DEVELOPMENT AND QUALITY EVALUATION OF READY TO EAT FOOD FROM SPECIALITY RICE AND NENDRAN BANANA

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DECLARATION

We here by declare that this project report entitled "***DEVELOPMENT AND QUALITY EVALUATION OF READY TO EAT FOOD FROM SPECIALITY RICE AND NENDRAN BANANA***" is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship, or other similar title of another University or society.

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CERTIFICATE

Certified that this project report, entitled, ***“DEVELOPMENT AND QUALITY EVALUATION OF READY TO EAT FOOD FROM SPECIALITY RICE AND NENDRAN BANANA”*** is a record of project work done jointly by Aneesa. E, Hridya Haridas and Surya Surendran under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

Place: Tavanur
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Dedicated to Almighty

And

Our loving parents

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SYMBOLS AND ABBREVIATIONS

%	percentage
/	per
^0C	degree celcius
cm	centimeter
mm	millimeter
nm	nano meter
µm	micro meter
N	Newton
Nm	Newton meter
Ns	Newton second
m.c	moisture content
w.b	wet basis
kW	kilo watt
D	diameter
L	litre
ml	milli litre
g	gram
mg	milligram
kg/hr	kilogram per hour
DM	dry matter
$NaCO_3$	sodium carbonate
NaOH	sodium hydroxide
H_2O	water
H_2SO_4	sulphuric acid
HCl	hydrochloric acid
O_2	oxygen
ppm	parts per million
hrs.	hours
kJ	kilo joule
kCal	kilo calorie
FAO	food and agriculture organization
WHO	world health organization
et al.	and other people
etc.	etcetera
No.	number

1. INTRODUCTION

Eating patterns are changing; snack foods play very important roles in the diet of the modern consumer. Many consumers do not have time to prepare traditional meals and increasingly even lack the knowledge of how to cook. After work they prefer a meal to eat or at the most assemble at home and not ingredients to cook. They also want to relax in the comfort of their own home rather than to spend time at a full service restaurant.

In India, several ready-to-eat (RTE) products are available in the market. The RTE foods are prepared by extrusion cooking, puffing, popping, flaking, frying, toasting, etc. It includes extruded snacks (*Kurkure, Lays* etc.), puffed cereals, popcorns, rice flakes, potato chips, French fries and Indian home made products like papads, kurdai, chakali, etc. which may be consumed after frying or roasting.

Nutritionally secured RTE food product has immense importance in this era, we have introduced a nutritional breakfast kit for the nuclear families, which has balanced mix of fibers, proteins, carbohydrates, vitamins and minerals, which will ensure food security and safety. In present study a new RTE food product was developed by blending speciality rice like *Njavara* or *Basmati* with banana and protein rich mushroom powder.

Njavara and *Basmati* are two types of rice. Rice has high digestability. It is low in fat, low in cholesterol, high in starch, and has a high nutritional content. Rice is also an excellent source of energy. It is comprised of 77.5% carbohydrate. Carbohydrate is one of the human body’s main sources of energy, the second being fat. Rice also contains a range of important nutrients, including vitamin B, vitamin E, proteins, and minerals, especially potassium, which helps the body to reduce toxins. Rice can contribute significantly to vitamin and mineral intake, although the contribution to micronutrient intake will depend on the proportion of germ, bran and endosperm consumed.

Banana is a tropical fruit, a large berry which is handy and healthy. Bananas provide 452 mg of potassium, 33mg of magnesium and just over 2g of fibers. People with high levels of potassium in their diets have lower chances to suffer from high blood pressure even if they do not care about their sodium intake. Bananas are low in calories, fats, sodium and much of its fibers are soluble-the kinds which help lowering the overall cholesterol.

Mushrooms, 'boneless vegetarian meat' contain ample amount of proteins, vitamins and fiber. Mushroom contains 20-35% of protein which is higher than those of vegetables and fruits and is of superior quality. It is considered ideal for persons with hyper tension and diabetes.

Extrusion is a multi variable unit operation comprising of mixing, shearing, cooking, puffing and drying in one energy efficient rapid continuous process. It has an important role in the food industry as an efficient manufacturing process. Extrusion is done with relatively dry materials to plasticize food mass, reduce microbial load, denature enzymes, gelatinize starch, polymerize proteins and, most importantly, texturize the end product into a desirable form. Screw extrusion has proved to be particularly a very attractive process in the food industry, with the advantages of versatility, high productivity, low cost, energy efficiency and absence of effluents.

In this back ground, a project entitled "Development and quality evaluation of ready to eat food from speciality rice and *Nendran* banana." was under taken at Kelappaji College of Agricultural Engineering and Technology, Tavanur with the following objectives.

1. Standardization of composition of RTE food from speciality rice and *Nendran* banana.
2. Standardization of extrusion process parameters.
3. Determination of engineering properties such as bulk density, apparent density, porosity and expansion ratio of the RTE food.
4. Quality analysis of newly developed RTE food.

2. REVIEW OF LITERATURE

This chapter gives the general information on *Njavara*, *Basmati*, Banana, and Mushroom, their chemical composition, nutritional importance and extrusion process. Research done on these aspects are also reviewed and discussed in detail.

2.1 *Njavara*

Njavara is a rice variety endemic to Kerala, mainly seen in the northern parts. The cultivation of this rice variety is recorded 2500 years back. *Njavara* is a unique grain plant in the *Oryza* group. Due to many reasons this species is in the verge of extinction. *Njavara* a special cereal, with properties to rectify the basic ills affecting our circulatory, respiratory and the digestive systems and is widely used in the Ayurvedic system of medicine, especially in Panchakarma treatment. It is also used in temples for ceremonies and for certain preparations of *Njavara*, offerings made to Gods. Edaphic, hydrological and atmospheric factors play an important role in quality and yield of rice and medicinal property may vary with environmental conditions. This may be due to the variation in the biosynthesis of active principles behind the medicinal property.

Morphologically, *Njavara* is similar to ordinary rice, with husk colour varying from golden yellow to brownish black, depending upon the edaphic and climatic conditions (Menon, 2004). This rice is grown in semi-dry conditions; it takes about 60 days to mature and is referred to locally as “sastika” variety of rice. *Njavara* is at the brim of extinction due to low yields, high cost and its present use, which is limited to ayurvedic preparations/treatments only. The medicinal quality of the rice is preserved by using only dehusked rice. *Njavara kizhi* is a specialized ayurvedic therapy for treatment of paralysis, arthritis and neurological problems.

Deepa *et al.* (2007) conducted a research on nutrient composition and physicochemical properties of Indian medicinal rice, *Njavara*. Results showed that the dehusked *Njavara* rice consisted of 73% carbohydrates, 9.5% protein, 2.5% fat, 1.4% ash and 1628 kJ per 100 g of energy. The carbohydrates, fats, apparent amylose equivalent, fatty acid profile and triglycerides of *Njavara* were comparable to *Jyothi* and IR 64. However, *Njavara* rice had 16.5% higher protein, and contained higher amounts of thiamine (27–32%), riboflavin (4–25%) and niacin (2–36%) compared to the other two rice varieties. The total dietary fibre content in *Njavara* was found to be 34–44% higher than that of Jyothi and IR 64. Significantly higher phosphorus, potassium, magnesium, sodium and calcium levels were found in Njavara rice, compared to the other two varieties. The cooking time of dehusked Jyothi and IR 64 varieties were found to be 30 min, while *Njavara* needed longer time to cook, (38 min). The cooked rice of *Njavara* was slimy in nature, probably due to the presence of non-starch polysaccharides.

2.2 *Basmati*

Basmati rice is considered to be the best variety throughout the world, owing to its soft texture, aroma, long and slender grains. It is a variety of long grain rice, grown in India and Pakistan notable for its fragrance and delicate, nuanced flavour. Its name means "the fragrant one" in Sanskrit, but it can also mean "the soft rice." India and Pakistan are the largest cultivators and exporters of this rice; it is primarily grown through paddy field farming in the Punjab region. The grains of *Basmati* rice are longer than most other types of rice. Cooked grains of *Basmati* rice are characteristically free flowing rather than sticky, as with most long-grain rice. Cooked *Basmati* rice can be uniquely identified by its fragrance.

2.2.1 Nutritional Highlights of Indian *Basmati* Rice

Basmati rice (cooked), 1 cup (200g)

Calories	205 cal
Protein	4.2g
Carbohydrate	44.5g
Total Fat	0.44g
Fiber	0.63g

Table 2.1 Nutritional Highlights of Indian *Basmati* Rice

Good source of: Iron (1.9mg), Selenium (11.8mcg), Thiamine (0.26mg), and Niacin (2.3mg).

In an experiment, Effects of drying methods and storage time on the aroma and milling quality of rice (*Oryza sativa* L.) was analyzed (Wongpornchai *et al.*, 2003). It was found that the methods that employed at lower temperature appeared to provide higher concentrations of the key aroma compound, 2-acetyl-1-pyrroline, and lower amounts of the off-flavour compounds, *n*-hexanal and 2-pentylfuran, regardless of the storage time. The sun-drying method yielded contrasting results. Overall, during 10 months storage, as the time increased, 2-acetyl-1-pyrroline concentrations decreased where as *n*-hexanal and 2-pentylfuran contents increased. Head rice yield was most clearly affected in the sample dried by hot air at 70 °C, giving a percentage yield slightly less than half of those obtained by the other drying methods. However, no significant variation in the percentages of whiteness was observed among the rice samples obtained from the different drying methods and storage times.

Arora *et al.* (2006) optimized the process parameters for milling of enzymatically pretreated Basmati rice. The optimum process parameters for minimum percentage of brokens and good cooking quality were: 0.0015 g/ml of cellulase enzyme concentration, 40°C of pretreatment temperature and 2 min of pretreatment time. The process parameters also showed significant effect on broken percentage, time of polishing and optimal cooking time.

Jasim *et al.* (2006) analyzed the effect of high-pressure treatment on rheological, thermal and structural changes in Basmati rice flour slurry. Rice flour dispersions exhibited a gradual liquid–solid gel transformation as they gelatinized and/or denatured and behaved as viscoelastic fluid following HP treatment. Mechanical strength (G') of pressurized gel increased with applied pressure and rice concentration. Differential scanning calorimeter (DSC) thermo grams of rice slurry measured after pressure treatment indicated a reduction in peak enthalpy in proportion with the extent of gelatinization and/or denaturation of starch and proteins. Pressure-treated rice samples had a progressively lower gelatinization temperature. A 15 min pressure treatment at 550 MPa was found sufficient to complete gelatinization of protein free isolated rice starch while the slurry required 650 MPa. The presence of proteins might have been responsible for the slower starch gelatinization in the rice slurry during pressure treatment. The sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) and Fourier-transform infrared (FTIR) spectroscopy results indicated some minor changes in protein subunits and secondary structure of rice protein. This study has provided complementary information on pressure-induced changes in physical (thermal stability, overall structure) and molecular level (secondary structure) of rice protein.

2.3 Banana (*Nendran*)

Bananas are highly recommended by health care providers for their patients with low potassium levels. By its high potassium to sodium content, bananas may prevent high blood pressure and its complications. High fiber content may also contribute to this effect. High potassium may also prevent renal calcium loss, in effect preventing bone breakdown. In diarrhea, it contributes to electrolyte replacement, as well as increased absorption of nutrients. One large banana, about 9 inches in length, packs 602 mg of potassium, 2 grams of protein, 36 grams of carbohydrates, 4 grams of fiber and carries 140 calories. The banana has been considered as an important food to boost the health of malnourished children.

Vitamins and minerals are abundant in the banana, offering 123 IU of Vitamin A for the large size. A full range of B vitamins are present with 0.07 mg of Thiamine, 0.15 mg of Riboflavin, 0.82 mg Niacin, 0.88 mg vitamin B6, and 29 mcg of Folic Acid. There are even 13.8 mg of vitamin C. On the mineral scale Calcium counts in at 9.2 mg, Magnesium 44.1 mg, with trace amounts of iron and zinc. Carotenoid content has antioxidant effects, and protects against vitamin A deficiency, resulting in e.g. night blindness. Moderate consumption decreases risk of kidney cancer, possibly due to antioxidant phenolic compounds. In contrast, large consumption of highly processed fruit juice increases the risk of kidney cancer. Putting all of the nutritional figures together clearly shows the banana is among the healthiest of fruits.

We traditionally use banana as a balanced and supplementary diet for babies of 4 to 10 months .The fully matured banana is chosen for this preparation. After peeling the banana, (*Nendran & Kunnan*) it is cut into thin, very fine pieces and dried under the sun, then ground well into fine powder. This powder is thickened by boiling with milk and one pinch of sugar, and fed to the babies. This is a wonderful nutritious diet for easy digestion, and prevents diahorrea and worm trouble in babies.

In the flakes made of banana pulp and full-fat Soya flour,

the amino acid composition showed that the chemical score as 89, the net protein utilization (NPU) as 55·9, the biological value (BV) as 67·9, and true digestibility (TD) as 83·1.The limiting amino acid was lysine.(Ruales *et al.*,1989).

In a study on physical and mechanical properties of green banana (*Musa paradisiaca*) fruit conducted by Kachru *et al*. (1994), the average pulp and peel moisture content were 264.17% (db) and 666.28% (db), respectively for Dwarf cavendish and 153.39% (db) and 516.41% (db), respectively for *Nendran*. At these average moisture contents, the average pulp to peel ratios were 1.39 and 2.32, and peel thickness were 3.65 mm and 2.95 mm, respectively. The maximum diameter of fruit without peel was 23.34 mm and 37.08 mm, and average pulp specific gravity was 0.993 and 1.110, respectively for the two varieties. The maximum effective length and width of the banana pulp resting at its most stable position was observed to be 137.0 mm and 66.5 mm, respectively for Dwarf cavendish and 194.5 mm and 50.0 mm, respectively for *Nendran*. The maximum load required to cut a cross-sectional slice of pulp was 22.4 N and 28.2 N for the two varieties, respectively. Maximum energy of 686.81 J/m^2 for Dwarf cavendish and 724.46 J/m^2 for *Nendran* was required to cut a slice of the fruit. The banana kept in a convex position required the most energy to cut, whereas the plain position was observed to be the best position *vis-à-vis* the energy requirement and consumer preference of chip shape.

2.4 Oyster Mushrooms

The Oyster mushroom is one of the most commonly sought wild mushrooms. Oyster mushroom (*Pleurotus ostreatus*) belongs to the family *Tricholomataceae*. It looks, smells and tastes like oyster.

Calories	686.52kcal/100gm
Protein	15-25%
Crude fiber	7.4%
Moisture	90%
Ash content	9.8%
Calcium	0.018%
Magnesium	0.996%
Iron	0.121%
Zinc	0.221%
Phosphorous	0.222%

Table 2.2 Chemical composition of oyster mushroom

The antioxidant properties of several commercial mushrooms (winter, shiitake and oyster mushrooms) were showed that, the antioxidant activities by the 1,3-diethyl-2-thiobarbituric acid method were moderate to high at 1.2 mg ml^{-1}. Reducing powers were excellent (and higher than 1.28 absorbance) at 40 mg ml^{-1}. Scavenging effects on 1,1-diphenyl-2-picrylhydrazyl radicals were moderate to high (42.9–81.8%) at 6.4 mg ml^{-1}. With regards to the scavenging effect on hydroxyl free radicals, tree oyster mushrooms were the highest (54.3%) at 40 mg ml^{-1} whereas other commercial mushrooms were low. Chelating effects on ferrous ions were 45.6–81.6% at 1.6 mg ml^{-1}. Total phenols were the major naturally occurring antioxidant components found. Overall, tree oyster mushrooms were better in antioxidant activity, reducing power and scavenging abilities and higher in total phenol content (Yang *et al.*, 2001).

Pamela *et al.* (2003) conducted study on nutritional quality of commercial mushrooms (*Boletus* group, *Agrocybe aegerita* and *Pleurotus eryngii*) and effect of cooking. The study revealed that the moisture values ranged from 67.2 to 91.5 g/100 g edible weight in the raw samples, and from 71.9 to 90.4 g /100 g edible weight in the cooked samples. The lipid fraction was not relevant. Proteins, higher in *Boletus* group dried samples than in the other mushroom species (*Agrocybe aegerita* and *Pleurotus eryngii*), ranged from 1.5 to 7.9 g/100 g edible weight, while the ash content varied between 0.5 and 2.0 g/100 g of edible weight. Dried and re-hydrated

Boletus samples showed higher levels of soluble and insoluble dietary fibre than the other samples. The amount of beta glucans varied within the same species (*Boletus* group samples) and represented from 2 to 13% of total dietary fibre. The chitin content ranged from 0.5 to 3.3 g/100 g edible weight. Finally, total phenols varied widely among different mushroom species, from 51.4 to 403.8 mg/100 g edible weight and from 70.4 to 301.6 mg/100 g edible weight, respectively, for raw and cooked samples.

In a study conducted by Barros *et al.* (2006), the macronutrient profile in general revealed that the wild mushrooms were rich sources of protein and carbohydrates, and had low amounts of fat. On the basis of the proximate analysis, it can be calculated that an edible portion of 100 g of these mushrooms provides, on average, 28 kcal (118 kJ). Unsaturated fatty acids in particular, oleic and linoleic acids were predominant and mannitol and trehalose were the most abundant sugars.

2.5 Extrusion cooking

The extrusion process is basically designed to continuously convert a soft material into a particular form and is an ideal method for manufacturing a number of food products like snacks and breakfast cereals to baby foods. The basic idea behind food extruding is pushing the material out through an opening of desired size with a screw extruder. Extrusion cooking was used early on for cake frosting in bakeries. Food extrusion has been primarily used in cereals and grains such as pasta, crackers, and other snacks since the 1950's. Snacks, using, new, controllable extrusion processes, can now be made with a crisp outer layer, and a soft inner layer. Extrusion is the act or process of shaping material by pushing or forcing through a die. Die is a device for cutting out, forming or stamping material. A die with a round opening produces pipe; a square die opening produces a square profile, etc. Other continuous shapes, such as the film, sheet, rods, tubing, and filaments, can be produced with appropriate dies.

Extrusion is done with relatively dry materials to plasticize food mass, reduce microbial load, denature enzymes, gelatinize starch, polymerize proteins and, most importantly, texturize the end product into a desirable form. Screw extrusion has proved to be a particularly very attractive process in the food industry, with the advantages of versatility, high productivity, low cost, energy efficiency and no effluents causing waste problems.

The screw has a number of sections, including a feed section to compress particles in to a homogenous mass, a kneading section to compress, mix and shear the plasticized food and, in high shear screws, a cooking section. Transport of material through single screw extruders depends largely on friction at the barrel surface. Material flows forward (drag flow), owing to the action of screw and, to a lesser extent, back wards along the barrel (pressure flow and leakage flow). Pressure flow is caused by the build up of pressure behind the die and by material movement between the screw and barrel. Slipping can be minimized by special groves on the inside of the barrel. Single- screw extruders have lower capital and operating costs and require less skill to operate and maintain than twin-screw machines.

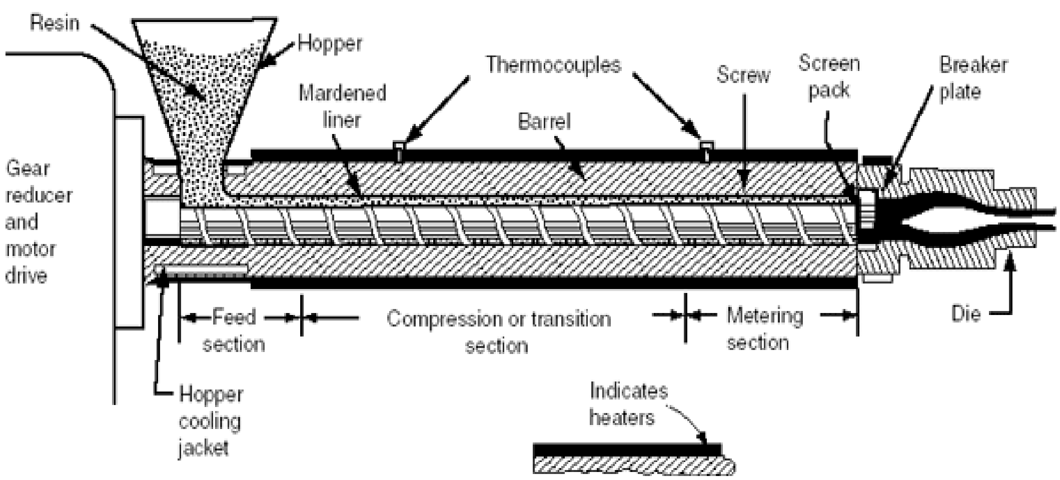

Fig 2.1 Single Screw Extruder

The screw has a number of sections, including a feed section to compress particles in to a homogenous mass, a kneading section to compress, mix and shear the plasticized food and, in high shear screws, a cooking section. Transport of material through single screw extruders depends largely on friction at the barrel surface. Material flows forward (drag flow), owing to the action of screw and, to a lesser extent, back wards along the barrel (pressure flow and leakage flow). Pressure flow is caused by the build up of pressure behind the die and by material movement between the screw and barrel. Slipping can be minimized by special groves on the inside of the barrel. Single- screw extruders have lower capital and operating costs and require less skill to operate and maintain than twin-screw machines.

Launay *et al.* (1983) studied twin-screw extrusion cooking of starches, flow behaviour of starch pastes, expansion and mechanical properties of extrudates.. The study revealed that, when water content and barrel temperature vary within certain limits the values of constants in the proper law equation describe a characteristic line which depends on the amylase and lipid contents of the starch. The formation of an amylase-lipid complex during extrusion is suggested as a key factor in the flow properties of pastes and probably also in the rupture strength of extrudates. There is generally a negative correlation between longitudinal and diametral expansion. It is considered that volume expansion phenomena are mainly dependent on viscous and elastic properties of melted starch.

A physico chemical model for extrusion of corn starch was developed by Gomez *et al.* (1984). Reducing extrusion moisture content resulted in a progressive change from gelatinized- like to a dextrinized-like properties. Maximum gelatinization was observed at 28-29%moisture. Below 20% moisture dextrinization become predominant during high shear cooking extrusion. Scanning electron micrographs also validate the assumptions of the model.

A study showing the effect of feed moisture and barrel temperature on physical properties of extruded cowpea meal was done by Phillips *et al.* (1984). Measured product temperatures ranged from 10-34% and were affected mainly by initial moisture. Expansion at the die was highest for 29% moisture extrudates (1.7-1.9), and lowest for 40% samples (0.9-1.3) the 20%-150^{0}c extrudates was dense (0.45g/cm^3) and twisted. The 20%-170^{0}c product was highly expanded (0.23

g/cm^3).Other products were intermediate in density. Tristimulus color values were determined.

A mathematical model was developed by Dio sady *et al.* (1984) for getting an idea on mechano-kinetic break down of cooked wheat starch, which relates the residence time of the starch in the barrel of a single screw extruder, the nominal shear stress acting on the starch and the degree of cook of the product to the extend of molecular degradation of starch. Solution viscometry was found to be more rapid than gel permeation methods previously used to determine the extend of molecular change.

An experiment revealing effect of extrusion cooking of blends of soy flour and sweet potato flour on specific mechanical energy (SME), extrudate temperature and torque showed that product temperature increased with increase in die diameter, s_s (screw speed) and f_c (feed composition). However, the effect of die diameter was greater than those of s_s and f_c. Decrease in die diameter with increase in sweet potato content increased torque. s_s exhibited a linear effect on torque (Zuilichem *et al.*, 1988).

According to Zulichem *et al*. (1988) the over heating effect possible in single screw extruders is related to the type of flow in extruder channel.

Khan *et al.* (1990) had studied the Instrumental and sensory evaluation of textural properties of extrudates from blends of high starch or high protein fractions of dry beans. The higher the process temperature, the lower was the sample stress and higher the sensory score for crispness. Product processed below 120^{0}C was unacceptable. Crispness was good for samples containing 13-16% protein or 17-21% fiber; outside these ranges the surfaces were too hard. Shear stress increased uniformly with increase in protein or fiber content .A satisfactory correlation was obtained between sensory and instrumental test results for texture: the higher the shearing stress, the lower was the sensory score for crispness.

The work presented by Artz *et al.* (1990) on twin –screw extrusion modification of a corn fiber and corn starch extruded blend revealed that the water holding capacity of starch increased with increase in extrusion temperature while the water holding capacity of the fiber decreased with increasing extrusion temperature. The foam stability decreases, while residual moisture increased, with an increase in fiber concentration. X-ray diffraction profiles indicated that extrusion did not affect fiber crystallinity. No significant changes in the ratio of soluble to insoluble fiber where found as a result of extrusion.

The effect of temperature on properties of extrudates from high starch fractions of Navy, Pinto and Garbanzo beans was assessed by Gujska *et al.* (1990). In this research the highest value of expansion was noted for pinto beans, and the lowest for garbanzo, extruded at 132^0C. Extrudates from HSF (high starch fraction) expanded significantly ($p<0.05$) less than corn extrudates. Oil absorption capacity increased slightly with increase in temperature and values were lower for navy and garbanzo beans than for pinto HSF and corn. Oil emulsion capacity of bean sample was about two times higher compared to corn. Water absorption index (WAI) of pinto and navy beans significantly increased ($p<0.05$) from 110 to 132^0C.

Badrie *et al.* (1991) studied the effect of extrusion variables on cassava extrudates. Optimum expansion (2.82) was at 11% feed moisture 120-125^0C; screw speed, 520rpm; feed rate, 250 gm/min. Effect of feed moisture was most significant on expansion, bulk density and extrudate moisture. Increase in temperature, increased expansion and water solubility, but decreased bulk density, extrudate moisture and water absorption. Screw speed most influenced water absorption and solubility. Extrudate moisture correlated negatively ($P<0.01$) with extrudate expansion. Water solubility index of extrudate negatively correlated ($P<0.05$) with extrudate moisture and water absorption index but correlated positively ($P<0.05$) with expansion.

By response methodology Batistuti *et al.* (1991) optimized the production of a snack food from chick pea. Expansion ratio increased steadily with decrease in feed moisture similar to cereal expansion. Regions of maxima were observed for sensory preference and shear strength, and these two product attributes were linearly related. The most acceptable chickpea snack was rated higher than a commercial corn snack.

Both specific energy and product temperature in the metering section decreased with the addition of rice bran and increased at the higher screw speed during the study on extrusion and extrudate properties of rice flour by Grenus *et al.* (1992) and they also found that both radial and axial expansion increased at 10% rice bran and decreased at higher levels. Shear strength increased with bran levels over 10% and with increase in screw speed. Extrudates that contained bran were darker than those that did not. An examination of puff micro structure showed and increase in structural organization at 10% rice bran and decreased cell size and incomplete cells at higher levels.

In a study revealing the effect of temperature on the extrusion behaviour of flour from sound and sprouted wheat, the diameter of the extrudates prepared from wheat flour sound grains decreased, but density increased, with the increase in temperature of the extruder die section. However, the use of wheat flour from sprouted grains resulted in increased expansion and decreased density of extrudates. The specific energy requirements decreased by 25 and 23 % with increase in temperature of die section from 145^0C to 190^0C in flours from sound and 48 h sprouted grains, respectively. Extrudates from wheat flour of sprouted grain were softer in texture and those of 48 h sprouted wheat showed higher overall acceptability scores, as compared to that of sound wheat (Singh *et al.*, 1994).

Relationship between processing condition and starch and protein modifications during extrusion cooking of pea flour was evaluated by Valle *et al.* (1994). Response surfaces showed that SME (specific mechanical energy) influenced starch and protein solubility more than did temperature. Decrease of protein solubility was attributed to formation of non covalent bonds and disulphide bonds which could partly take place at the die, according to flow conditions (SME>250Kwh/t) led to the creation of other covalent bonds. Immunoassay proved an efficient method for assessing the severity of treatment by following the loss of legumin anti genicity.

Matthey *et al.* (1996) reported the physical and functional properties of twin-screw extruded whey protein concentrate (WPC)-corn starch blends. A Split- plot experiment was conducted to investigate four levels amylose in starch with four levels of WPC in WPC-corn starch blends (sub-plots). The design was a randomized complete block with the three replications being three different WPC sources.

Measured properties were shear strength(51.4 to 361 KPa), radial expansion ratio (4.32 to 13.1), specific mechanical energy (SME) (240 to 383 J/Kg), water absorption index (WAI) (1.98 to 8.57), % water solubility index (% WSI) (9.51 to 67.6%), total colour difference (8.08 to 35.9) and % apparent amylose content (0-66%) of extrudates. The WPC source affected several extrudate properties. Data were modeled with polynomial regression. Waxy starch differed from amylose starch in terms of % WSI, WAI and SME. Significant interactions between the levels of amylase and WPC were found for radial expansion ratio, total colour change and apparent amylase content. This suggested the presence of a physico-chemical interaction between amylose and WPC.

A comparative study of mixing elements during twin- screw extrusion of rice flour was done by Choudhury *et al*. (1998). It was found that, specific mechanical energy input and water solubility index were lowest for screw profiles with kneading elements, and increased in the order: kneading elements, reverse screw elements and combination kneading and reverse screw elements, irrespective of element position the screw profile. A systematic increase in specific mechanical energy input and solubility was observed as the mixing elements were moved farther from the die and with increased spacing between two elements. Extrudate expansion was highest for kneading elements followed by reverse screw element and combination of kneading and reverse screw elements, irrespective of element position and spacing in the screw profile. For each type, maximum expansion was observed when the element was placed at 200mm from the die end. Kneading elements seemed to be the element of choice for maximizing extrudate expansion.

Blends of corn and soy were developed to provide 20% protein, 12% fat, 68% carbohydrate and 8% moisture. Two types of soy isolate and concentrate were evaluated (Konstance *et al.*, 1998) under extrusion temperature from 100 to 130^{0}C and feed moistures 8.5-18%. The extrusion (twin-screw extruder) of lower valued concentrates at 100-115^{0}C with moisture from 12-18% produced a pre cooked mix that was high in nutrients and contained the most available lysine.

Chauhan *et al.* (1988) reported the effect of some extruder variables on physico-chemical properties of extruded rice legume blends. The trend observed was that, the expansion ratio of all the extruded products increased and density decreased with the increase in extruder temperature, irrespective of feed rate. Incorporation of different legume flours with rice flour increased the crispness and decreased breaking strength of the product. The magnitude of water solubility index (WSI) increased perceptibly with increased temperature of extruder. Higher gelatinization occurred in rice gram blends at higher temperatures and lower feed rate with a simultaneous increase in reducing and non reducing sugars and decrease in water-soluble proteins. In general, and the extruded product extruded at 95^{0}C with 27.2kg h feed rate were adjudged superior in quality.

The product quality attributes, PQA (Bulk density, color b index, and moisture content), of extrudates produced using a twin-screw food extruder with two different screw configurations(A and B) were evaluated and analyzed as function of operating and process variables. Relationships were obtained using multiple linear regression configurations B (Two reverse kneading paddles added to the shear section of the extruder).Models of online measured PQA (extrudate moisture and color b index) could be used in the design of extrusion process control system (Lo *et al.*, 1998).

The screw profiles of twin screw extruder on the extrusion of rice flour significantly influenced apparent density, product expansion (radial, axial and overall), and breaking strength. Apparent density and overall expansion were functions of die temperature. Kneading block was best element for maximizing radial expansion. Product hardness decreased with increase in radial expansion (Choudhury and Gautam, 1998).

Jhoe *et al.* (2007) had conducted study about soy-protein-fortified expanded extrudates: baseline study using normal corn starch. Increasing screw speed resulted in higher specific mechanical energy (SME) and expansion, and lower mechanical strength. On the other hand, addition of 5–20% SPC (soy protein concentrate) led to lower SME and expansion, and higher mechanical strength. X-ray micrographs showed smaller yet more cells, and cell wall thickening with SPC addition. Water absorption index increased and water solubility index decreased with increase in screw speed and SPC level. Increasing screw speed resulted in a slight shift towards smaller molecular weight fractions of starch, as determined by gel permeation chromatography.

A study on Physico chemical characteristics, nutritional quality and shelf life of pearl millet based extrusion cooked supplementary foods was done by Sumathi *et al.* (2007). The cold and cooked paste viscosity, the melt energy and also the carbohydrate digestibility of the extrudates indicated that the products were pre-cooked and were of ready-to-eat nature. The millet was blended with grain legumes (30%) and also with defatted soy (15%) separately and extruded to prepare ready-to-eat nutritious foods suitable as food supplements to children and mothers. The foods based on the millet and legumes and also the millet and soy contained 14.7% and 16.0% protein with 2.0 and 2.1 protein efficiency ratio values, respectively. The shelf-life of the foods was about 6 months in different flexible pouches at ambient storage conditions.

Altan *et al.* (2008) had studied the effect of screw configuration and raw material on some properties (specific mechanical energy (SME), expansion (SEI), bulk density, water absorption index (WAI), hardness, breaking strength and colour) of barley extrudates. Means of the responses were significantly different for all responses except bulk density and WAI with respect to screw configuration. For raw material, the means of the responses were significantly different for all responses except SEI and WAI. Barley flour extrudates produced by severe screw configuration had significantly lower SME than barley grits extrudates. Severe screw configuration produced more expanded product with low bulk density than that of medium screw configuration. Correlations were found between product responses.

In an experiment extrudates were used to analyze the effect of an addition of everlasting pea wholegrain meal on the content of ash, fat, protein, and dietary fibre. The share of everlasting pea wholegrain meal in the raw material mixture varied from 3 to 21%. As a result of the process of extrusion, a reduction was observed in the content of fat, protein, raw fibre, neutral-detergent fibre (NDF), acid-detergent fibre

(ADF), hemicellulose (HCEL), cellulose (CEL), total dietary fibre (TDF) and insoluble dietary fibre (IDF). At the same time an increase was recorded in the content of soluble dietary fibre (SDF) and lignin (ADL) (Kasprzak and Rzedzicki, 2008).

The results obtained from the analysis of the extrudates are discussed in terms of the effect of cauliflower co-products on nutritional and textural characteristics, and the effects of processing conditions. Valentina *et al*. (2008) found that addition of cauliflower significantly increased the dietary fibre and levels of proteins. Extrusion cooking significantly increased the level of phenolic compounds and antioxidants but significantly decreased protein in vitro digestibility and fibre content in the extruded products. The expansion indices, total cell area of the products, wall thickness showed negative correlation to the level of cauliflower. Sensory test panel indicated that cauliflower could be incorporated into ready-to-eat expanded products up to the level of 10%.

2.6 Fabricated foods

With advances in food technology, fortification of foods for proper nutrition is becoming more complex. Eating patterns are changing; snack foods and formulated products are becoming a larger part of the diet. At the same time, consumers want food that is convenient, requires minimal preparation and has a good shelf life. The food industry has responded to these expectations—for example, by developing techniques which involve milder processing, fewer additives, less fat, salt and sugar, using environmentally friendly packaging and by introducing fabricated foods.

2.6.1 CHANGING TRENDS IN FOOD HABITS

Hunter gatherer

↓

Farming

↓

Processed foods

↓

Convenience foods

↓

Fabricated foods

We are now at the stage where some foods are completely fabricated. Some examples of these foods are margarines, extruded savory snacks and some fruit flavoured drinks.

In an experiment for preparing extruded snack from rice (*Oryza sativa .L*) and chick pea (*Cicer arietinum. L*), found that, while increasing the proportion of chick pea in the blends, the diametric expansion and water holding capacity (W.H.C) decreased but peak shear force and B.D increased (Bhattacharya *et al*., 1994).

Chaiyakul *et al.* (2007) studied the effect of extrusion conditions on physical and chemical properties of high protein glutinous rice-based snack. They found that the high protein nutritious snack was obtained using glutinous rice flour, vital wheat gluten and toasted soy grits, Increasing feed moisture and reducing barrel temperature reduced non-protein nitrogen (NPN) and enhanced lysine retention. The protein and moisture content of raw material and barrel temperature had no significant influence on cysteine and methionine content. The conditions providing high expansion, low bulk density, and low shear strength of extruded snack were feed moisture of 20 g/100 g w.b and 180^0C.

The effects of extrusion conditions on system parameters and physical properties of a chickpea flour-based snack were observed and the results evolved as, the product temperature and die pressure were affected by moisture content(16-18%), screw speed (250-320 rpm) and barrel temperature ($150\text{-}170^0$c) while motor torque and SME (specific mechanical energy) were only influenced by screw speed and barrel temperature. All three variables affected product responses significantly. Desirable products, characterized by high expansion ratio and low bulk density and hardness, were obtained at low feed moisture, high screw speed and medium to high barrel temperature. Finally, Meng *et al.* (2009) demonstrated that chickpeas can be used to produce nutritious snacks with desirable expansion and texture properties.

3. MATERIAL AND METHODS

This chapter includes preparation of samples, standardization of moisture content, extrusion, analysis of physical and chemical properties, objective and subjective evaluation of extrudates.

3.1. Raw material

Raw materials required are *Njavara* or *Basmati*, *Nendran* banana and oyster mushroom, were procured from the local markets. Mushroom is kept in RRLT-NC for one day at 70^0C and then all the raw materials were grounded.

3.2. Preparation of samples

In the first trial three different samples were prepared by blending *Njavara*, banana and mushroom powder in the ratios of 60:40:00, 50:50:00 and 50:40:10 respectively. In the second trial five different samples were made by using *Njavara* or *Basmati* and banana in the ratio of 50:50, 60:40, 70:30, 80:20 and 90:10 respectively.

3.3. Standardization of moisture

Moisture of each sample is measured by gravimetric method and was made to 16% by adding milk in first treatment and by water in next treatment. Simulation of moisture content was done by keeping the samples in refrigerator for two days and was shaken at regular intervals.

3.4. Extrusion

Extrusion of the prepared samples was done by using brabender single screw extruder, keeping screw diameter, feed rate and rpm as constant. The temperature of die section was varied from 150 to 170^0C temperature. Technical details of the extruder is given in the table 3.1

Parameters	Stand alone extruder	Stand alone extruder
Barrel diameter	KE 19 19mm	KE 30 30mm
Screw length	20-25D	20-25D
Drive power	1.5 KW	7.5 KW
Speed	0.2- 150 min^{-1}	0.2-400min^{-1}
Maximum torque	100Nm	300Nm

Parameters	Stand alone extruder	Stand alone extruder
Maximum operating temperature	450^{0}C	450^{0}C
Maximum throughput	Approximately 5Kg/hr	Approximately 15Kg/hr
Identity number	837415	837900

Table 3.1 Technical details of extruder

Plate 3.1 Extruder in operation

3.5. Flow Chart for the Production of RTE food

Njavara rice/ Basmati rice ⇓ Dehusking

Nendran banana ⇓ Peeling

Washing

Drying

Powdering

Slicing

Drying

Powdering

Blending
(50:50, 60:40, 70:30, 80:20, 90:10)

Conditioning with Water /Milk up to 16% M.C.

Extrusion
(150ºC, 160ºC, 170ºC)

Coating with sugar/spices

Packing

Storage

3.5. Proximate analysis

3.5.1. Estimation of starch and total sugars

Starch was estimated according to the procedure given by Moorthy *et al.,* 2002. A rapid titrimetric method has been standardized, which permits precise quantification of starch and total sugar content in fresh tubers, dry chips, floor and processed products.

3.5.1.1. Principle

Treatment with 80% ethanol will extract the sugar present in the sample. The extract was filtered and the filtrate was used for the analysis of sugar. The residue was acid hydrolyzed for the analysis of starch. The starch was completely hydrolyzed by the treatment with 2N HCl, while non reducing sugars were converted into reducing ones using concentrated HCl. Analysis of both the components was done in a similar manner based on number of reducing groups.

3.5.1.2. Reagents

a. Potassium ferricyanide reagent (1%)

Dissolve exactly 1g potassium ferricynaide in100ml distilled water and stored in a brown bottle. The solution is stable for one month if kept in dark.

b. Sodium hydroxide (2.5 N)

Dissolve 10g NaOH pellets in 100ml of distilled water.

c. Hydrochloric acid (2N)

Dilute concentrated HCl six times by adding 250ml distilled water to 50ml concentrated HCl acid.

d. Methylene blue (aqueous) indicator (M/S Qualigen fine chemicals, Mumbai).

e. Glucose standard

Dissolve 100ml D-glucose (A.R grade) in 100ml distilled water

f. 80% ethanol

Dilute 80ml absolute ethanol to 100ml using distilled water.

3.5.1.3. Procedure

2g pieces of each sample were weighed into 100ml Erlenmeyer flask. To each flask 20ml, 80% ethanol was added and left overnight to extract the sugars. Flours or powdered samples of food product (1g) can also be done similarly.

The extracted sugar was separated from the residue by filtration through Whatman No.1 filter paper. The filtrates were collected separately for sugar estimation. Residue on the filter paper was tied with two lots (10 ml each) of distilled water to remove the adhering sugar particles and the filtrate added to the original filtrate. The residue was transferred back into the conical flask using 20ml of 2N HCl. The starch in the residue was then hydrolyzed by leaving the flask on a hot plate at 100^{0}C for 30 minutes. The hydrolysates were cooled to room temperature and their volume increased to 100ml using distilled water. The supernatant was then directly use for titration for the starch. The alcoholic sugar filtrate was treated with 1ml concentrated HCl and heated for 30minutes on a hot plate at 100^0C. The volume of sugar extract was raised to 50ml and used for titration.

3.5.1.4. Titrimetric assay

Pippeted out 10ml of Potassium ferricyanide in 100ml Erlenmeyer flask. To this 5ml NaOH (2.5N) was added. Mixed the contents thoroughly. The flask was then kept over the flame for boiling. When reagents began to boil, the flame was lowered and three drops of dilute methylene blue is added. The solution immediately changed to blue green. The starch hydrolysate was taken in a 2ml bowl. Pipette during starch estimation and added drop by drop to the boiling reagent, while for sugar estimation the sugar extract was taken in a 10ml bowl pipette (since the titre value will be generally around 5-8ml). The nearing end point was indicated by change of colour from blue green to violet. A few more drops were added carefully to reach the end point as indicated by rapid disappearance of violet colour. At this stage titre reading was noted. Titrations were repeated for each of the aliquots.

3.5.1.5. Calculations

Each lot of Potassium ferricyanide is calibrated using standard glucose solution and the relation.

10mg of Glucose = 10ml of Potassium ferricyanide, is to be established.

Starch content of the sample is calculated from the formula.

$$\text{Starch (g/100g fresh weight)} = (10^{a} \times 100^{b} \times 0.9^{c} \times 100) / (T \times 2^{d} \times 1000)$$

Where,

a- Titre obtained for ferriccynaide reagent, while calibrating against standard glucose solution (if a value different than 10 is obtained. e.g. 9.2, 10.4 etc. this has to be used).

b- Total volume of starch hydrolyzed.

c- 0.9 is the Morris factor for converting sugar to starch.

d- Weight of the sample (g) used for analysis.

T- Titre value of starch hydrolysate for expressing starch on dry matter basis, the dry matter of the sample can be determined by

Dry matter (%)

= (Dry weight of the sample) ×100/ (Fresh weight of the sample)

Starch (g/100g dry matter)

= Starch content (g/100g fresh weight) ×100 / Dry matter (%)

For calculating the total (reducing + non reducing) sugar content the following formula is used.

Sugar (g/100g fresh weight) = $(10^{a} \times 50^{b} \times 100) / (T \times 2^{c} \times 1000)$

Where,

a- titre obtained for ferricynaide reagent while calibrating against standard glucose solution

b- total volume of hydrolysate

c- weight the sample (g) used for analysis

T- Titre Value for hydrolysate

Sugar (g/100g DM) = (sugar in %×100)/ (DM in %)

3.5.2. Estimation of reducing sugars (Modified Nelson Somo geyi method)

Nelson Somo geyi method is most commonly accepted method for the determination of reducing sugars. This method was appropriately modified for the estimation of reducing sugars in fresh tubers leaves, flours, composite flour samples and processed products etc.

3.5.2.1. Principle

The sugar was heated with an alkaline solution of copper tarrate and the cuprous oxide produced reacts with arseno molybdate to give molybdenum blue, and the colour was then measured in a spectro photometer at 520nm. Sodium sulphate was added to the reaction mixture to minimize the entry of atmospheric O_2 into the solution to prevent the reoxidation of cuprous oxide.

3.5.2.2. Reagents

A. Copper reagent A

Dissolve 2.5gm anhydrous $NaCO_3$, 2gm sodium bi carbonate, 2.5gm Rochelle salt (sodium potassium tartarate), 20gm anhydrous $NaSO_4$ in 80ml distilled water make up to 100ml.

B. Copper reagent B

Dissolve 15g $CuSO_4$ 5H2O in a30ml distilled water add one drop of con.H_2SO_4 and make up to100ml.

C. Arseno molybdate reagent

Dissolve 2.5gm ammonium molybdate in 45ml water; add 2.5ml con.H_2SO_4 and mix well. Now add 0.3gm disodium hydrogen arsenate dissolved in 25ml water to this and mix well. Then incubate at 37^0C for 24-40hrs and store in brown bottle.

D. Glucose standard (1mg/ml)

(i) Stock solution: dissolve 100mg D-glucose in 100ml distilled H_2O.

(ii) Working standard: Dilute the stock solution ten times.

3.5.2.3. Procedure

Powdered sample of 1g was homogenized with 10ml H_2O to extract the sugar and then filtered.

3.5.2.4. Calorimetric assay (Nelson, 1944)

Pipetted out 0.2ml aliquots from homogenate. Made up the volume to 1ml each of samples using distilled water one ml copper reagent (25 parts reagent A + one part reagent B) was added and solution mixed well. The samples were then placed in the boiling water bath for 20 minutes. On cooling 10ml of arseno molybdate reagent was added to each sample. The volume was then added up to 20ml.The OD is of the blue complex was measured at 520nm. A standard graph was prepared using different concentrations of D-glucose solutions under identical conditions.

3.5.2.5. Calculations

The procedure is standardized using a glucose standard and factor is calculated based on final dilution.

Factor, F is the concentration of standard in mg required to obtain optical density of 1-529nm.

Sugar content (g / 100g fresh weight) = $T \times F \times 5$

Where,

T- Test reading.

3.5.3. Estimation of crude protein (AOAC official methods of analysis 1960).

Protein is the most essential nutrient present in many food crops. The major element present in the protein is nitrogen, which generally constitutes 16% of the total make up. Determination of the nitrogen content is the easiest way to compute the crude proteins. The crude protein content is obtained by multiplying the total nitrogen content by a factor of 6.25.

3.5.3.1. Principle

Nitrogen in the protein of the food products are first converted to ammonium sulphate during digestion with H_2SO_4. The ammonium sulphate is then converted into ammonia using 40% of NaOH which is absorbed into boric acid solution and titrated against standard HCl. The N_2 content is determined using semi automated Kjeltec apparatus.

3.5.3.2. Reagent

1. Concentrated H_2SO_4.
2. Kjeltab catalyst tablets from Kjeltec.
3. 40% NaOH dissolved 200gm NaOH pellets in 1 liter distilled water.
4. 4% boric acid containing mixed indicator solutions.

Dissolved 400gm boric acid in about 5-6 L of very hot distilled water. Mixed and added more distilled H_2O to make up 9 L.

Prepared mixed indicator solution by dissolving 500mg bromo cresol green and 100mg methyl red in100ml of 95% ethanol. Added 70ml of indicator solution to boric acid and made up to 10 L with distilled water. Mixed carefully and stored in brown bottle.

5. 0.1N HCl

Dilute concentrated HCl 120 times.

3.5.3.3. Procedure

Five hundred milli gram flour sample was taken in the Kjeldahl digestion tube and 10ml of concentrated H_2SO_4 is added along with one Kjeltab (catalyst).

The tube was then kept in a digestion track for two hours at 420^0C. The sample was cooled and added 50ml distilled water.

The tube was then kept in distillation unit. The distillation was done with 60ml of 40%NaOH for each sample. The distilled ammonia was collected in a flask containing 20ml of 4% boric acid. This was then titrated against 0.1N HCl and the appearance of the light pink colour was taken as the end point. The nitrogen value obtained from the titration was multiplied with 6.25 for determining the concentration of crude protein.

3.5.3.4. Calculation

Total nitrogen by micro Kjeldahl method.

% N_2= (T-B) $\times 0.1^a \times 14.007 \times 100$/ weight of the sample in mg

(i.e. 500mg)

Let % of N_2 in the sample be X

Crude protein percentage = X × 6.25

Where,

T= titre value for sample (ml)

B= titre value for blank (ml)

a = Normality of acid

3.5.4. Estimation of fat (Folch *et al*., 1957)

The fat (ether extract) present in food crops contribute considerably to the energy content. Approximately 1g of fat gives energy of 9 kCal. Extraction of fat using organic solvent and quantification by gravimetry is the easiest way to determine the fat content.

3.5.4. 1. Reagents

1. Alcohol: ether mixture (3:1)

Three parts of ethyl alcohol (absolute) was mixed with one part of diethyl ether and stored in a tightly capped bottle.

2. Chloroform: methanol mixture (1:1)

One part of chloroform was mixed with one part of methanol and stored in a tightly capped bottle.

3.5.4. 2. Procedure

Weigh 2gm of powdered sample into wide mouthed boiling tube 30ml. Add 20ml alcohol: diethyl ether mixture (3:1) to this and stir well. Keep in thermostatic water bath for 2hr at 55^0C. Centrifuge at 300rpm for 10minutes and decant the clear supernatant to a weighed petri dish. Add another lot of alcohol: diethyl ether mixture, and extract for 2hr centrifuge and decant to the sample plate. Add 20ml chloroform: methanol (1:1) to the residue. Extract at 50^0C for 1hr. Centrifuge and decant to same petridish and dry the petridish in the oven at 60^0C. Take the weight of the dish.

The quantity of fat was calculated based on the following formula

Weight of fat = (weight of petridish + extract)-(weight of the empty dish)

% of crude fat (ether extract) = (weight of the fat / 2.0) ×100

3.5.4. 3. Energy content

The energy in any sample is the crucial parameter deciding the nutritive value. This can be computed from the available nutrient information like starch, sugar, fat and protein content. This can be determined using bomb calorimeter. However for the convenience formula method was used.

3.5.4. 4. Calculation

Energy content of the sample can be computed using Atwater formula (FAO / WHO 1985).

Energy (KJ/100gm)

= 17 (% protein) + 38 (%fat) + 17 (% starch) + 16 (% total sugar)

Energy content is converted into kilo calories using the equation

1 Kcal = 4.186 KJ

3.6. Measurement of structural properties

3.6.1. Bulk density

The diameter of the extrudates was measured with a vernier caliper and length per unit weight (g) of the samples was also measured as suggested by Launay and Lisch (1983). The bulk density of the extrudates was determined by using the equation.

$P_b=4 / (\pi d^2 L)$

Where,

d- Diameter (cm)

L- Length (cm/g)

P_b- bulk density (g/cm^2)

3.6.2. True density (Apparent density)

The extrudates were milled and sieved through 500µm sieve. A 5ml graduated measuring cylinder was tared and gently filled with extrudates. The bottom of the cylinder was repeatedly tapped gently until there was no reduction of the sample volume and it was weighed (Bley *et al*., 2004). The apparent density of the extruded sample was calculated as mass/ unit volume. Three measurements were performed to calculate the average.

3.6.3. Porosity

The porosity of the extruded product is calculated according to the following equation (Tyler *et al.*, 1981)

Porosity = (Bulk volume- Apparent volume) ÷ Bulk volume

Bulk volume = 1/Bulk density (P_b)

Apparent volume = 1/apparent density (P_s)

$$P = 1-(P_b/P_s)$$

3.6.4. Expansion ratio

The expansion ratio of extrudates was calculated for various compositions by keeping die diameter constant. It was calculated as the ratio of the diameter of the extrudate to the diameter of the die (Gujska *et al*., 1990).

3.7. Objective analysis

3.7.1. Colour

Hunter lab colour flex meter (made by: Hunter Associates Laboratory, Reston, Virginia, USA) was used for the measurement of colour. It works on the principle of focusing the light and measuring the energy reflected from the sample across the entire visible spectrum. The colour meter has filters that relay on “standard observation curves” which defined the amount of red yellow and blue colours. It provides readings in terms of L, a, b. there parameters indicate the degree of brightness (L), degree of redness (+a) or greenness (-a) and the degree of yellowness (+b) or blueness (-b) respectively (Tyler *et al*., 1981).

Plate 3.2 Hunter lab colour flex meter

3.7.2. Texture

The texture of extruded product was measured with the help of TA.XT plus texture analyzer (Stable micro systems Ltd.). The texture analyzer is a microprocessor controlled texture analysis system. It measures force, distance and time, thus providing thee dimensional product analysis. The probe carrier contains a very sensitive load cell. Compression platens were used for conducting the test. Size of the probe used was 5mm at test speed of 2mm/s.

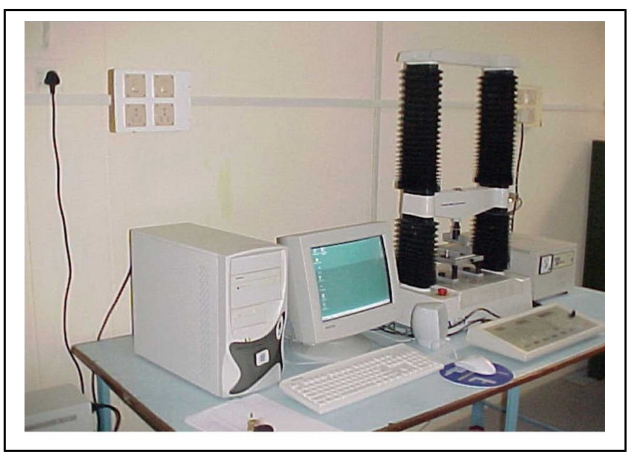

Plate 3.3 Experimental set up of Texture Analyzer

3.8. Sensory evaluation of extruded products

When the quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or subjective or organoleptic. Sensory quality is a combination of different senses of perception coming into play in choosing and eating a food. Appearance, flavour and mouth feel decide the acceptance of the food. Sensory analysis was done by consuming the product by a sensory panel. Details of the parameters are discussed below.

3.8.1. Sensory characteristics of the food

3.8.1.1. Appearance

Surface characteristics of the food products contribute to the appearance. Sight plays an important role in the assessment of extruded foods.

3.8.1.2. Colour

Colour is used as an index to the quality of number of foods.

3.8.1.3. Flavour

The flavour of food has three components – odour, taste and mouths feel.

A substance which produces odour must be volatile and the molecules of the substance must come in contact with receptors in the epithelium of the olfactory organ. Aroma is able to penetrate even beyond the visual range when comparatively volatile compounds are abundant.

We value food for its taste. Taste sensation which the taste buds register are categorized as sweet, salt, sour or bitter. The pleasant sensations in eating come more from odour than from taste.

Texture indicates the easiness of the mouth to disintegrate and swallow the food. The brittleness of the food is another aspect of texture.

3.8.2. Conducting sensory test

Two sets of sensory evaluations were conducted. In the first set extrudates of different treatment at 170^0C were coated with sugar, cardamom, and vanilla essence and in the second set chat masala, chicken powder, pepper powder and sauce were coated.

3.8.2.1. Preparation of samples

1. The extrudates of 12g from different treatments were fried with coconut oil for seven minutes and were uniformly coated with sugar (2g), cardamom (0.1g), and vanilla essence (1 drop).

2. The extrudates of 18g from different treatments were fried with coconut oil for seven minutes and were uniformly coated with chat masala (2g), chicken powder (0.25g), pepper powder (0.1g) and sauce (1 ml).

Marked samples were displayed in uniform coloured plates in a well lighted room for sensory analysis to identify the samples.

3.8.2.2. Panel members

We selected 10 panel members whose sensitivity and consistency have been good. They analysed the samples and made judgements on appearance, colour, odour, taste and texture were observed by a five point hedonic rating scale. The scale was easily understood by each of the panelist and their response was converted to numerical values for computation purpose.

The following five point hedonic scale (excellent-5, very good-4, good-3, fair-2, poor-1) was used for this purpose (Lima *et al*.,2007).

Final results were obtained by calculating the average of all the marks given by panelist.

4. RESULTS AND DISCUSSIONS

This chapter includes results of proximate analysis, structural properties, colour analysis, objective analysis of texture and sensory analysis.

4.1. Proximate analysis

The starch, sugar, protein and fat content of the extrudates were found out by proximate analysis and is given in the table below.

Sample	Starch (%)	Sugar (%)	Protein (%)	Fat (%)	Energy content (kJ/100gm)
T1 50:50	76.27	4.94	8.05	0.4	1514
T1 60:40	76.27	6.0	7.0	**6.0**	**1739.57**
T1 70:30	76.9	4.15	7.5	4.15	1658.9
T1 80:20	75.6	4.94	8.05	4.94	1694.60
T1 90:10	76.6	4.27	**8.55**	4.27	1676.51
T2 50:50	74.3	5.34	6.3	0.3	1467.04
T2 60:40	76.27	5.117	7.0	0.45	1514.56
T2 70:30	73.7	4.24	7.35	0.1	1449.49
T2 80:20	72.55	8.86	6.47	0.05	1487
T2 90:10	73.1	4.92	8.4	0.15	1469
T3 50:50	**77.58**	9.6	6.1	0.05	1578.06
T3 60:40	74.3	**11.5**	5.95	0.05	1550.15
T3 70:30	74.3	6.4	7.0	0.1	1488.3
T3 80:20	74.66	6.5	7.35	0.05	1500.04
T3 90:10	77.5	7.15	7.5	0.05	1561.3
T4 50:50	77.58	9.6	6.1	0.05	1578.06
T4 60:40	76.27	7.81	6.65	0.1	1538.4
T4 70:30	74.3	6.4	7.0	0.1	1488.3
T4 80:20	74.66	6.5	7.35	0.05	1500.07
T4 90:10	77.5	7.15	7.7	0.05	1564.7

Table 4.1 Results of Proximate analysis

T1-*Njavara*:Banana (fortified with milk), T2- *Njavara*:Banana, T3- *Basmati*:Banana (fortified with milk),T4- *Basmati*:Banana

In the proximate analysis highest starch (77.58), sugar (11.5), protein (8.55) and fat (6.0) was observed for *Basmati* :Banana (50:50,fortified with milk), *Basmati* :Banana (60:40,fortified with milk), *Njavara*:Banana (90:10, fortified with milk), *Njavara*:Banana (80:20, fortified with milk) respectively. Higher energy content was obtained for *Njavara*:Banana (60:40, fortified with milk).

4.2 Structural properties

The structural properties of the extrudates were found out by standard laboratory procedure as mentioned in chapter 3 and their variation with sample ratio and temperature are represented in the graphs shown below.

4.2.1. Effect of temperature and feed composition on bulk density

4.2.1.1. *Basmati*: Banana

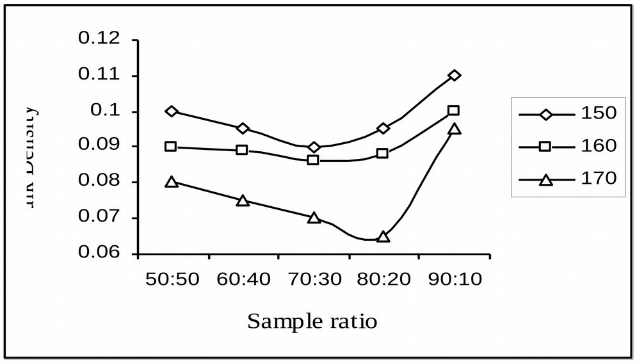

Fig 4.1 Effect of temperature on bulk density of treatment 4

From fig 4.1, Decrease in die temperature was found to cause rise in bulk density from 0.095 to 0.11 g/cm^3. This was in accordance with the result of Yacu (1995) and the highest value of bulk density was noted for the extrudates with lower proportion of banana.

4.2.1.2. *Basmati*: Banana (fortified with milk)

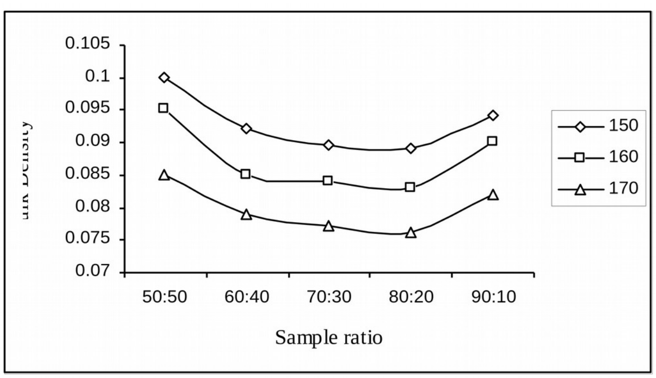

Fig 4.2 Effect of temperature on bulk density of treatment 3

The highest value of bulk density (0.1 g/cm^3) was noted at 150^{0}C for the sample with the ratio of 50:50 and then it decreased for further proportions and slight increase was observed when the proportion was 90:10.

4.2.1.3. *Njavara*: Banana

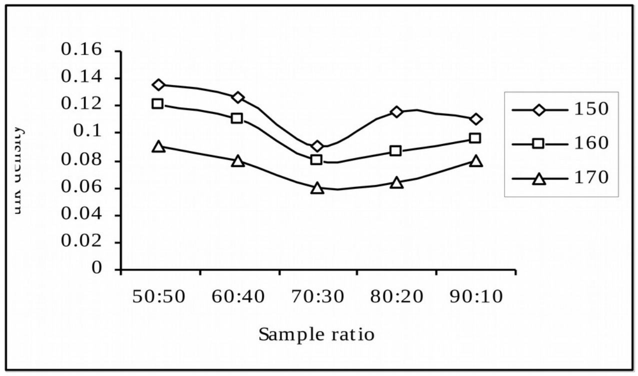

Fig 4.3 Effect of temperature on bulk density of treatment 2

The bulk density of extrudates enhanced with decrease in die temperature. Highest value of bulk density was observed for the ratio of 50:50 at 150^0C (0.135 g/cm^3).

4.2.1.4. *Njavara*: Banana (fortified with milk)

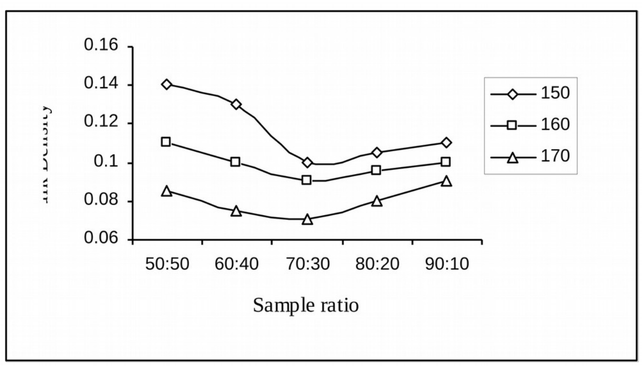

Fig 4.4 Effect of temperature on bulk density of treatment 1

Bulk density was minimum for the proportion of 70:30 at 170^0C (0.07 g/cm^3). Bulk density has a negative correlation with percentage of *Njavara* or *Basmati* rice up to 70:30 and then increased.

4.2.2. Effect of temperature and feed composition on expansion

4.2.2.1. *Basmati*: Banana

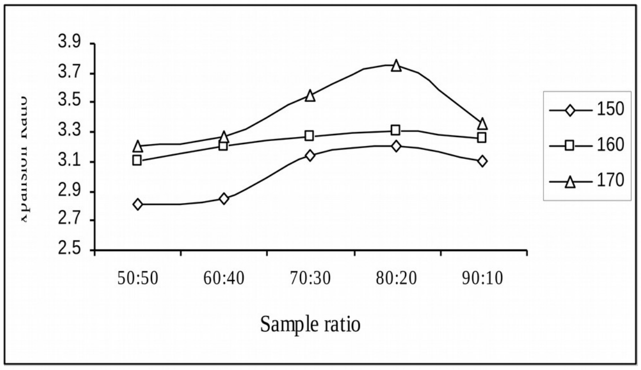

Fig 4.5 Effect of temperature on expansion ratio of treatment 4

The expansion ratio was highest for 170^{0}C (3.75) for the ratio of 80:20 and in general, temperature beyond 150^{0}C was found to cause significant increase in diameter of extrudates. When die temperature was low, less flashing occurred at the die, resulting in less overall expansion (Yacu, 1995).

4.2.2.2. *Basmati*: Banana (fortified with milk)

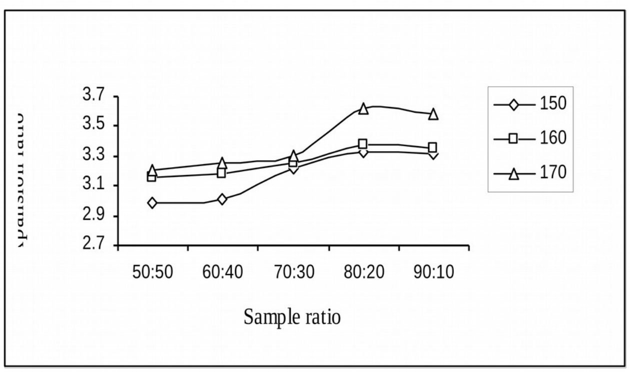

Fig 4.6 Effect of temperature on expansion ratio of treatment 3

Generally, the expansion ratio was lower for the extrudates fortified with milk (3.62) for the sample 80:20. The expanded matrix in the extrudate was provided by the starch component (Kokini *et al*., 1991).

4.2.2.3. *Njavara*: Banana

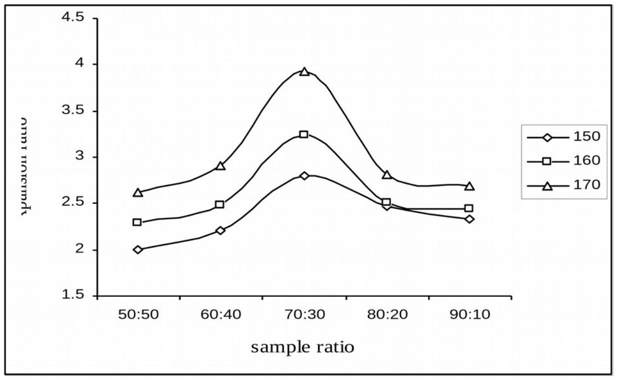

Fig 4.7 Effect of temperature on expansion ratio of treatment 2

Extrudates from *Njavara* rice had higher expansion ratio (3.92) for the sample 70:30 at 170^{0}C.

4.2.2.4. *Njavara*: Banana (fortified with milk)

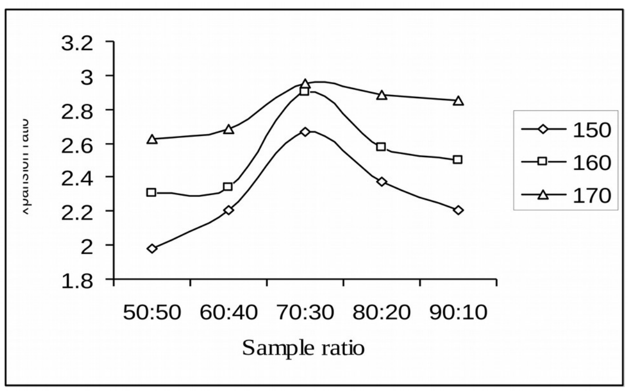

Fig 4.8 Effect of temperature on expansion ratio of treatment 1

Khalil Khan *et al.* (1990) suggested the quantity of protein was important for determining expansion ratio of extrudates. Addition of milk resulted change in protein content which caused decrease in expansion ratio from 3.92 to 2.95 for the sample 70:30 at 170^{0}C. Expansion Ratio has a positive correlation with percentage of *Njavara* or *Basmati* rice up to 70:30 and 80:20, respectively and then decreased. Extrudate exhibited a better expansion ratio for the proportion of 70:30 and 80:20 for *Njavara* rice and *Basmati* rice respectively.

PLATE 4.1 Extrudates of different treatments at 170^{0}C

Extrudates obtained from the blend of *Njavara*, banana and mushroom in the ratio of 50:40:10 (T5) showed lower expansion. This is due to the high protein content of mushroom. Owing to this reason mushroom was discarded in the second trial.

4.2.3. Effect of temperature and feed composition on porosity

4.2.3.1. *Basmati*: Banana

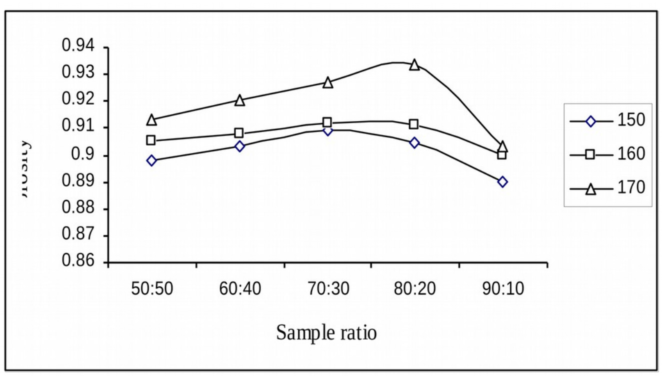

Fig 4.9 Effect of temperature on porosity of treatment 4

Increase in die temperature resulted in increase in porosity of extrudates and is maximum at 170^{0}C (93.33%).

4.2.3.2. *Basmati*: Banana (fortified with milk)

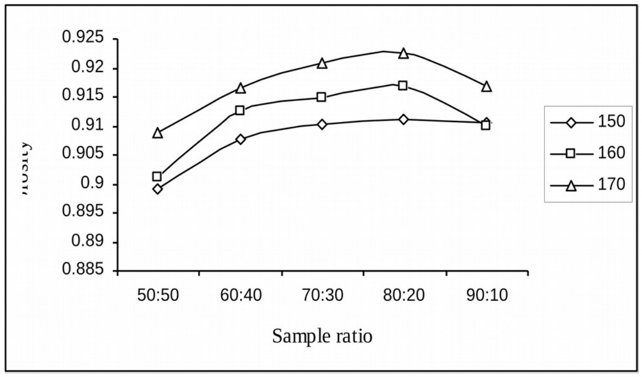

Fig 4.10 Effect of temperature on porosity of treatment 3

Maximum porosity was observed for the ratio of 80:20 at the die temperature of 170^{0}C (92.24%).

4.2.3.3. *Njavara*: Banana

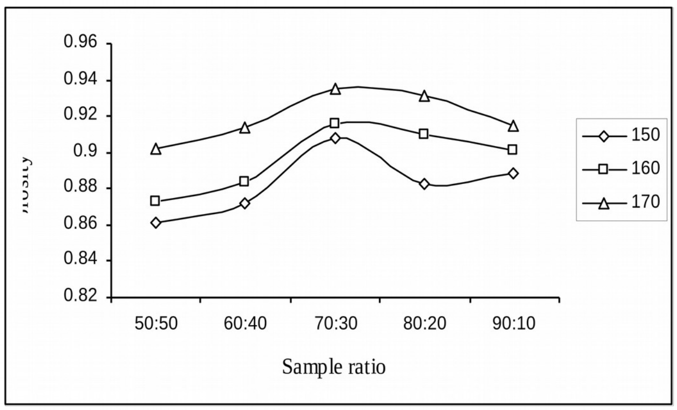

Fig 4.11 Effect of temperature on porosity of treatment 2

Maximum porosity was observed for the ratio 70:30 at die temperature of 170^{0}C (93.48%). Increase in porosity was probably due to the concurrent reduction in the level of fiber. The same trend was observed in fig 4.12.

4.2.3.4. *Njavara*: Banana (fortified with milk)

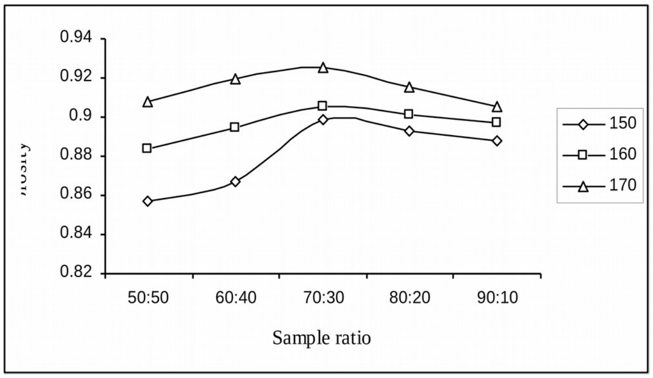

Fig 4.12.Effect of temperature on porosity of treatment 1

In general, *Njavara* extrudate with rice exhibited a better porosity over *Basmati* rice. Addition of milk increased porosity of extruded product. Porosity has a positive correlation with percentage of *Njavara* or *Basmati* rice up to 80:20 and then decreased.

4.3. Results of Colour Analysis

The colour of the powdered extruded products was found out by Hunter lab colour flex meter and graphs were plotted as shown below.

4.3.1. *Basmati*:Banana

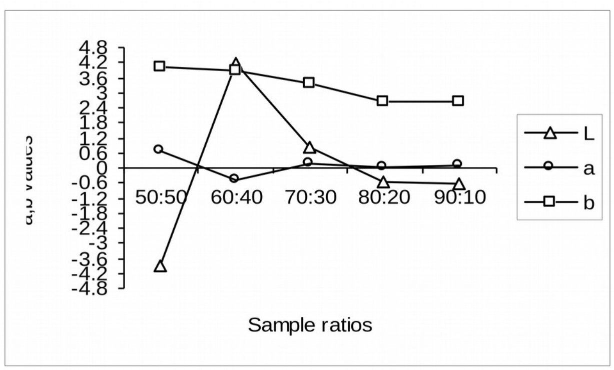

Fig 4.13 Effect of sample ratio on colour of treatment 4

4.3.2. *Njavara*:Banana

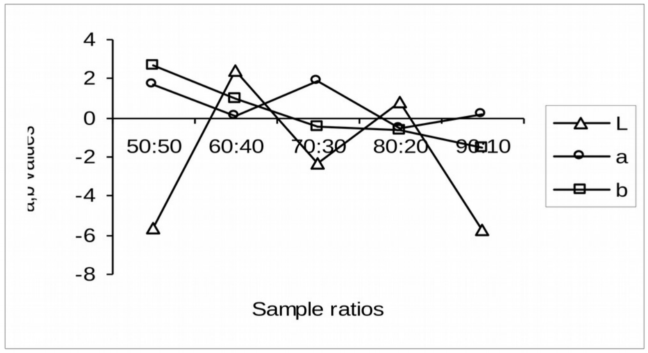

Fig 4.14 Effect of sample ratio on colour of treatment 2

The degree of brightness was maximum when the sample ratio is 60:40 and then slowly decreased. Minimum ‘a’ (greenness) value was observed for the proportion 60:40.The ‘b’ (yellowness) value decreased as the proportion of banana flour decreased.

4.3.3. *Basmati*:Banana (fortified with milk)

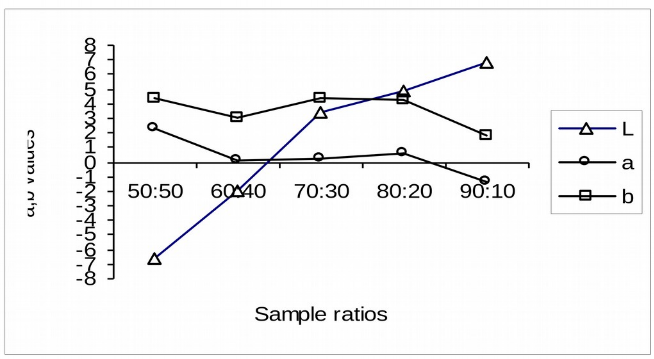

Fig 4.15 Effect of sample ratio on colour of treatment 3

4.3.4. *Njavara*:Banana (fortified with milk)

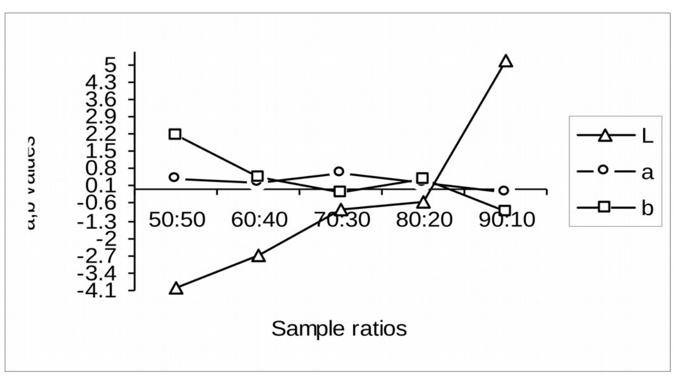

Fig 4.16 Effect of sample ratio on colour of treatment 1

The degree of brightness increased as the proportion of banana flour decreased. The ‘a’ and ‘b’ value decreased when the cereal flour increased that means the colour of the extrudates tends to green and blue respectively.

4.4. Results of objective analysis on texture

Texture of the extruded product was determined using TA.XT plus texture analyzer and the results are tabulated below.

Sample	Hardness (N)	Toughness (Ns)
T1 50:50	81.54	58.01
T1 60:40	52.82	39.73
T1 70:30	60.14	36.42
T1 80:20	92.29	56.03
T1 90:10	90.73	50.53
T2 50:50	75.65	50.14
T2 60:40	**110.52**	**58.67**
T2 70:30	64.18	37.27
T2 80:20	**41.19**	**22.83**
T2 90:10	83.85	43.60
T3 50:50	68.73	41.08
T3 60:40	70.13	40.44
T3 70:30	65.58	33.38
T3 80:20	76.91	30.47
T3 90:10	85.94	34.96
T4 50:50	73.18	36.75
T4 60:40	78.78	50.01
T4 70:30	74.16	49.08
T4 80:20	69.20	29.56
T4 90:10	114.23	39.94

Table 4.2 Objective analysis on texture

T1-*Njavara*:Banana (fortified with milk), T2- *Njavara*:Banana, T3- *Basmati*:Banana (fortified with milk),T4- *Basmati*:Banana

From table 4.3 the results of objective analysis on texture pointed that the extruded product obtained from blend of *Njavara* rice and banana powder in the ratio of 60:40 and 80:20 at 170^{0}C possess the maximum and minimum value respectively.

4.5. Subjective analysis

The sensory test of the extrudates was conducted and the average value of each of the sensory characteristics is given below.

4.5.1. Extrudates with spicy coating

Sample	Flavour	Texture	Taste	Appearance	Total
T1 50:50	3.38	3.00	3.00	2.625	12.005
T1 60:40	3.00	2.50	2.00	2.00	9.50
T1 70:30	3.10	2.65	2.20	2.45	10.40
T1 80:20	3.5	2.12	2.90	3.00	11.52
T1 90:10	2.00	1.50	1.62	2.00	7.12
T2 50:50	2.00	1.20	1.50	2.00	6.70
T2 60:40	3.00	2.10	1.13	3.25	11.48
T2 70:30	2.89	2.75	1.80	2.50	9.94
T2 80:20	1.90	2.85	3.00	1.65	9.40
T2 90:10	2.45	1.50	2.46	2.02	8.43
T3 50:50	1.92	2.56	2.40	1.90	8.78
T3 60:40	2.56	2.85	3.20	1.90	10.51
T3 70:30	2.50	1.5	3.50	2.70	10.20
T3 80:20	2.11	2.70	3.02	2.50	10.33
T3 90:10	3.25	3.25	2.50	2.625	11.625
T4 50:50	3.52	2.40	3.12	2.54	11.58
T4 60:40	3.24	2.7	1.56	2.80	10.3
T4 70:30	2.75	3.12	3.20	1.50	10.57
T4 80:20	1.20	1.46	1.92	1.67	6.25
T4 90:10	**3.125**	**3.00**	**3.00**	**2.90**	**12.025**

Table 4.3 Sensory analysis of extrudates with spicy coating

T1-*Njavara*:Banana (fortified with milk), T2- *Njavara*:Banana, T3- *Basmati*:Banana (fortified with milk),T4- *Basmati*:Banana

4.5.2. Extrudates with sugar coating

Sample	Flavour	Taste	Texture	Appearance	Total
T1 50:50	2.78	2.78	2.67	2.67	10.90
T1 60:40	3.56	3.67	3.89	3.78	14.90
T1 70:30	2.89	2.33	2.89	2.89	11.00
T1 80:20	2.89	3.00	3.33	3.11	12.33
T1 90:10	2.89	3.00	3.22	3.33	12.44
T2 50:50	3.88	4.22	3.77	3.44	15.31
T2 60:40	3.11	3.44	3.56	3.23	13.44
T2 70:30	**4.22**	**4.33**	**4.33**	**3.94**	**16.85**
T2 80:20	3.33	3.67	3.89	3.72	14.61
T2 90:10	3.00	2.67	2.78	3.00	11.45
T3 50:50	3.83	2.67	3.14	2.69	12.33

Sample	Flavour	Taste	Texture	Appearance	Total
T3 60:40	3.33	3.28	3.28	3.33	13.22
T3 70:30	3.11	3.12	3.28	2.98	12.49
T3 80:20	3.11	3.67	3.33	2.89	09.44
T3 90:10	2.89	2.33	3.89	2.89	12.00
T4 50:50	2.89	3.00	3.42	3.56	12.87
T4 60:40	3.33	2.67	3.56	2.89	12.45
T4 70:30	3.11	3.56	3.22	3.00	12.89
T4 80:20	2.78	2.58	3.14	3.68	12.08
T4 90:10	3.00	2.10	2.42	3.00	10.52

Table 4.4 Sensory analysis of extrudates with sugar coating

T1-*Njavara*:Banana (fortified with milk), T2- *Njavara*:Banana, T3- *Basmati*:Banana (fortified with milk),T4- *Basmati*:Banana

The results of organoleptic evaluation are presented in table 4.3 and 4.4 and the samples with spicy and sugar coating are given in plate 4.2. From the results it can be interpreted that the extruded product obtained from blend of *Basmati* rice and banana powder in the ratio of 90:10 and extrudate from *Njavara* rice and banana powder in the ratio of 70:30 at 170^{0}C gave the best product for spicy and sugar coating respectively when evaluated as a ready- to- eat snack.

PLATE 4.2 Extrudates with spicy and sugar coating

5. SUMMARY AND CONCLUSION

A ready to eat cereal based extruded product was developed by blending of speciality rice like *Njavara*, *Basmati* with *Nendran* banana powder in different ratios. The moisture content of blend was standardized to 16% with water/milk. Each blend was extruded and the observations were taken at three die temperatures viz; 150^0C, 160^0C, 170^0C and extrudates were subjected to standard laboratory procedures for proximate and sensory analysis along with objective studies on texture and colour. The observations of the study can be summarized as follows.

Increase in temperature resulted in enhancement of expansion ratio and porosity of the extrudates. In the proximate analysis highest starch, sugar and protein content was observed for *Basmati*:Banana(50:50,fortified with milk),*Basmati* :Banana (60:40,fortified with milk), *Njavara*:Banana (90:10, fortified with milk) respectively. Fat and energy content was higher for *Njavara*:Banana(60:40, fortified with milk).

The addition of milk increased porosity but reduced expansion ratio. In general the extrudates obtained from blending *Njavara* and *Nendran* banana powder in the ratio 70:30 and *Basmati* with *Nendran* banana in the ratio 90:10 with the exit temperature of 170^0C were adjudged superior in quality by conducting sensory test for spicy and sugar coating respectively. In the first stage of study mushroom powder was also blended, later it was discarded due to the lower expansion ratio.

The results of objective analysis on texture revealed that the extruded product obtained from blend of *Njavara* rice and *Nendran* banana powder in the ratio of 60:40 and 80:20 at 170^0C possess the maximum and minimum value for hardness and toughness respectively.

In the colour analysis it was found that the minimum ‘a’ (greenness) value and maximum brightness was for *Njavara/ Basmati* with Banana in the ratio 60:40 and then slowly decreased. The ‘b’ (yellowness) value decreased as the proportion of banana flour decreased. While in the case of samples fortified with milk the degree of brightness increased as the proportion of banana flour decreased. The ‘a’ and ‘b’ value decreased when the cereal flour increased that means the colour of the extrudates tends to green and blue respectively.

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APPENDIX I

Physical properties of extrudates at different temperature and feed composition

Sample	Bulk density (g/ cm^3)			True density (g/ cm^3)			Porosity			Expansion ratio		
	150^{0}C	160^{0}C	170^{0}C	150^{0}C	160^{0}C	170^{0}C	150^{0}C	160^{0}C	170^{0}C	150^{0}C	160^{0}C	170^{0}C
T1 50:50	0.14	0.11	0.085	0.975	0.945	0.92	0.856	0.884	0.908	1.98	2.3	2.62
T1 60:40	0.13	0.1	0.075	0.975	0.945	0.925	0.867	0.894	0.919	2.2	2.34	2.68
T1 70:30	0.1	0.09	0.07	0.98	0.95	0.93	0.898	0.905	0.925	2.66	2.9	2.95
T1 80:20	0.105	0.095	0.08	0.98	0.96	0.94	0.893	0.901	0.915	2.37	2.57	2.88
T1 90:10	0.11	0.1	0.09	0.98	0.965	0.95	0.888	0.896	0.905	2.2	2.5	2.85
T2 50:50	0.135	0.12	0.09	0.97	0.94	0.915	0.861	0.872	0.902	2	2.28	2.62
T2 60:40	0.125	0.11	0.08	0.97	0.945	0.92	0.871	0.884	0.913	2.2	2.48	2.9
T2 70:30	0.09	0.08	0.06	0.975	0.945	0.92	0.908	0.915	0.935	2.79	3.23	3.92
T2 80:20	0.115	0.086	0.064	0.98	0.95	0.93	0.883	0.909	0.931	2.47	2.5	2.81
T2 90:10	0.11	0.095	0.08	0.985	0.955	0.935	0.888	0.901	0.914	2.33	2.43	2.68
T3 50:50	0.1	0.095	0.085	0.99	0.96	0.93	0.899	0.901	0.909	2.98	3.15	3.2
T3 60:40	0.092	0.085	0.079	0.995	0.97	0.945	0.908	0.912	0.916	3	3.17	3.25
T3 70:30	0.0895	0.084	0.077	0.995	0.985	0.97	0.911	0.915	0.921	3.21	3.25	3.3
T3 80:20	0.089	0.083	0.076	1	0.995	0.98	0.911	0.917	0.922	3.32	3.37	3.62
T3 90:10	0.094	0.09	0.082	1.05	1	0.985	0.910	0.91	0.917	3.31	3.35	3.58
T4 50:50	0.1	0.09	0.08	0.98	0.95	0.92	0.898	0.906	0.913	2.8	3.1	3.2
T4 60:40	0.095	0.089	0.075	0.98	0.965	0.94	0.903	0.908	0.920	2.85	3.2	3.26
T4 70:30	0.09	0.086	0.07	0.985	0.97	0.96	0.909	0.911	0.928	3.14	3.26	3.55
T4 80:20	0.095	0.088	0.065	0.99	0.985	0.975	0.904	0.911	0.933	3.2	3.3	3.75
T4 90:10	0.11	0.1	0.095	1	0.995	0.98	0.890	0.899	0.903	3.1	3.25	3.35

APPENDIX II

Colour parameters of extrudates at 170^{0}C

Sample	L	a	b
T1 50:50	-3.986	0.366	2.0966
T1 60:40	-2.686	0.176	0.403
T1 70:30	-0.893	0.57	-0.166
T1 80:20	-0.604	0.238	0.3493
T1 90:10	5.146	-0.16	-0.9366
T2 50:50	-5.646	1.686	2.63
T2 60:40	2.42	0.066	0.916
T2 70:30	-2.35	1.843	-0.433
T2 80:20	0.815	-0.535	-0.69
T2 90:10	-5.8	0.12	-1.53
T3 50:50	-6.6	2.32	4.37
T3 60:40	-2	0.03	2.953
T3 70:30	3.38	0.14	4.35
T3 80:20	4.86	0.56	4.23
T3 90:10	6.773	-1.376	1.75
T4 50:50	-3.95	0.66	3.97
T4 60:40	4.113	-0.52	3.86
T4 70:30	0.81	0.11	3.32
T4 80:20	-0.603	0.026	2.59
T4 90:10	-0.63	0.1	2.61

DEVELOPMENT AND QUALITY EVALUATION OF READY TO EAT FOOD FROM SPECIALITY RICE AND NENDRAN BANANA

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ABSTRACT OF THE PROJECT REPORT

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ABSTRACT

Njavara/ basmati, was blended with *Nendran* banana powder in the ratios: 60:40, 70:30, 50:50, 80:20 and 90:10 respectively. The moisture content of the blend was made to 16% by adding water/milk. Each blend was extruded in a Brabender single screw extruder using 500gm per trial at 80 rpm with three extruder exit temperatures (150, 160, 170^{0}C) through a 2mm die. When the temperature increased beyond 150^{0}C, there was considerable increase in the expansion ratio (3.2-3.75), where as in the case of milk there was slight decrease in expansion ratio (3.08). Higher die temperature caused decrease in bulk density, while addition of milk produced not much effect on bulk density. In the colour analysis, addition of milk caused rise in 'L'value and decrease in 'a' and 'b' values with increase in proportion of cereal flour. But in the case of without milk, the 'a' and 'b' value decreased with increase in cereal flour. In sensory analysis the extrudate from njavara and banana (70:30) and basmati with banana (90:10) at 170^{0}C were adjudged superior in quality for sugar and spicy coating respectively. In the first stage of study mushroom powder was also blended, later it was discarded due to lower expansion ratio.