DEVELOPMENT OF FIBRE FORTIFIED PASTA USING BANANA PEEL POWDER

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DECLARATION

We here by declare that this project report entitled **"DEVELOPMENT OF FIBRE FORTIFIED PASTA USING BANANA PEEL POWDER"** is a bonafide record of project work done by us during the course of project 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 any other university or society.

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CERTIFICATE

Certified that this project report entitled **"DEVELOPMENT OF FIBRE FORTIFIED PASTA USING BANANA PEEL POWDER"** is a record of project work done jointly by Ashitha.G.N, Athira Dayanandan and Naslin.N under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship to them.

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Dedicated to

Agricultural Engineering Profession

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SYMBOLS AND ABBREVIATIONS

%	Percentage
ΔE	Total colour difference
≈	Approximate
AD	After death
ADA	American Dietetic Association
ADF	Antioxidant dietary fibre
BP	Banana peel
CD	Celiac disease
Cfu	Colony forming unit
CRD	Completely Randomized Design
Dwb	dry weight basis
DM	Dry matter
DF	Dietary fibre
et al.,	and others
etc.	etcetera
Fig.	Figure
FAC	Fat adsorption capacity
FDA	Food and Drug Administration
FT-NIR	Fourier Transform Near-Infrared
g	Gram(s)
g-1	per gram
GI	Glycemic index
h	hour(s)
HI	Hydrolysis index
Ha	Hectare
i.e.	that is
IDF	Insoluble dietary fibre
IS	Indian Standard
IU	Int. Units

K.C.A.E.T	Kelappaji College of Agricultural Engineering and Technology
KAU	Kerala Agricultural University
Kg	kilogram
kgcm-2	kilogram per square centimeter
KJ	Kilo Joules
kW	kilo Watt
L	Luminosity, Litre(s)
LDPE	Low Density Poly Ethylene
L-1	per litre
Mm	milli meter
mg	milli gram
min	minute(s)
ml	milliliter
M ha	million hactare
MT	Metric tones
MT	Million tonnes
nm	nanometer
N	Normality, Newton
NHB	National Horticulture Board
NIIR	National Institute of Industrial Research
No.	Number
oB	Degree Brix
oC	Degree Celsius
oF	Degree Fahrenheit
P	Probability
PE	Pectin Estrase
PFA	Prevention of Food Adulteration
ppm	parts per million
PPO	Polyphenol oxidase
Rpm	Revolution per minute
RH	Relative Humidity
RTU	Ready-to-Use
Sec	second(s)
S	Significant

SD	Standard Deviation
SDF	Super Dimension Fortress
SW	Swelling capacity
TPA	Texture Profile Analysis
TSS	Total soluble solids
viz.,	namely
wt.	weight
w/w	weight/weight
WGP	Wine grape pomace
WP	whole pomace powder
WRC	water retention capacity

INTRODUCTION

CHAPTER I

INTRODUCTION

Fruits and vegetables play an important role in human diet and nutrition. They are indispensable sources of essential dietary nutrients, vitamins and minerals besides providing crude fibre. The production of fruits and vegetables in India during 2010-11 is 74877.6 MT and 146554.5MT, respectively (National Horticulture Board, 2011). Though India is the largest producer of fruits and vegetables next to China, , the lack of processing and storage of fruits and vegetables results in huge wastes estimated about 35 %, which is approximately Rs 30,000 crores annually (Ministry of Food Processing Industries, 2011). Therefore the thrust should be to process and convert such perishable commodities into value added products that can be stored for extended periods there by reducing losses and making them available throughout the year.

Banana (*Musa paradisiaca*) belongs to Musceae family, is one of the oldest tropical fruits cultivated by man from prehistoric time in India with great socio-economic significance. It is indigenous to Asia, originated in the mountainous region of Indo-China. From there it has spread to tropical parts of America, Africa, Australia, Philippines and Hawaii. It is the fourth important food crop in terms of gross value after paddy, wheat and milk products and forms an important crop for subsistence farmers. India is the largest producer of banana with an annual production of around 29780MT during 2010 -11 from an area of 830 HA which contributes 39.8% of the total fruit production. Among the different states, Tamilnadu produces the maximum with 8253 MT during 2010-11-08 from an area of 125.4 ha. Though this state has the highest banana production level in the country, it does not enjoy the highest productivity level, which is bagged by Maharashtra (NHB, 2008-2009). In Kerala banana is cultivated in the entire state and is an integral part of homestead farming system. Banana is a vegetable as well as fruit apart from being used for the preparation of various value added products. It provides a more balanced diet than any other fruit or vegetable. It is also a desert fruit for millions apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67 to 137 Calories/100 g fruit (Chandler, 1995).

Among the different varieties of banana, Nendran is the most popular one. Production of Nendran variety of banana in Kerala during 2006-07 is 463.766 MT from an area of 0.059

M ha (Farm guide, 2009). The unripe banana of proper maturity is widely used for making chips. Banana wafers is a popular snack food in South India especially in Kerala. It has good internal as well as external demand. The wafers can be prepared throughout the year since banana is available at cheap price in all seasons. The commercial chip production involves mainly four unit operations such as peeling, slicing to small wafers, frying and packaging.

The long-term objective of our country's economic development is a good balance between a strong industrial sector and a resilient agricultural sector. The development of micro, small and medium scale rural agro industry is seen as a strategic step towards achieving this goal. There are large numbers of micro and small scale food processing enterprises run by farmers, which produce a wide variety of processed foods. Processed foods /snack foods may be described as mini meals in between main meals. Snacks like banana chips, jack fruit chips, coconut chips etc are light to eat and serve a variety of useful purposes in our day to day life. Banana chips making has already developed into a cottage and small scale industry in Kerala and the product is in high demand in India as well as abroad, especially in Middle East countries. There is great potential for this to be developed further, exploiting the domestic and fast increasing export demand.

Significant quantities of banana or plantain peels, equivalent to 40% of the total weight of fresh banana, are generated as a waste product in industries producing banana chips. At present, these peels are not being used for any other purposes and are mostly dumped as solid waste at large expense. It is thus significant and even essential to find applications for these peels as they can contribute to real environmental problems. The manipulation of food processing wastes is now becoming a very serious environmental issue. Potential application for banana peel depends on its chemical composition. Banana peel is rich in dietary fibre, proteins, essential amino acids, polyunsaturated fatty acids and potassium.

Pasta is a part of well balanced diet.http://en.wikipedia.org/wiki/Pasta - cite_note-2 It is also commonly used to refer to the variety of pasta dishes. Typically pasta is made from an unleavened dough of a durum wheat flour mixed with water and formed into sheets or various shapes, then cooked and served in any number of dishes. Pastas may be divided into two broad categories, dried (*pasta secca*) and fresh (*pasta fresca*).

Most dried pasta is commercially produced via an extrusion process. Fresh pasta was traditionally produced by hand, sometimes with the aid of simple machines, but today many varieties of fresh pasta are also commercially produced by large scale machines, and the products are widely available in supermarkets. Both dried and fresh pasta come in a number of shapes and varieties, with 310 specific forms known variably by over 1300 names having been recently documented. In Italy the names of specific pasta shapes or types often vary with locale. For example the form *cavatelli* is known by 28 different names depending on region and town. Common forms of pasta include long shapes, short shapes, tubes, flat shapes and sheets, miniature soup shapes, filled or stuffed, and specialty or decorative shapes.

Pasta is an excellent source of complex carbohydrates, which provide a slow release of energy. Unlike simple sugars that offer a quick, yet fleeting boost of energy, pasta helps sustain energy. Pasta is very low in sodium and cholesterol-free. Per cup, enriched varieties provide a good source of several essential nutrients, including iron and several B-vitamins. Whole wheat pasta can provide up to 25% of daily fibre requirements in every one cup portion.

Adding fibre to pasta seems a natural fit, but it can be challenging. Fibre-fortified pasta appeals to those who want the health benefits of whole wheat without the grainy taste and rougher texture of whole wheat pasta. As a whole pasta is rich in carbohydrates but not in fibre content. Fibre is a very much important content for digestion process. Thus taking into consideration, the lack of fibre in wheat pasta and wastage of fibre rich banana peels, the present study was undertaken with the following objectives

a) To study the effect of pre treatments on retention of colour of banana peel.

b) Preparation of fibre fortified pasta using banana peel powder.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

2.1 Agronomy

A banana is an edible fruit produced by several kinds of large herbaceous flowering plants in the genus *Musa*.[1] (In some countries, bananas used for cooking may be called plantains.) The fruit is variable in size, color and firmness, but is usually elongated and curved, with soft flesh rich in starch covered with a rind which may be green, yellow, red, purple, or brown when ripe. The fruits grow in clusters hanging from the top of the plant. Almost all modern edible parthenocarpic (seedless) bananas come from two wild species – *Musa acuminata* and *Musa balbisiana*. The scientific names of most cultivated bananas are *Musa acuminata*, *Musa balbisiana*, and *Musa* × *paradisiaca* for the hybrid *Musa acuminata* × *M. balbisiana*, depending on theirgenomic constitution. The old scientific name *Musa sapientum* is no longer used.

Musa species are native to tropical Indo-Malaya and Australia, and are likely to have been first domesticated in Papua New Guinea.[2][3] They are grown in at least 107 countries,[4] primarily for their fruit, and to a lesser extent to make fiber, banana wine and banana beer and as ornamental plants. In 2013 bananas were fourth among the main world food crops (after rice, wheat, and maize) in financial value.

2.2 Varieties

Cultivated varieties are broadly divided into two groups: table and culinary. Among the former are ‘Poovan’ in Madras also known as ‘Karpura Chakkare-keli’ in Andhra Pradesh; ‘Mortaman’, ‘Champa’ and ‘Amrit Sagar’ in West Bengal; ‘Basrai’, ‘Safed Velchi’, Lal Velchi’ and ‘Rajeli’ in Maharashtra; ‘Champa’ and ‘Mortaman’ in Assam and Orissa; and ‘Rastali’, ‘Sirumalai’, ‘Chakkare-keli’, ‘Ney Poovan’, ’Kadali’ and ‘Pacha Nadan’ in southern India. ‘Basrai’, which is known under different names, viz., ‘Mauritius’, ‘Vamankeli’, ‘Cavendish’, ‘Governor’, ‘Harichal’, is also grown in central and southern India. Recently, the ‘Robusta’ variety is gaining popularity in Tamil Nadu and Karnataka. The ‘Virupakshi’ variety (Hill banana) is the most predominant variety in the Palni Hills of

Tamil Nadu. Among the culinary varieties, Nendran, 'Monthan', 'Myndoli' and 'Pacha Montha Bathis' are the leading commercial varieties in southern India, 'Gros Michel' is a recent introduction into southern India; it is suitable for cultivation only under garden-land conditions and is generally fastidious in its cultural requirements. It is not, therefore, in favour with the cultivators.

2.3 Composition of banana

Shyamala B N et al., in 2010 reported that banana is a highly nutritious fruit which contains an ample proportion of nutritive constituents which are easily digested and absorbed, while available at reasonable cost. It is one of the most easily assimilated fruits. It has a rare combination of energy value, tissue building elements, proteins, vitamins and minerals. It is a good source of calorie being richer in solids and lower in water content than any other fresh fruit. A large banana supplies more than 100 calories. It contains a large amount of easily assimilable sugar, making it a good source of quick energy and an excellent means of recovery from fatigue. As the fruits of the banana trees are consumed at green, average ripe and ripe stages, the amount of fruit waste from the peels is expected to increase with the development of processing industries that utilize the green and ripe banana. Like its pulp flour counterpart, banana peel flour can potentially offer new products with standardized composition for various industrial and domestic uses. The peel of banana represents about 40% of the total weight of fresh banana and has been underutilized. Various studies have been conducted to investigate banana peel, including the production of banana peel flour , the effects of ripeness stage on the dietary fibre components and pectin of banana peels and the chemical composition of banana peel, as influenced by the maturation stage and varieties of banana.

2.4 Banana Peel

A banana peel is the outer covering of the banana fruit. As bananas, whether eaten raw or cooked, are a popular fruit consumed worldwide, with yearly production over 145 million tonnes in 2011, there is a significant amount of banana peel waste being generated as well.

Banana peels are used as feedstock as they have some nutritional value. Banana peels are widely used for that purpose on small farms in regions where bananas are grown. There are some concerns over the impact of tannins contained in the peels on animals that consume them. Banana peels are used as feedstock for cattle, goats, pigs, poultry, rabbits, fish and several other species. Banana peels are also used for water purification, to produce ethanol, cellulose, and lactase and in composting. (Debabandya Mohapatra et al.,2010).

2.5 Applications of banana peel

Hossain, et al., (2012) reported that banana peels are agricultural waste that discarded all over the world as useless material. They cause waste management problems although they have some compost and cosmetics potentiality. Besides that, banana peels have absorbent potentiality. It is very useful for purification and refining processes. Banana peel has absorption capabilities for some elements and ions in liquid or solution and that it can remove copper.

Sakaltar et al., 2011 revealed that banana peels also contain high potassium and phosphorus, which prove to be helpful in the compost. The substance could be used for medicine as well as personal care and known for anti-fungal and antibiotic properties, loaded with lot of vitamins, minerals and fibber that benefit for skin care and for healing the wound.

Banana peel has absorption capacities to remove chromium from wastewater (Memon, et al., 2008) and also some dyes (Velmurugan, et al., 2011). Unfortunately, the benefits of banana peels are not popular as many people still do not realise about.

2.6 Chemical composition and nutritive value of banana peel

Debabandya.M.*et al*.,2011 reported that banana peel is a rich source of starch (3%), crude protein (6-9%), crude fat (3.8-11%),total dietary fibre (43.2-49.7%), and polysaturated fatty acids, particularly linoleic acid ,pectin, essential amino acids(lecune, valine, phenylalanine and threonine), and micro nutrients(K,P,Ca,Mg).Except for lysine, content of all essential amino acids are higher than FAO standard. Maturation of fruits involves, increase in soluble sugar, decrease in starch and hemicelluloses and slight increase in protein and lipid content. Skin can also be utilised for extraction of banana oil (amyl acetate) that can be used for food flavouring. Banana peels are also good source of lignin (6-12%), pectin (10-

21%), cellulose (7.6-9.6%), hemicelluloses (6.4-9.4%) and galactouronic acid. Pectin extracted from banana peel can also be used in wine, ethanol production.

2.7 Inhibition of enzymic browning

Polyphenol oxidase (PPO) from fresh-cut Chinese water chestnut (CWC) was extracted and the effect of citric acid on the PPO activity assayed. Citric acid at low concentrations stimulated PPO activity, but at 0.1 M or higher markedly inhibited the activity. On the basis of the inhibition of PPO activity in vitro, the use of 0.1 M citric acid for shelf life extension and quality maintenance of fresh-cut CWC was investigated. Fresh-cut CWC were dipped in a solution of 0.1 M citric acid, placed in trays over-wrapped by plastic films, and then stored at 4 °C. Changes in surface discoloration, eating quality and disease incidence were evaluated. Treatment with 0.1 M citric acid markedly extended the shelf life, inhibited surface coloration and disease development, and reduced the loss in eating quality associated with the contents of ascorbic acid and total soluble solid, titratable acidity and ascorbic acid. It is suggested that application of citric acid better maintained quality and extended shelf life of fresh-cut CWC.

2.8 Fibre Fortification

Dietary fibre has been shown to aid in cardiovascular health, gastrointestinal health, cancer prevention, and weight management. Yet Americans fall short in their consumption of this important nutrient. The American Dietetic Association (ADA) recommends the consumption of 20–35 g of dietary fibre /day, but an average American currently eats only 12– 17 g. Since about one-fourth of this is soluble fibre, the average American is only consuming 3–4 g of soluble fibre / day, below the recommended 5–10 g.

2.8.1 Cardiovascular Health.

Bryan Tungland,, reported that soluble fibre has been proven to reduce blood cholesterol levels, thus helping to reduce the risk of heart disease. The heart-health benefits of fibre are acknowledged in the Food and Drug Administration's approved health claim for the relationship soluble dietary fibre. When used as an ingredient in food products, inulin can be measured and added to foods as a source of dietary fibre.

2.8.2 Gastrointestinal Health.

Fibre increases stool weight and improves laxation, maintaining regularity. Dietary fibre also functions as a prebiotic, increasing the number of beneficial microflora in the gut and enhancing the gastrointestinal system and immune system.

2.8.3 Weight Management.

Fibre-rich meals are processed more slowly, and nutrient absorption occurs over a greater time period. This aids in the feeling of satiety. Liu et al., 2003 conducted a study on more than 74,000 female nurses in the United States showed that those with the greatest increase in intake of dietary fibre gained an average of 1.52 kg less than did those with the smallest increase in intake of dietary fibre. Women in the highest quintile of dietary fibre intake had a 49% lower risk of major weight gain than did women in the lowest quintile.

2.8.4 Cancer.

Fibre has been associated with preventing certain types of cancer, such as bowel and breast. A study published last year (Bingham et al., 2003) examined the association between dietary fibre intake and incidence of colorectal cancer in 519,978 individuals age 25–70 years taking part in the European Prospective Investigation into Cancer and Nutrition study and concluded that in populations with a low average intake of dietary fibre, an approximate doubling of total fibre intake from foods could reduce the risk of colorectal cancer by 40%. To obtain these benefits, it is clear that people need to consume more fibre. This is where fibre-fortified foods can help. Since banana peel is a good source of fibre, food formulators can use banana peels for producing fibre fortified products.

2.10 Studies on fibre fortification

Saifullah Ramli *et al* (2009) studied about the utilization of banana peel as a functional ingredient in yellow noodle. Banana peel (BP) noodles prepared by partial substitution of wheat flour with green Cavendish banana peel flour were characterized for physicochemical properties and *in-vitro* starch hydrolysis. Cooked noodles were assessed for pH, colour, tensile strength and elasticity and *in-vitro* hydrolysis index (HI) and estimated glycemic index (GI). BP noodles had lower L* (darker) and b* values (less yellow) than the control noodles. The tensile strength of BP noodles was similar to control but their elasticity was higher. Following *in-vitro* starch hydrolysis studies, it was found that the GI of BP noodle was lower than control noodles. Partial substitution of banana peel into noodles may be useful for controlling starch hydrolysis of yellow noodles.

This report also suggested that it is considered desirable if the rate of ingestion and absorption of carbohydrates in noodles is reduced because this could be beneficial in the dietary management of metabolic disorders such as diabetes and hyperlipidaemia. Noodles prepared using plantain starch has been shown to exhibit limited digestibility due to their relatively high resistant starch content and a moderate *in-vitro* glycemic index. Since low glycemic index food release glucose at a slower rate compared to a higher glycemic index food, banana peels that contain a high amount of dietary fibre have potential to slow the rate of starch hydrolysis in yellow noodles. These studies indicated a high content of dietary fibre in the peel; it would be possible to utilize the peel as a functional ingredient in starch-rich products such as the yellow noodles.

Thongsombat, W., *et al* (2007) investigated on the production of guava juice fortified with dietary fibre. The production of guava juice fortified with soluble dietary fibre as pectin extracted from guava cake (peel, pulp, and seeds) was conducted. (Alkorta *et al.*, 1998). Guava cake (peel, pulp and seeds) a by-product from juice production, accounts for 30% of the guava fruit weight and is commonly used as animal feed or fertilizer. However, very recent investigations indicate that guava peel and pulp can also be used as a new source of dietary fiber (DF) and antioxidant phenolic compounds. Hence the waste guava cake from juice processing plant was used for pectin extraction using sodium hexa metaphosphate method followed by pectin precipitation using acidified ethanol method. A yield of 30.50±0.34% crude pectin was achieved. Crude pectin also contained 4.71±0.18% moisture, 0.34±0.21% protein, 0.68±0.00% ash, 20.70±0.16 g soluble dietary fibres. It was found that the perceived scores of the overall acceptability attribute decreased ($p<0.05$) with increasing of pectin concentration. The greatest perceived score of the mouth feel attribute was observed from the use of 0.25% pectin. Therefore, the optimum concentration of 0.25% soluble dietary fibre as pectin for guava juice fortification is selected for further guava juice processing. (Woranong Thongsombat, 2007).

Angela and Yanyun (2012) studied on wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. Dried whole pomace powder (WP) fortified products had dietary fibre content of 0.94-3.6% (w/w product), mainly insoluble fractions.

Wine grape pomace (WGP), the residual seed and skins 5 from winemaking, contain high phenolic compounds and dietary fibre (Deng, Penner & Zhao, 6 2011; Llobera & Cañellas, 2007).

Jiménez 8 et al. (2008) found that fibres from grapes show higher reducing efficacy in lipid profile and blood pressure than that from oat fibre or psyllium due to combined effect of dietary fibre and antioxidants.

WGP as ADF not only retarded human low-density lipoprotein oxidation *in vitro* (Meyer, Jepsen & Sorensen, 1998), but also helped enhance the gastrointestinal health of the host by promoting a beneficial microbiota profile (Pozuelo et al., 2012).

There are increasing interests in applying fruit processing wastes as functional food ingredients since they are rich source of dietary fibre, and most of the beneficial bioactive compounds are remained in those by products (Balasundram, Sundram & Samman, 2006). (Zhao, 2012)

Fernando Figuerola *et al*. carried out a research to evaluate some functional properties of fibre concentrates from apple and citrus fruit residues, in order to use them as potential fibre sources in the enrichment of foods. Fibre concentrates were analysed for their proximate content (moisture, lipids, protein and ash); caloric value; dietary fibre composition and functional properties (water retention capacity – WRC, swelling capacity – SW, fat adsorption capacity – FAC and texture). All the fibre concentrates had a high content of dietary fibre (between 44.2 and 89.2 g/100 g DM), with a high proportion of IDF. Protein and lipid contents ranged between 3.12 and 8.42 and between 0.89 and 4.46 g/100 g DM, respectively. The caloric values of concentrates were low (50.8–175 kcal/100 g or 213–901 kJ/ 100 g).

Apples are good sources of fibre with a well balanced proportion between soluble and insoluble fraction (Gorinstein et al., 2001). Apple pomace was incorporated into wheat flour as fibre source to improve the rheological characteristics of cake (Sudha, Baskaran & Leelavathi, 2007).

GrigelmoMiguel & Martin Belloso, 1998 reported that residues from orange juice extraction are potentially an excellent source of DF because this material is rich in pectin and may be available in large quantities. Citrus and apple fibres have better quality than other dietary fibres due to the presence of associated bioactive compounds, such as flavonoids, polyphenols and carotenes (Fernandez Gines, Fernadez Lopez, Sayas Barbera, & Perez Alvarez, 2003; Wolfe & Liu, 2003).

Khalid Bashir(2012) et al. studied about physio-chemical and sensory characteristics of pasta fortified with chickpea flour and defatted soy flour. Pasta is a popular carbohydrate based food because of its low glycemic index (GI) and ease of preparation, its low GI can be attributed to its specific structure. Effects of fortification of pasta with the combination of chickpea flour and defatted soy flour at different levels were assessed on the nutritional, sensory and cooking quality of the pasta. The fortification of durum wheat semolina was done by the combination of chickpea flour and defatted soy flour at levels (0,0)% containing only semolina as control, (10,6)%, (14,10)%, (18,14)% respectively. A novel legume fortified pasta product was successfully produced and it was observed as the concentration of legumes was increased the cooking time also increased. The cooking quality of the pasta was enhanced by steaming. On the basis of cooking and sensory quality, pasta containing 14% chickpea flour and 10% defatted soy flour resulted in better quality and nutritious pasta. Defatted soy flour and chickpea flour increased the protein, fibre and ash content of the pasta keeping the fat at optimum level. Fortification increased the cooking time, water absorption and stiffness of the samples than control. Fortified pasta was highly acceptable with respect to sensory attributes and cooking time. On the basis of cooking and sensory quality, pasta when fortified with blends of 10% Chickpea flour and 6% defatted soy flour resulted in better quality and nutritious pasta (carbohydrate content 68.61%, protein content 17.99%, fat content 1.40% and fibre content 4.19%). Resultant pasta can be used as a nutritious food for low income group in developing countries and for patients suffering with life style diseases.

Irene Fung and Sonia Malhotra(2011) studied about Psyllium husk fortified gluten-free pasta. Psyllium husk had been studied as a possible fibre source and a gluten replacer for those with celiac disease (CD). The use of psyllium in cooking might help to improve the life of CD patients by allowing them to consume fibre with regular meals instead of separately as a form of supplementation, which may not be as appealing in taste. In this experiment, the addition of two different ratios of psyllium powder was tested in a gluten-free pasta recipe. The products were served with marinara sauce to twenty-nine subjects. The ratings were generally somewhat acceptable. The potential of psyllium fortification in pasta might be useful in the future as an alternative fibre source for CD patients.

Vijay Jayasena *et al.,* (2007) revealed that noodles are widely consumed throughout the world and their global consumption is second only to bread. The instant noodle market is growing fast in Asian countries, and is gaining popularity in the Western market. Wheat flour which is usually used to make instant noodles is not only low in fibre and protein contents but also poor in essential amino acid lysine. Australian sweet lupin, a low cost grain legume, is becoming popular in various food applications as it is rich in fibre and protein with high lysine content. In addition, lupin contains a wide range of phytochemicals with beneficial health effects. The wheat flour in the traditional noodle formulation was replaced with 10, 20, 30, 40 and 50% lupin flour. The flours were mixed with other ingredients and instant noodle samples were prepared by extruding through 1.2 mm die (La Monferrina P3, Italy) using a standard method. The samples were evaluated for changes in colour and protein, fat and ash contents. The samples were cooked and analysed for colour, texture and sensory properties in comparison with the control sample. The results revealed that the extrusion rate decreased with the increase in lupin concentration. The colour of the uncooked and cooked noodles became more yellowish with the increase in lupin concentration. Addition of lupin up to 20% had no significant effect on the sensory properties of instant noodles. Addition of 20% lupin flour improved the nutritional value of the product by increasing protein by 42% and dietary fibre by 200%. The results showed that lupin flour can be incorporated up to 20% in instant noodles to improve the nutrient value without affecting the sensory properties.

2.9 Drying studies

Marilyn *et al*., reported that vegetables for drying should be fresh, tender and just mature .Avoid immature vegetables because their colour and flavour tend to be weak or poor. Also avoid excessively mature vegetables, which are inclined to be tough or woody .For best quality and nutrition, dry, vegetables as soon as possible after harvest. Ascorbic acid/citric acid dips are often used as a pre-treatment for fruits and vegetables. They prevent fruits such as apples, pears, peaches etc from turning brown when cut and exposed to air .For enhanced pathogen destruction, prepare a citric acid solution by stirring 1 teaspoon of citric acid crystals into one quart of cold water and place the fruit in solution and soak for 10 minutes.

Hernawati et al., has reported the physical and chemical characteristics of banana peels flour which was derived from oven and sun drying processes. Three varieties of banana (tanduk, nangka and kepok) were used as research material. Oven drying process was done for 24 hours in a temperature of 60^0C, whereas sun drying process was done within 3-4 days in an average temperature of 28^0C with duration 6 days/hour. After the drying process, banana peels was refined by a blender to produce banana peels flour. The results of the research showed that the product of flour from three different varieties of bananas undergoing the oven and sun drying process didn't produce bitter taste. Generally, both of drying processes produced soft flour, except sun drying process on kepok banana that produced rough flour. Banana's peel flour derived from oven drying process was darker in color, and more aromatic than the flour which was produced using the sun drying process. The proximate results for chemical element i.e.: protein, fat, BETN, dietary fibre, ash, calcium and phosphor degree, from three different varieties of bananas did not show significant differences ($P>0.05$) between oven and sun drying process, except in particular water and energy degree.

2.9.1 Preparation of banana peel flour

Abbas *et al.*, studied the physicochemical properties of banana peel flour. A total of 222-302 green (stage 1 of ripening: all green) and ripe (stage 6 of ripening: yellow with green tip) bananas of Cavendish and Dream variety were studied. The fruit were washed and separated into pulp and peel. To reduce enzymic browning, peels were then dipped in 0.5% (w/v) citric acid solution for 10 min, drained and dried in an oven at 60^0C overnight. The dried peels were ground in a Retsch Mill to pass through 40 mesh screens to obtain banana peel flour (BPF). The yield of flour was calculated by dividing the amount of flour produced by the amount of fresh banana used and the results were converted to g/Kg (g of flour/Kg of banana). All BPF's were stored in air tight plastic packs in cold storage (15±2˚C) for further analyses.

2.7 Pasta evolution

Pasta, one of the most consumed foods in the whole world, continues its evolution as a product as well as the way it is consumed. With the continuous flow of migration of various people to different countries, the knowledge of different habits including that of eating continues to spread. Various people consume various foods according to the availability of the raw materials in their respective countries. Similarly, the availability of the raw materials most of the time is conditioned by various factors such as the climatic conditions, quality of the soil, availability of arable lands and the socio-political-economic condition of the country. Among the most diffused foods are the different kinds of pasta. But pastas are not equal to all countries; The Arabian people, who travelled long distances across the desert, are believed to have been the first to make dried pasta as a means of preserving flour when the island of Sicily was under Arab rule (ad 827–1061). While many people believe that pasta originated in Italy, explorer Marco Polo is said to have introduced noodles into Italy from China in the late thirteenth century. The Italians then adapted them to create what we now know as pasta . The Italian pastas as they are known are produced with durum semolina. The other pastas available in Europe, particularly in the northern hemisphere, are made with soft wheat flour. The pastas in the Orient (most of Asian countries) are prevalently made of soft wheat but are processed in a different way from the pastas available in the Occident (Europe and the Americas). Pastas of other raw materials such as buckwheat (*soba*), rice flour (*beehoon*) and green mungbean starch (*tanghoon*) also exist. The desire to increase the nutritional value of food and also to face and find solutions to the diffusion of various allergies and diseases such as the celiac disease have also helped the development of the new types of pasta as for example pasta made from "kamut", pasta made of farro and gluten-free pasta particularly those without gliadin. These raw materials used for the latter are corn, quinoa, cassava, rice and potato.

2.11 Cold extruded pasta products

Moy *et al*. (1980) evaluated the effect of protein supplementation on the extrudability of tare flour. The tare flour was prepared from Bun- long taro corns by washing, peeling, slicing, air drying and grinding prior to extrusion into rice noodle and macaroni. To improve the extrudability and nutritional qualities of these tare products, *mung* bean flour or soy protein was added to the dough before extrusion. Results showed that the addition of 15% *mung* bean flour to taro flour improved the firmness of the rice and noodle. Soy protein also improved the texture of taro rice with 30 and 40% dough moisture and macaroni with 30 % dough moisture. Protein supplement can be incorporated into the extruded taro samples to make them comparable in protein and energy level to conventional wheat products and rice. It was concluded that taro flour can be extruded successfully into rice, noodle or macaroni by proper adjustment of initial dough temperature and moisture content. Protein enrichment improved to a limited extent the overall quality of extruded tare samples.

Cole *et al*. (1990) showed the effects of wheat type and functional ingredients on selected characteristics of pregelatinized *pasta* manufactured by high temperature-short time twin-screw extrusion. The products were evaluated by physicochemical methods. Although wheat type exerted minor influence on maximum force, total organic matter and water absorption index, both durum and hard wheat were suitable as raw materials for production of pre-gelatinized *pasta*. Most differences in quality characteristics of *pasta* supplemented with additives were attributable to effects of glyceryl monostearate. Neither disodium phosphate (1.0%) nor wheat gluten (5.0%) substantially affect the physicochemical properties related to textural quality.

Stephano and Marco (2009) evaluated the chemical and physical characteristics of cooked fresh egg *pasta* samples obtained using two different production methodologies: extrusion and lamination. The extruded *pasta* were tougher than the sheet-rolled *pasta*, absorbed more water during cooking and released more total organic matter in the rinsing water. The colour difference between the two types of *pasta* after the heat treatment of pasteurization was reduced after the cooking due to water absorption and two samples showed to be more similar. The results obtained showed that the extrusion process led to higher furosine content than sheet rolled processes.

Carini *et al*. (2009) reported that fresh *pasta* is a very common food in Italy and it can be produced by subjecting semolina-water dough to either extrusion or lamination to obtain the desired shape. The objective of this work was to evaluate the effect of the extrusion, lamination and lamination under vacuum on physico-chemical properties of selected fresh *pasta*. The water status (macroscopic and molecular) of fresh *pasta* was slightly affected by the shaping process.

Samuel *et al.* (2011) analysed the impact of the die material on engineering properties of dried *pasta*. Extruding wheat semolina dough through a Teflon die allows to process *pasta* with a smooth and even surface, whereas bronze die can be used to obtain a product with a rough texture. *Pasta* were processed with fine semolina using a *pasta* extruder equipped with a 2.5 mm Teflon or bronze die and they were dried inside an environmental chamber under a controlled atmosphere at 40°C or 80°C for 20 hours. *Pasta* shrinkage, porosity and effective moisture diffusivity were measured. Results showed that extrusion with a bronze die induces the production of more porous and less dense *pasta*. Effective moisture diffusivity coefficients were higher for *pasta* extruded with a bronze die compared to a Teflon die for both drying temperatures studied.

Zardetto and Rosa (2009) evaluated the chemical and physical characteristics of cooked fresh egg *pasta* samples obtained using two different production methodologies: Extrusion and Lamination. The samples of fresh egg *pasta* were produced in an industrial plant and subjected to the different lamination processes. The obtained *pasta* samples were then pasteurized and cooked in water. For each type of sample, colour, cooking behaviour, texture, furosine content and *pasta* surface characteristic were evaluated. Besides, the two kinds of products were analyzsed using Fourier Transform Near-Infrared (FT-NIR) spectroscopy. Results obtained showed that the extrusion process has led to higher furosine content than sheet rolled processes. FT-NIR analysis suggested that the products had different matrix–water associations, different degrees of starch gelatinization and also different surface structure characteristics. More differences between the two types of *pasta* were reduced by cooking; rendering them more similar and this result has been confirmed by sensory analysis. In fact, experimental extruded *pasta* was not discriminated from sheet rolled *pasta* by most of the sensory panelists (less than 29%).

Clara and Valeria (2012) studied the effects of the toasting process on the carbohydrate profile and antioxidant properties of chickpea flour, along with the cooking behaviour, antioxidant and nutritional properties of *pasta* enriched with the chickpea flour. The toasting process increased the resistant starch, insoluble dietary fibre and antioxidant properties of the flour. Addition of chickpea flour (raw and toasted) to durum wheat semolina changed the carbohydrate profile in the uncooked and cooked enriched *pasta* especially with the toasted chickpea and worsened the overall quality of the *pasta*. The increase in total phenolic content and total free phenolic acid content in the uncooked *pasta* was due to positive effects of addition of the chickpea flours, while the increase in the bound phenolics fraction in the cooked *pasta* was from the durum wheat which was crucial for its high concentrations of ferulic acid.

Ranganna *et al* (2012) used a sophisticated Brabender single screw extruder to develop small millets based extruded *pasta* by blending cassava flour.

Corn-broad bean spaghetti type *pasta* was made with a corn/broad bean flour blend in a 70:30 ratio through an extrusion-cooking process (Brabender 10 DN Single-Screw Extruder with a 3:1 compression ratio). The effect of temperature (T = 80, 90 and 100 ^{0}C) and moisture (M = 28%, 31% and 34%) on the extrusion responses (specific consumption of mechanical energy and pressure) and the quality of *pasta*-like product (expansion, cooking-related losses, water absorption, firmness and stickiness) was assessed. The extrusion-cooking process, at M = 28% and T = 100^{0}C, was reported to be appropriate to obtain corn-broad bean spaghetti-type *pasta* with high protein and dietary fibre content. The cooking characteristics and resistance to overcooking depended on the degree of gelatinization and formation of amylose–lipid complexes. The critical gelatinization point was 46.55^{0}C; beyond that point, the quality of the product declines (Gimenez *et. al.* (2013).

Sudha Devi (2012) reported the development of pasta products using different small millets namely, little, foxtail, kodo, proso and barnyard using wheat flour as binder. Sensory evaluation of various products indicated that the pasta extruded from the formulation proso:wheat flour was best in terms of its quality.

Alberto *et al.* (2013) investigated the structural changes of starch and proteins in rice *pasta* as a function of raw-materials and *pasta*-making conditions, and their impact on cooking behaviour and glycemic index was assessed. Rice *pasta* was prepared from untreated or parboiled rice flour by conventional extrusion or by extrusion cooking. Starch structure was studied by assessing starch accessibility to specific enzymes (α-amylase and pullulanase) and by evaluating the molecular properties of fragments from enzymatic action. Protein solubility in presence/absence of chaotropes and accessibility of protein cysteine thiols allowed evaluating the intensity and nature of inter-protein interactions. Parboiling stiffens the protein network in rice flour and makes starch more accessible to hydrolysis. *Pasta*-making induced further changes in the starch structure that were most evident in *pasta* made from untreated rice and were mainly related to the amylopectin fraction.

Lakshmi *et al*. (2013) developed *pasta* products using refined wheat flour (*Triticum aestivum*), semolina (*Triticum durum*), green gram (*Pharsalus aureus Roxb*), black gram (*Phaseolus mungo Roxb*), cheese flavour and fish mince (*Katla Katla*) with a lab scale extruder. Acceptability studies on the *pasta* products were conducted initially and at the end of the storage period that is, two months at laboratory level by panel of judges using a 5-point hedonic scale. Cooking quality and proximate principles were assessed. Among the different blends studied, the most acceptable *pasta* was the product made with combination of refined wheat flour + semolina + black gram dhal + cheese flavour + fish in the ratio of 32.5:32.5:10:5:20. The results of present study indicate that fish mince can be utilized for the development of well accepted *pasta* products.

Nisha *et al.* (2012) investigation on two inulins with differing degrees of polymerization and crystallinity demonstrated different levels of integration with the starch–gluten matrix during *pasta* preparation. The impact of higher molecular weight inulin incorporation on technological and sensory properties was minimal, with deterioration in properties becoming significant only at 20% incorporation, while lower molecular weight had a greater negative impact on *pasta* firmness, cooking loss, and sensory acceptability. In vitro starch digestion of *pasta* was reduced with up to 5% addition of inulin with degree of polymerization 12–14 (FH-D), but increased with high levels of addition. These effects were not observed in inulin with a degree of polymerisation of 7–8 (LV-100).

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the methodology adopted for obtaining dried banana peel powder and preparation of pasta product and its quality evaluation.

3.1 Moisture content determination

The moisture content of the peel sample was determined using oven drying method by keeping a small quantity of three samples of peels in in the hot air oven at 100^0C for 24 hours.

Moisture content = $\frac{initial\ weight - final\ weight}{initial\ weight}\ x\ 100$

3.2Collection of banana peel

Banana peels of raw and matured Nendran variety which is the main by-product of chips industry were procured from nearby cottage industries at Valanchery were used for this study.

3.3 Pre-treatments

250g of banana peels were thoroughly washed in distilled water followed by dipping in 0.1%, 0.5% and 1% citric acid solution for 10 minutes to reduce enzymic browning. After draining it was sliced manually using clean knives into approximately 2X2 cm square pieces for uniform drying.

3.4 Drying studies

Weighed samples were spread on the perforated trays were dried in sun and in a cabinet drier at a temperature of $60^0 \pm 1^0$C. An inbuilt digital temperature controller in the dryer maintained the air temperature within $\pm 1^0$C. Whereas, the temperature in the case of sun drying was measured using an ordinary thermometer. The moisture content of the peel at hourly intervals was calculated from the weight loss of the sample during drying.

Plate 3.1 sun drying of peel

Plate 3.2 cabinet drying

3.5 Preparation of peel powder

The dried peel slices were finely powdered with the help of a mixer grinder which was sieved through a clean sieve of 40 mesh screen to obtain fine banana peel powder. The powders were packed separately in LDPE covers and were sealed and kept in a refrigerator for further analyses.

3.6 Qualitative Analysis of banana peel powder

The stored peel powder were subjected to various tests to find out the crude fibre content, carbohydrate content and TSS .The procedures of the tests are as given below:

3.6.1 Crude fibre

Materials used were Sulphuric acid solution (0.225 ± 0.005N) : 1.25g concentrated sulphuric acid diluted to 100 ML and Sodium hydroxide solution (0.313 ± 0.005N) : 1.25g sodium hydroxide in 100ML distilled water.

2g of powdered sample was taken in a 500ML conical flask and 200 ML sulphuric acid was added to the taken sample and boiled for 30 minutes with bumping chips. After that it was filtered through muslin and was washed with boiling water until washings are no longer acidic. Then it was boiled with 200 ML of sodium hydroxide solution for 30 min and after that it was filtered through muslin cloth again and washed with 25 ML of boiling 1.25% H_2SO_4 , three 50 ML portions of water and 25 ML alchohol. The residue was removed and transfered to ashing dish (preweighed dish W_1). After that the residue was dried for 2h at 130 ± 2^0C and the dish was cooled in a dessicator and weighed (W_2).It was then ignited for 30 min at 600 ± 15^0C and again cooled in a dessicator and reweighed (W_3).

Calculation

$$\% \text{ crude fibre in ground sample} = \frac{Loss\ in\ weight\ on\ ignition (W2 - W3) X\ 100}{Weight\ of\ sample}$$

3.6.2 Carbohydrate by anthrone method

Materials used were 2.5N-HCl, Anthrone reagent: Dissolve 100mg anthrone in 100 ML of ice cold 95% H_2SO_4.Prepare fresh before use and standard Glucose: Dissolve 100mg in 100 ML water. Working standard- 10ML of stock diluted to 100 ML distilled water. Store refrigerated after adding a few drops of toluene.

100mg of the sample was taken in a boiling tube and was hydrolysed by keeping it in a boiling water bath for three hours with 5 ML of 2.5 N-HCl and cooled to room temperature. Then it was neutralised with solid sodium carbonate until the effervescence ceases. After that it was made up to volume to 100 ML and centrifuged. Supernatant was collected and 0, 0.2, 0.4, 0.6, 0.8 and 1 ML of the working standard was taken and'0' serves as blank._Volume was made upto 1 ML in all the tubes including sample tubes by adding distilled water._4 ML of anthrone reagent was added to each of the tubes and was heated for 8 minutes in a boiling water bath. Then it was cooled rapidly and the green to dark green colour at 630nm was read. After that a standard graph was plotted with the concentration of the standard on the X-axis and the absorbance on the Y-axis. From the graph the amount of carbohydrate present in the sample tube was calculated.

Calculation

Amount of carbohydrate present in 100mg of the sample

$$= \frac{mg\ of\ glucose \times 100}{volume\ of\ test\ sample}$$

3.6.3 Total soluble solids

Total soluble solid (TSS) was measured using a hand refractometer. One or two drops of the sample solution were placed on the hand refractometer for TSS measurement. It was expressed in degree Brix. (Ranganna , 1995).

Plate 3.3: Hand refractometer

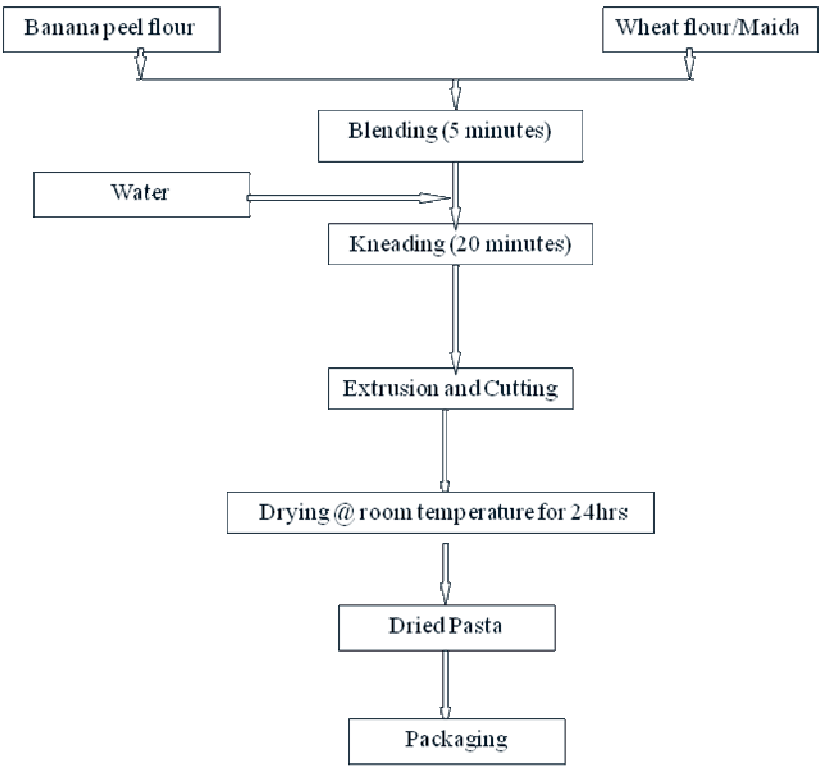
3.7 Preparation of pasta

3.7.1 Description of *Pasta* Machine (Cold Extruder)

The laboratory model *Pasta* Machine (Make: La Monferrina, Italy; Model: P6) was a small, compact cold extruder (Plate 3.3). The unit was basically a single screw extruder with a short stainless steel screw of uniform pitch powered by a 3 hp electrical motor through a speed reduction system. The main screw could be easily dismantled for cleaning once the end die was removed. Different dies could be attached to produce *pasta* of various shapes as per the requirement. The dough to be extruded was actually prepared just prior to extrusion in the same *pasta* machine using the kneading facility. The flours and other ingredients were put in the feeding trough and the kneader (paddle type) switch was first selected to blend the ingredients thoroughly. Later, required quantity of water was added and the flours were worked for a while to get optimum dough characteristics suitable for cold extrusion. Once the dough of required consistency was ready, extrusion switch was selected to continuously produce *pasta* of desired shape. A *pasta* cutter blade, optionally attached at the outlet of the die could cut the extruded *pasta* to the desired size. Selection of faster cutter speeds will result in short (sized) *pasta* and slower speeds will be suitable to produce longer *pasta*. The rated capacity of the laboratory model *pasta* machine was reported to be 6 kg/h for hard durum wheat semolina.

3.7.2 Pasta product manufacture

The fibre fortified *pasta* products were prepared by following the systematic procedure advocated by the *pasta* machine manufacturer (especially for hard semolina of durum wheat). The flours of nendran banana peel powder and wheat or maida were first blended (in the machine itself) for 5 min and then kneaded for about 20 min after adding optimum quantity of water. The quantity of water was decided based on manufacturer recommendations (for maida and wheat flour). When the dough characteristic was optimum, it was extruded using dies in three available shapes – shanku, ribbed tube, twisted ribbons. The cutter speed was set to optimum level (3 to 12 rpm) depending upon the shape of the final product. The extruded *pasta* were collected in trays, and then dried in a tray in room temperature for 24 hours to obtain translucent *pasta*. The products were then packed in LDPE pouches, thermally sealed and stored at ambient conditions. As per the above procedure different composition of wheat and maida flour was used to prepare fibre fortified pasta .Apart from this in order to improve the flavour of pasta it was again fortified with chocolate and small amount of sugar with banana peel powder.Fig 3.1:Flow chart for ready to cook *pasta*



3.7.3 Preparation of plane pasta

Pasta was prepared from different compositions of flour and peel powder using pasta making machine (La Monferrina s.r.l). The machine consists of an outer metal frame, a motor, a blender, an extruder screw and dyes of different shapes which can be used according to the desired shape.

Plate 3.4 Pasta making machine

The different compositions of flour and peel powder used for preparing plane pasta is given in Table 3.1. This mixture was fed into the pasta making machine through the feed inlet at the top after fixing the extruder screw and blender

Table 3.1 Formulation of plane pasta

	Peel powder	Wheat flour	Maida	Total
S 1	15g (10%)	67.5g (45%)	67.5g (45%)	150g
S 2	15g (10%)	135g (90%)	0	150g
S 3	15g (10%)	0	135g (90%)	150g

10 ml water was added with all the composition for getting a smooth blending. Then a dye of desired shape was fixed at the outlet where the pasta will extrude out. The machine was switched on and allows 20 minutes to get proper blending followed by extrusion of long strips of pasta through the dye. These strips were made into small pieces manually. Drying of pasta was done at room temperature for 24 hours and then packed and sealed in LDPE covers and sealed for further quality analysis.

3.7.4 Preparation of fortified pasta

Since these samples of pastas were not having any particular flavour apart from the flavour of wheat flour, it was again fortified by adding chocolate powder and sugar to get a pleasant flavour. The composition of those samples were given in Table 3.2

	Peel powder	Wheat flour	Maida	Chocolate powder	Sugar	Total
S 4	15g (10%)	60g (40%)	60g (40%)	11.25g (7.5%)	3.75g (2.5%)	150g
S 5	15g (10%)	120 (80%)	0	11.25g (7.5%)	3.75g (2.5%)	150g
S 6	15g (10%)	0	120g (60%)	11.25g (7.5%)	3.75g (2.5%)	150g

Table 3.2 Formulation of fortified pasta

Plate 3.5 Extrusion die of Pasta Machine

The product was packed in LDPE covers and sealed for further quality analysis

3.7 Quality analysis

3.7.1 Sensory evaluation

Sensory evaluation of both plane as well as fortified pasta with respect to colour, flavour, texture and overall acceptability was adjudged on a 5 point hedonic scale (Ranganna, 1986) by a panel of 9 untrained judges. (AppendixV)

The prepared samples of pasta was cooked and kept for sensory evaluation. The first three samples were cooked by boiling in water for 5 minutes by adding equal quantity of masala powder and vegetables and were served neatly. The next three chocolate flavoured samples were simply cooked in water for 5 minutes and served.

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The outcomes of various experiments conducted to fortify pasta using banana peel powder and the various quality parameters involved are analysed and discussed in this chapter.

4.1 Moisture content

The moisture content of the banana peel was estimated by oven dried method as explained in 3.1 and found to be 80.2%.

4.2 Banana peel

The effect of citric acid on prevention of enzymic browning was studied. After the pre-treatments, the banana peels that were dipped in 1% citric acid for 10 minutes resulted better in colour. Similar results were also reported by Yueminj *et al,* . (2004) for fresh Chinese water chestnut.

Plate 4.1 Banana peel in different concentration of citric acid

4.3 Results for drying studies of peel powder

4.3.1 Sun drying

The samples treated with 1% citric acid were uniformly spread on SS trays and dried in sun, and in a mechanical drier at 60^0C. The temperature in the case of sun drying was noted with an ordinary thermometer as 43^0C. In the case of mechanical drier the temperatures of 60 ^{0}C with ± 1^0C were maintained by an inbuilt digital temperature controller. The reduction in moisture contents of the banana peel at hourly intervals were calculated from the weight loss of the sample during drying and it was plotted as shown in figure 4.1**.**It took 480 hours for the peels to get dried under sun. The peels appeared very shrinken after sun drying and the powder obtained from the peel was also not so fine textured. Similar results were reported by Hernawati *et al,*. Aiming at saving the time and because of the unpleasant texture of the peel powder, sun dried peels were not used for further experiments.

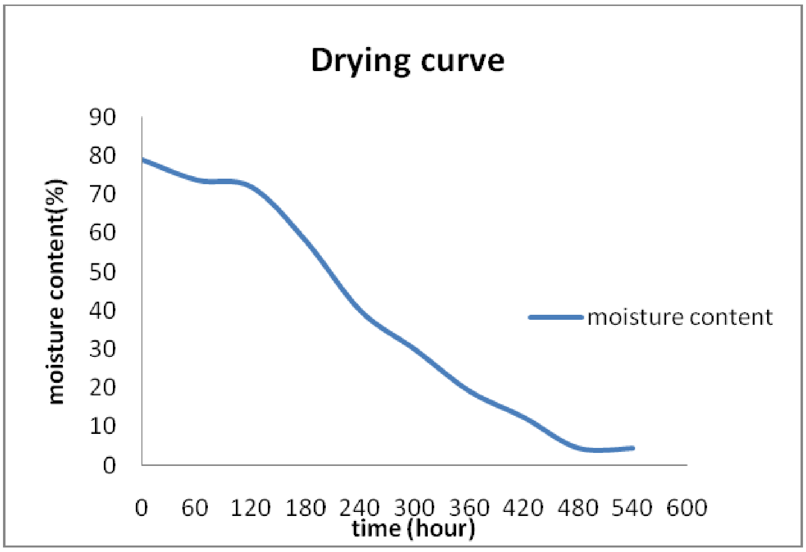


Fig.4.1 Drying curve of sun drying

The values are given in Appendix II

4.3.2 Cabinet drying

Drying of the pre-treated banana peel kept in cabinet drier at 60^0C took about 420 hours. The powder obtained from the cabinet dried peels was also brown in colour but not as dark as those obtained in sun drying. Since the time consumption was less and the colour and texture was better, the cabinet dried peels were used for further experiments.

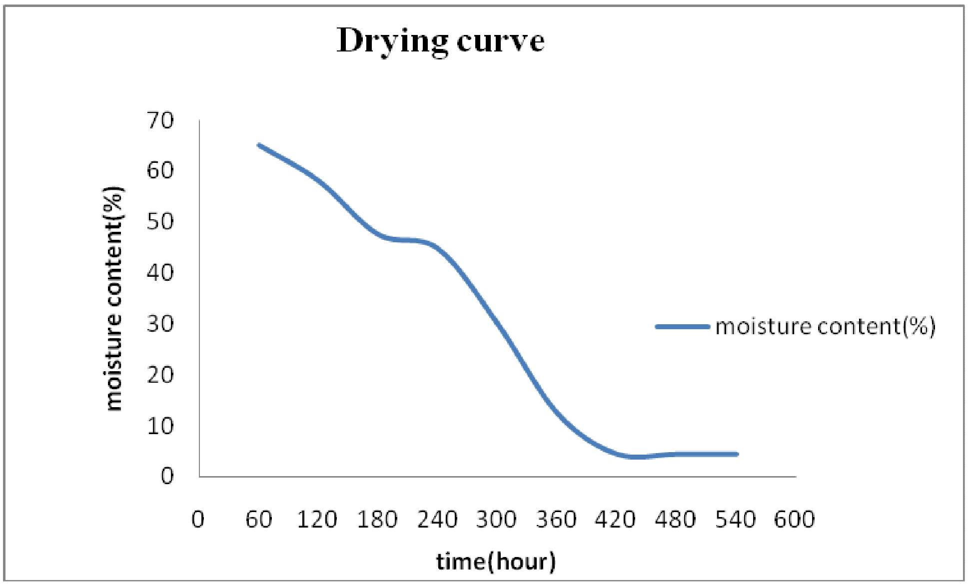


Fig 4.2: **Drying curve for cabinet drying**.

The values are listed in Appendix III

4.3 Results of qualitative analysis of banana peel powder

4.3.1 Crude fibre

The percentage of crude fibre was calculated as

$$\frac{Loss\ in\ weight\ on\ ignition(W2 - W3)X\ 100}{Weight\ of\ sample}$$

$$= \frac{(46.721 - 45.860)}{2} x100 = 43.05\%$$

Jamuna Prakash(2011)*et al.*, was also reported that insoluble dietary fibre in three varieties of banana peel samples ranged from 35-50% which was similar to this result.

4.3.2 Carbohydrate

The absorbants values obtained from the experiment, shown in fig 4.4 was plotted in the glucose curve given in Appendix IV to get the corresponding concentrations. From the concentration values, the final carbohydrate value was found as 12.3% per 10 ml., The values are listed in Appendix IV

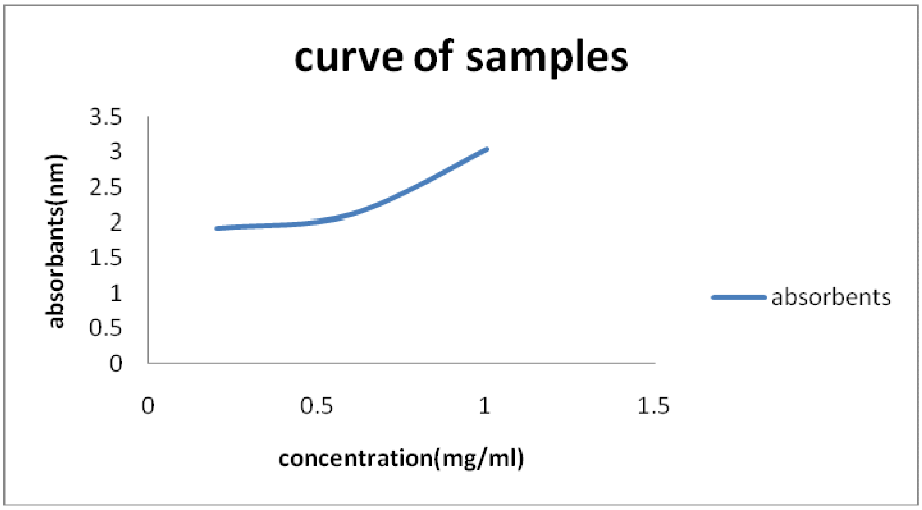


Fig 4.4: Samples curve

4.3.3 Total soluble solids

Using the hand refractometer the total soluble solids was found to be 6.72^0 Brix.

4. 4 Production of pasta

Six samples of pasta were produced from different compositions of flour and peel powder as listed in table 3.1 & 3.2 , through cold extrusion process using pasta making machine(Make: La Monferrina, Italy; Model: P6).

The banana peel powder produced by this study was brown in colour, hence pasta made using banana peel powder also look like light brown in colour. Saifullah Ramli *et al* (2009)., reported that BP (banana peel) noodles produced was brownish in colour with visible dark spots scattered about the samples with banana flavour. The chocolate fortified pasta gave a chocolate brown colour and chocolate flavour

4.3.5 Sensory evaluation

The scores given for different treatments on different organoleptic traits namely colour, flavour, texture and overall acceptability are presented in Table 4.1

Table 4.1 Mean scores for sensory evaluation

Sample	Mean scores			
	Colour	Flavour	Texture	Overall acceptability
S1	3.11	3.66	3.66	4.05
S2	3.44	3.88	4.22	4.44
S3	3.22	3.77	3.77	3.66
S4	2.88	2.5	2.66	3.11
S5	2.77	2.44	2.55	2.66
S6	3.11	2.88	2.66	2.77

From the sensory scores, it was observed that sample 2 made with 10% banana peel powder and 90% wheat flour resulted in better colour, flavour, texture and overall acceptability followed by sample 1 made with 10% 0f banana peel,45% maida and 45% of wheat flour.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

India is blessed with a variety of fruits and vegetables whose production during 2010 - 11 was 74877.6 and 146554.5 MT, respectively. Though India is the largest producer of fruits and vegetables after China, it processes only less than 2.5% of the huge production as compared to 70 - 83% in advanced countries.Fruits and vegetables play an important role in human diet and nutrition. They are indispensable sources of essential dietary nutrients, vitamins and minerals besides providing crude fibre. Therefore the thrust should be to process and convert such perishable commodities into value added products that can be stored for extended periods there by reducing losses and making them available throughout the year.

Significant quantities of banana or plantain peels, equivalent to 40% of the total weight of fresh banana, are generated as a waste product in industries producing banana chips. At present, these peels are not being used for any other purposes and are mostly dumped as solid waste at large expense. It is thus significant and even essential to find applications for these peels as they can contribute to real environmental problems.

Since there has been a minimum research in the field of banana peel processing and storage, the present study of “Development of fibre fortified pasta using banana peel powder” was under taken at Kelappaji College of Agricultural Engineering and Technology, Tavanur to reduce the wastage of banana peel which is a rich source of fiber, amino acids and carotenoid.

Banana peel, of ‘Nendran’ variety, was used for the study. The suitable pretreatments including dipping in 1% citric acid for 10 minutes to reduce enzymatic browning was done. Then the samples were dried using cabinet drier at 60 $\pm 1^0$C.The dried peel slices were finely powdered with the help of a mixer grinder which was sieved through a clean sieve of 40 mesh screen to obtain fine banana peel powder ,packed in LDPE pouches and stored. The stored peel powder were subjected to various tests to find out the crude fibre content, carbohydrate content and TSS and it was found that 4.6%,12.35% and 6.72% respectively.

Plane pasta was prepared with flour, banana peel powder and maida at various compositions and was evaluated. Since the plane pasta is of brown colour this was fortified with chocolate and sugar using pasta making machine and the sensory evaluation was carried out for all six samples on a 5 point Hedonic scale by a panel of 9 untrained judges and it was found that composition containing 90% wheat and 10% peel was most accepted.

Thus it was concluded that banana peel is a good source which can be used for preparing fibre fortified pasta with desired organoleptic qualities.

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APPENDICES

APPENDIX I

Samples	Initial weight (g)	Final weight after 24 hours (g)
Sample 1	20.125	4.017
Sample 2	20.385	4.047
Sample 3	20.052	3.937

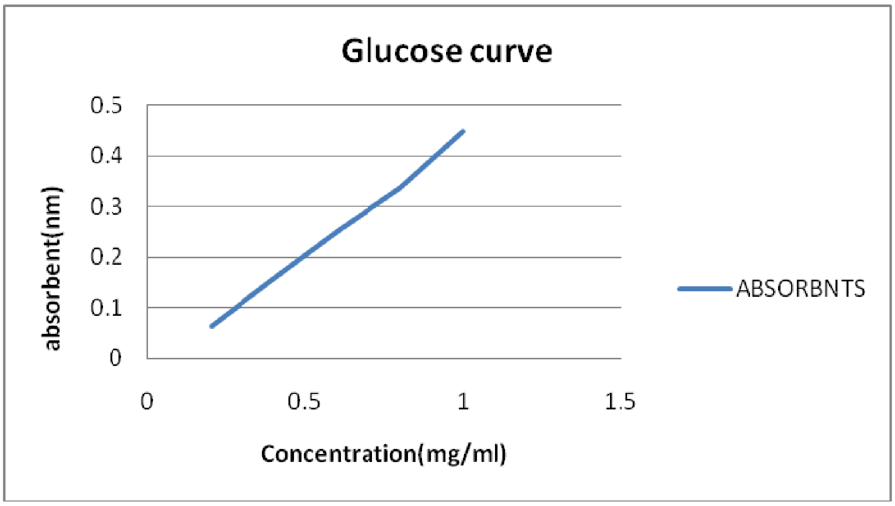
APPENDIX II

Time (seconds)	Weight of sample (g)	Moisture Content
0	100	79
60	80	73.75
120	75	72
180	50	58
240	35	40
300	30	30
360	26	19.23
420	24	12.43
480	22	4.5
540	22	4.5

APPENDIX III

Time (seconds)	Weight of sample(g)	Moisture Content(%)
0	60	65
60	50	58
120	40	47.5
180	36	44.73
240	30	30
300	24	12.5
360	22	4.5
420	22	4.5
480	22	4.5

APPENDIX IV



Concentration(mg/ml)	Absorbents (nm)
0.2	0.065
0.4	0.157
0.6	0.250
0.8	0.337
1	0.448

1. Absorbents values of glucose

Samples	Absorbents (nm)	Concentration(mg/ml)
Sample 1	1.925	3.75
Sample 2	2.115	4.1
Sample 3	3.042	5.8

2. Absorbents values of samples

APPENDIX V

Sensory Evaluation Card

Hedonic Scale

Name of the examiner:

SAMPLE	COLOUR	FLAVOUR	TEXTURE	OVERALL ACCEPTABILITY
S1				
S2				
S3				
S4				
S5				
S6				

Date:

Signature of the examiner:

1-DISLIKE VERY MUCH

2-DISLIKE

3-NEITHER LIKE NOR DISLIKE

4-LIKE

5-LIKE VERY MUCH

DEVELOPMENT OF FIBRE FORTIFIED PASTA USING BANANA PEEL POWDER

By
ASHITHA.G.N
ATHIRA DAYANANDAN
NASLIN.N

ABSTRACT OF THE THESIS REPORT

Submitted in partial fulfilment of the
Requirement for the degree

Bachelor of Technology
In
Agricultural Engineering

Faculty of Agricultural Engineering &Technology
Kerala Agricultural University

Department of
Food & Agricultural Process Engineering

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ABSTRACT

The production of fruits and vegetables in India during 2010-11 is 74877.6 MT and 146554.5MT, respectively (National Horticulture Board, 2011). India is the largest producer of banana with an annual production of around 29780MT during 2010 -11from an area of 830 HA which contributes 39.8% of the total fruit production. Banana peels are dumped in huge quantities as solid wastes from various chips industries therefore , the wastage of peels is at a peak rate. These peels are a rich source of dietry fibre , amino acids , proteins and potassium. Therefore, utilising of these peels can benefit a lot to human health.Thus a conclusion was reached to utilise the dietry fibre of these peels to prepare fibre fortified pasta., which is a part of well balanced diet.Banana peels were collected and pre-treatments were given to retain the colour and were kept for drying at 60 ± 1^0C in cabinet drier. Dried peels were subjected to grinding in a mixer grinder to obtain peel powder. Various tests were conducted on the peel powder for determining the crude fibre, carbohydrate and total soluble solids for finding out the nutritional composition. This powder was used for preparing pasta by extruding it through pasta making machine.(La Monferrina.s.r.l).Six samples using different compositions of flour and peel powder were prepared. In that , 3 samples were fortified using chocolate. The samples were kept for sensory evaluation after cooking and found out that one of the composition secured good score.

Front page

abstract