i.e. colour, aroma, mouth feel, taste, overall acceptability and rehydration ratio were studied. Significant quadratic equations were developed for mouth feel (R^2: 0.80), taste (R^2: 0.86), overall acceptability (R^2: 0.82), and rehydration ratio (R^2: 0.88). Based on compromised optimization, the optimum combinations of ingredients viz. vanaspati (43.6 g/100g pearl millet *suji*), citric acid (0.19/100g pearl millet *suji*) and water for rehydration (251 ml/100 g dry mix) with 2.97 rehydration ratio and 86.4% desirability were obtained.

Pearl millet based Halwa dry mix

Fig. 23. Reconstituted Pearl Millet *Halwa* Preparation

The experiments were planned using CCRD with three variables i.e. vanaspati (35-45 g/100g pearl millet *suji*), sugar (85-95 g/100g pearl millet *suji*) and water for rehydration (120-160 ml/100g dry mix) for preparation of Halwa dry mix (Fig. 23). Different sensory responses i.e. colour, aroma, mouthfeel, taste, overall acceptability and rehydration ratio were studied. Significant quadratic equations were developed for mouth feel (R^2: 0.79), taste (R^2: 0.84), overall acceptability (R^2: 0.80), and rehydration ratio (R^2: 0.86). Based on compromised optimization, the optimum combinations of ingredients were vanaspati (38.6g/100g pearl millet *suji*), sugar (88.7 g/100g pearl millet *suji*) and water for rehydration (151 ml/100 g dry mix) with 1.98 rehydration ratio and 84.4% desirability. The proximate compontions at both the products was as given in table 13

Table 13: Proximate composition of pearl millet *upma* and *halwa* dry mix as well reconstituted mix (100g, as is basis)

	Moisture	Fat	Protein	Ash	Carbohydrate
Pearl Millet	12.50	4.80	11.8	2.10	68.80
Pearl Millet *Suji*	12.00	3.10	10.4	1.40	73.10
Halwa Dry Mix	3.67	18.30	4.60	0.62	72.80
Reconstitute *Halwa*	48.40	9.50	2.40	0.32	39.38
Upma Dry Mix	2.60	34.20	7.50	1.08	54.62
Reconstitute *Upma*	54.30	11.20	2.80	0.38	31.32

Studies on cryogenic grinding for retention of flavour and medicinal properties of some important Indian spices”

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Experiments were conducted to determine physical, mechanical and thermal properties, of selected spices viz. (black pepper (*var*. Panniyur-1) and coriander (*var*. RCR-4) for five moisture levels; fenugreek (*var*. AM-2, RMT-1) for four moisture levels and turmeric at 9.81% d.b. moisture content.

Black pepper (*Piper Nigrum* L.)

Physical properties

Mean axial dimensions of major (a), medium (b) and minor (c) axes of black pepper seeds increased linearly from 4.92 to 5.37 mm, 4.59 to 5.08 mm and 4.42 to 4.89 mm, respectively with increase in moisture content from 3.3% to 18.1% d.b. Geometric mean diameter (D_g) and sphericity increased linearly from 4.63 - 5.10 mm and 0.94 to 0.95 with increase in moisture content from 3.3 to 18.1 % d.b., respectively. Mean surface area (S) and unit volume (V) increased linearly from 67.7 to 81.9 mm^2 and 53.1 to 70.4 mm^3 with increase in moisture content