DEVELOPMENT AND QUALITY EVALUATION OF FRUIT BASED INSTANT SNACK AND PASTA PRODUCT

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DEVELOPMENT AND QUALITY EVALUATION OF FRUIT BASED INSTANT SNACK AND PASTA PRODUCT

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(2011-24-102)

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DECLARATION

I, hereby declare that this thesis entitled **'Development and quality evaluation of fruit based instant snack and pasta product'** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title of any university or society.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

viz.	Namely
l.	Litre
h.	Hours
CD	Critical Difference
^{0}C	Degree Celsius
^{0}B	Degree Brix
g	Gram
kg	Kilo gram
et al.	And other co-workers
ml	Milli litre
Fig	Figure
cfu	Colonies forming unit
i.e.	That is
Kcal	Kilo calories
mg	Milli gram
gf	Gram Force
µg	Micro gram
cv	Cultiver

1. INTRODUCTION

India is the second largest producer of fruits and Vegetables (F&V), accounting for 82 million tones and 10.9 per cent of global fruit production, and 47 million tones and 8.4 per cent of vegetables production (MOFPI, 2013).

Even though India is second largest producer of fruits and vegetables in the world after China, the present quantity of fruit and vegetable processing is very meager (2.2%) as compared to 80 per cent in USA, 70 per cent in France, 80 per cent in Malaysia and 30 per cent in Thailand (Shetti, 2011).

The prominent processed items in India are fruit pulps and juices, fruit based ready to serve beverages, canned fruit and vegetables, jams, squashes, pickles, chutneys and dehydrated vegetables. The major products processed and exported are dried and preserved vegetables, mango pulp, pickle, and chutney. It is estimated that the level of processing in fruit and vegetables is only about 2 per cent and the wastage is about 25 per cent (MOFPI, 2013).

Chomsri *et al.* (2012) stated that development and research plans are interestingly increasing for developing new value added fruit and vegetable based products because food habits in India also changed due to the western influence and the use of processed foods are on rise. Ahmad (2013) reported that consumption of processed foods has been associated with potential health problems thus value added fruit and vegetable based convenient food products are in need.

Ray and Athwali (2000) opined that more and more people are going for convenient foods and it is estimated that over 10 per cent of total expenditure incurred in the household for foods is spent on processed foods. With the rapid increase in the per capita income and purchasing power along with increased urbanization improved standard of living, it is estimated that 360 million upper and middle class consume processed food.

Consumers are increasingly demanding convenient, ready to use and ready to eat foods with a fresh like quality containing only natural ingredients being fruits, vegetables, milk products and nuts. Therefore development of innovative

nutritious convenient foods is the need of the hour, to replace unhealthy processed foods (Kumar *et al.,* 2008).

People prefer convenient foods mainly because of its convenience, variety, taste and attractive packing. High consumption of processed foods, fast foods and street foods are becoming part of daily life style thus increasing the incidence of obesity and cardio vascular diseases (John, 2011).

Changing lifestyles and increasing consumer awareness, due to increasing proportion of working women and the emergence of nuclear/double income families, especially in urban areas is also changing the food consumption patterns of Indian population.

Market survey conducted by Goodwin (2010) showed that many of the processed foods in the market are high in calories and fat and less in micronutrients and fiber, thus the consumption of which leads to obesity. The chemical coloring agents, artificial flavors and artificial preservatives added in processed food items make it more attractive and tasty.

Anand (2000) proposed that more Indians are becoming health conscious, but due to paucity of time, they prefer processed and convenient foods which will be fuelling the demand of processed products in India in years to come.

As consumers are more aware of what they eat, improving the nutritive quality of the final food product through the addition of different natural sources has been the goal of much research in recent years around the world (Jabs and Devine, 2006).

Steinmetz and Potter (2011) proposed that healthy value added fruit and vegetable incorporated convenient and shelf stable foods can be developed by utilizing the newer processing technologies.

Consumers want foods that taste good and smell good, feel good, look good and in addition, nutritionally superior and healthy (Jaeger and Cardello, 2007). Consequently innovative nutritious convenient food products are necessary; to replace fat and salt enriched fast foods/snacks.

The concept of developing health promoting convenient foods based on our local food resources and by observing the principle of food square and food

pyramid model is the basis of proposed research. Thus the present study focuses to develop fruit based ready to eat instant snack and pasta products using low cost locally available, less utilized food ingredients. Quality of the developed products in terms of sensory, nutritional and shelf stability and also consumer preference were ascertained.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The review of literature of the study entitled **"Development and quality evaluation of fruit based instant snack and pasta product"** is given below.

2.1. SIGNIFICANCE OF FRUITS IN THE DIET

Let your food be your medicine or let your medicine be your food (Hypocrates). Shab (2003) opined that food has a wide application which could be summed up any plant or animal material which is consumed for nutrition and sustenance. Indra (2004) stated that modern life style demands a consistent food supply with high quality that is convenient as well as affordable. The food consumed may vary among the population but the basic structure of composition remains same, mainly comprising of pulses, cereals, fruits, vegetables, milk and milk products, oils and seeds, eggs and poultry.

Kumar *et al.* (2003) stated that fruit has been a major food for mankind from time immemorial and it constitutes an important item in our diet. George (2004) stated that fruits are no longer a luxury, since they belong to an important class of protective foods, which provide adequate vitamins and minerals needed for the maintenance of health.

Mehta (2002) remarked that fruits not only meet the quantitative needs of foods but also supply vitamins and minerals, which improve the quality of diet and maintain health. Therefore it is necessary to ensure its availability throughout the year in fresh, processed or preserved forms.

Kaur and Maini (2001) is of the opinion that fruit of vegetables contain phytochemicals & antioxidants, which have significant health promoting effects and can reduce the incidence of cardiovascular diseases, cancer, AIDS and various other degenerative diseases.

Dubey (2008) opined that fruits are known to provide the vigor and vitality. The chief energy constituent in fruit is carbohydrate mainly as sugars. He further reported that, fruits and vegetables contain the indigestible material called fiber, which adds bulk to stools and this act as mild laxative.

Consumption of fruits and vegetables is increasing because of strong evidence that many beneficial effects for human health are associated with the dietary intake of fruits and vegetables (Rupasinghe *et al.*, 2012).

As suggested by epidemiological studies, the consumption of fruit and vegetables may lead to prevention of many chronic diseases, including cardiovascular disease, type II diabetes and some cancers (Lila, 2007). These disease prevention effects of fruits could be due to the presence of health promoting phytochemicals such as carotenoids, flavonoids other phenolic compounds and vitamins (Gutiemez, 2008).

Furthermore, the health-protective effects may be rather produced by complex mixtures of interacting natural chemicals than a single component in these plant-de-rived foods.

According to Ponce *et al.* (2007) fruits and vegetables are one of the sources of dietary fiber, although the amount of dietary fiber is not as high as in cereals, but fruits and vegetables have been shown to have high amount of soluble dietary fibre which plays an important role in lowering serum cholesterol and glucose level. Insoluble dietary fibre on the other hand, is essential in maintaining intestinal health.

2.1.1. Nutritional Benefits of Jack Fruit

Jack fruit is a sweet and delicious fruit with many health benefits. It contains high amount of carbohydrate and calories that provides energy instantly. It is rich in antioxidants which protect from cancer, ageing and degenerative diseases. One hundred gram of edible jackfruit bulbs provide 95 calories. The fruit is made of soft, easily digestible flesh (bulbs) with simple sugars like fructose and sucrose that when eaten replenishes energy and revitalizes the body right away (Ko *et al.,* 2003).

Jagtap *et al.* (2010) reported that jack fruit is an excellent source of vitamin C which increases immunity to protect against common diseases like cough, cold and flu. It provides vitamin C about 13.7 mg or 23 per cent of RDA. Consumption of foods rich in vitamin C helps the body develop resistance against infectious agents and scavenge harmful free radicals.

Jack fruit is a rich source of potassium which is required to maintain electrolytic balance and hence helps to lower high blood pressure and decreases the risk of stroke and heart attack (Selvaraj and Pal, 2009).

Rahman *et al.* (2005) stated that jack fruit act as laxative and relieves constipation due to high fiber content. It also cleans up colon thus preventing from colon cancer. Studies proved that jack fruit is a best food to slow down ageing process it also keeps skin moisture level high and protect from skin disorders.

Kumar *et al.* (2002) stated that by daily consumption of jack fruit both in processed form or as whole fruit can strengthen bones and prevent osteoporosis. Magnesium, found in large amounts in jackfruit, absorb calcium in the body and contribute to strengthening of bones and prevention of bone related disorders like osteoporosis. Jackfruits play a significant role in thyroid metabolism due to the presence of copper in their flesh, thereby promoting hormone production and absorption.

Sambamurty *and* Ramalingam (2005) reported that jackfruit is rich in phytonutrients that can fight cancer and slow down degeneration of cells that can lead degenerative diseases. Jackfruit is rich in antioxidants, fiber, vitamin A, vitamin C and it is a rich source of minerals like calcium, potassium, iron, and zinc. Incorporating jackfruit in snack products provides nutritional and health benefits to consumers (Susan *et al.*, 2007).

Jackfruit is an indigenous and underutilized fruit crop with great yield potential and excellent nutritional qualities. However, its intense flavor may hinder its liking by the consumers. Through processing and product diversification, it is possible to alter the flavor and make it acceptable to the consumers (Jagadeesh *et al.,* 2009).

Kousalya (2006) stated that jackfruit can be wisely incorporated in many snack products. Due to its intense flavor, it is commonly used in ice cream, chutney, jam, jelly, and found in paste form or canned in syrup. Ripe bulbs of the jackfruit is often dried, fried in oil, and salted like potato chips while the seeds are rich in vitamins B1 and B2 and can be dried and used as a vitamin supplements.

Soong and Barlow (2004) reported that jackfruit pulp is eaten fresh and used in fruit salads and possesses high nutritional value. Jackfruit pulp also has been reported to contain antioxidant phenylflavones.

2.1.2. Nutritional Benefits of Banana

Banana is the second largest produced fruit after citrus, contributing about 16 per cent of the world's total fruit production. India is largest producer of banana, contributing to 27 per cent of world's banana production (MOFPI, 2013). Banana (Musa sp.) a wonder fruit is a staple food of millions. It provides a more balance diet than any other fruit or vegetable. Banana is the cheapest, plentiful and most nourishing of all fruits.

Banana is considered as the symbol of prosperity and fertility. Owing to its greater socio economic significance and multifaceted uses it is referred as kalpatharu (Hazarika, 2009).

Polly (2005) stated that nutritionists, physicians, food scientists and biochemists are unanimous in this view that banana is one of the most nutritious and health giving natural food as it contains high levels of sugar such as glucose, sucrose and fructose, dietary fiber, vitamins, minerals, phytochemicals and are free of allergen.

Usmakulk (2006) stated that year round availability, affordability, varietal range, tastes, nutritive and medicinal value makes banana as favorite fruit among all classes of people. Banana serves as an ideal and low cost food source for developing countries where most of the population relies.

According to Mohapatra and Mitra (2010) banana is highly nutritious and easily digestible than many other fruits. Digestion time of banana fruit is less (105 minutes) than apple (210 minutes). Bananas are popular for its aroma, texture and easy to peel and eat, besides rich in potassium and calcium and low in sodium content. They are rich in phenolic compounds and flavanoids, which have antioxidant properties.

Banana is rich in potassium. According to Rao (2002) potassium is also known as the salt of intelligence. It is a vital mineral for muscle and nerve function which help to regulate blood pressure, increased learning ability, and

regulates water balance in the body. Banana is rich in phosphorous, which helps bone and teeth and problems afflicting muscle of nerve functions.

Banana is rich in vitamin, nicotinic and, of vitamin B6 which helps the body to heal and defend against infections, enhances the absorption of iron and formation of connective tissue and blood, and prevents diarrhea, eczema, anemia and related disorders. It is also found helpful in stomach ulcer (act as natural antacid), colitis, digestive disorder, diarrhea, constipation and hemorrhoids. This is the only fruit rich in tryptophan, an essential aminoacid (Shanmughasundaram *et al.,* 2005).

According to Rai (2002) ripe plantains have mild laxative property and hence are very useful in the diet of children particularly as a remedy for constipation.

Being a highly perishable fruit, banana suffers from post harvest losses to an extent of 30- 40 per cent thus processed banana products being jam, jelly, puree, dehydrated banana are becoming popular.

Bananas provide with many health benefits, but in addition to all of that, most people enjoy eating bananas as well. They can be eaten alone or combined with a fruit salad, added to jelly, or made into a smoothie or a milkshake. They are one of the most affordable fruits in the marketplace and can be found year round nearly everywhere in the world (Bagavan, 2011).

2.1.3. Nutritional Benefits of Papaya

Papaya (Carica papaya L.) fruit is rapidly becoming important commodity worldwide, both as a fresh fruit and as processed products. Papaya is a very healthy fruit, and is appreciated because of its attractive pulp color, flavor, succulence, and characteristic aroma. Main varieties used for production are Pusa delicious, Pusa dwarf, Punjab sweet and honey dew (Anon, 2004).

Papaya fruit is highly appreciated world-wide for its flavour, nutritional qualities, digestive properties and serotonin content. It is called as common man's fruit which is reasonably priced and has high nutritive value (Fernandes *et al.,* 2006). Papaya is a good source of serotonin (0.99mg/100mg), which has been

associated with enabling the gut to mediate reflex activity and also decreasing the risk of thrombosis (Labanca *et al.*, 2011).

Various pharmacological action and medicinal uses of different parts of papaya are well reported in the ancient literature.

According to the study conducted by Hendringson (2011) fermented papaya fruit is a promising nutraceutical as an antioxidant. It improves the antioxidant defense in elderly patients even without any overt antioxidant deficiency state at the dose of 9 g/ day orally.

Papaya when consumed regularly will ensure a good supply of vitamin A and C which is essential for good health especially for eyesight. A study by Krishna *et al.* (2008) indicated that the consumption of guava and papaya fruits reduced oxidative stress and altered lipid profiles. Thus, it could reduce the risk of diseases caused by free radical activities such as cancer, and cardiovascular disease.

The comparative low calorie content (32 kcal /100 g of fruit) makes it a favorite fruit for obese people who are on a weight reducing regime. Also, papaya ranks the highest per serving among fruits for carotenoids, potassium, fiber, and ascorbic acid content (Marotta *et al.,* 2006).

Hamed *et al.* (2012) proved that papaya is rich in vitamins, minerals, proteins, polysaccharides, lectins, saponins and flavonoids and can be used in the prevention of complications of diabetes mellitus.

Many biologically active phytochemicals have been isolated from papaya and studied for their action, recently an antifungal chitinase has been gene cloned and characterized from papaya fruit (Hasis *et al.* 2008).

Apart from its nutritional value; it is an excellent fruit suitable for processing. The each part of papaya fruit can be very well utilized for value added products. The unripe papaya can be utilized for preparation of good quality candy and also for the isolation of papain (Hamed *et al.,* 2012).

2.2. RECENT TRENDS IN CONVENIENCE FOODS

Convenience foods can be defined as a food product which is beneficial to the customer during any of the meal preparation and consumption stages planning,

purchasing, storing, preparation, eating and disposal/tidy-up. This means a product which can be easily obtained, prepared, stored, served, or eaten, thus proving to be convenient by saving time, physical energy and/or mental energy. With the high availability of frozen prepared meals, grocery prepared meals, fast take-out and sit-down restaurants, many people are now eating less home prepared meals and more convenience foods (Anderson *et al.,* 2001).

Buckley *et al.* (2007) have defined convenient food as those products in which all or a significant portion of their preparation has been transferred from the consumers kitchen to the processing plant.

The term convenience foods is used for a very heterogeneous group of foods which vary in composition, shape, size, method of preparation and processing and even with regard to their functions in the diet (Lake *et al.,* 2006).

Rapid urbanization and sociological changes, like the desire on the part of the housewives to spend less time in the kitchen, the increased value she places in leisure, the habit of eating out, women taking full time jobs, the weakening of family ties, the spread of television and its impact, the increasing difficult and expenses involved in obtaining domestic help, finally the changing life styles and growth of foreign travel have create a demand for prepackaged, precooked food which could be cooked quickly and also ensues top quality, variety, taste and flavour (Caraher *et al.,* 2000).

Frobisher *et al.* (2005) reported that the changing life style and food habits of middle income group and availability of better quality processed foods as a result of modern technology advances have also enhanced the production and consumption pattern of convenience foods.

According to Wales (2009) there is a considerable increase in the use of convenience foods due to various reasons *viz.*, urbanization, and increase in per capita income, changing lifestyle, increase in working women population, scarcity of household labors as well as technical developments.

An increase in urbanization, migration of rural population to urban areas, rising literacy and health awareness have influenced the increased the use of convenience foods (Candel, 2001).

Frequent consumers of convenience foods are children and adolescents than the adults in the households. The younger generations have shown more inclination toward convenience foods when compared with elderly people who have reservations about its healthfulness.

A study conducted by Mehta (2002) among middle and high income groups revealed that the expenditure on convenience foods was almost same in both middle and high income group.

Botonaki *et al.* (2009) reported that better the literacy status higher the frequency of use of convenience foods. Noodles, cornflakes, ice-cream mix and custard powder were most frequently used in urban areas because the adolescents like these products very much.

Larson *et al.* (2007) proposed that even though traditionally convenience has been examined in the context of strategies used by the consumer to reduce time pressures, time is not the only dimension involved in the consumption of convenience foods.

Darison and Cohen (2008) proposed two dimensions of convenience. The first one concerns the type of convenience, which can be saving time, physical energy and/or mental energy. The second dimension refers to the stage of the meal process that convenience is obtained.

Consumer may require convenience when deciding what to eat, purchasing, preparing the meal, consuming it and clearing up (Jaeger, 2006).

Berry *et al.* (2002) pointed out that over the last ten years; consumer demand has increasingly required processed foods to have a more 'natural' flavour and colour, with a shelf life that is sufficient for distribution and a reasonable period of home storage before consumption.

This can be achieved by adopting modern processing technologies that preserve foods but also retain to a greater extent their nutritional quality and sensory characteristics by reducing the reliance on heat as the main preservative action (Buckley *et al.,* 2007).

Technologies applied in the processing of food must assure the quality and safety of the final product (Candel, 2001). Modern food production techniques

and preservation methods minimize nutritional loss and also improve sensory appeal of products.

Jaeger and Meiselman, (2004) opined that based on the processing technology applied, some foods can be eaten immediately (Instant food/ Ready to eat foods) whereas some foods need a little preparation before consumption (Ready to cook food).

According to Anderson *et al.*(2001) different kinds of convenience foods are moist fried products, popped or puffed cereal, expanded cereal, extruded foods, fermented products papads and wafers, instant mixes, ready to eat products stabilized by anti-mycotic agents, canned convenience foods, breakfast cereals and minimally processed intermediate moisture fruits and vegetable based convenience foods.

2.2.1. Ready to Cook Foods, Pasta

Pasta is a popular food because of its convenience, sensory appeal, low cost and storage stability (Martinez *et al.,* 2007). Pasta means dough in Latin and pasta dough is made of water and hard wheat flour, often semolina (Androos, 2003).

Marcus (2005) stated that pasta is the one of the easiest and most versatile food products used today and is available in variety of sizes, shapes, colors and flavors. Pasta increases in volume as it cooks and yields a high profit and is now very popular menu choice.

Manthey and Twombly, (2006) reported that pasta can be used in place of other starchy foods in a meal. The main ingredient of pasta is wheat flour. The other main ingredients in pasta are liquid such as water or eggs. Oil is sometimes added to pasta dough to give it a richer texture.

Most commercial pastas are made from semolina flour hard grain wheat flour that rich in proteins that form gluten. Durum wheat is used in pasta manufacturing because of its high content of protein, which gives the yellow color to the pasta (Sissons *et al.,* 2009).

Amarowicz (2009) reported that pasta is generally a simple dish, but comes in large varieties because it is a versatile food item. Petitot (2009) stated

that pasta, with its origin in Italy has gained wide popularity as a convenient and nutritionally palatable. Pasta has the ability to give sustained energy. Athletes have pasta to load up on carbohydrates to increase and store glycogen for prolonged activities (Arlotti *et al.,* 2007)

Usually, pasta products are prepared using cereals like wheat, which are limiting in some essential amino acids. In order to increase the nutritive value of such products, the supplementation and fortification with protein and vitamins from natural sources is an alternative (Shavikla *et al.,* 2011). The consumption of pasta products is steadily increasing around the world due to its versatility, shelf life, and convenience. A numbers of studies have also been carried out to develop pasta with enhanced nutritional attributes as well.

Sadehi and Bhagya (2008) reported that traditionally pasta is made from durum wheat semolina which imparts the desired texture and cooking quality to the product, wheat semolina proteins are deficient in lysine and threonine leading to low biological value for the product. Fortification of pasta with various protein sources such as legume flours, cheese, soy proteins, mustard protein isolate and gluten meal has been attempted by several workers, with a view to enhancing the nutritional value of pasta.

High protein pasta, with low starch digestibility was developed from pale cream fleshed sweet potato, using protein sources like whey protein concentrate, defatted soy flour and fish powder. The products exhibited high Swelling Index and significantly high lysine and threonine contents. Electron Microscopic studies provided evidence for the formation of strong protein-starch network in WPC-fortified sweet potato pasta, while the other two protein sources such as defatted soy flour and fish powder resulted in a loose network leading to higher starch digestibility than WPC pasta (Jyothi *et al.,* 2011).

Lakshmi *et al.* (2013) stated that development of pasta products using cereals, fish mince, fruits, alovera, vegetables, pulses and tubers without compromising on the quality of the final product, would help improve the nutritional quality apart from adding a distinct falvor and taste. Sinha *et al.* (2013) opined that nutritious macaronis could be developed by incorporating finger

millet, aloe vera gel, soy flour and germinated green gram with semolina up to the extent of 50 per cent. Supplementation of green gram flour and soy flour further increased the nutritive value of product.

Davide (2000) proposed that there are two major classifications: pasta *fresca* (fresh) and pasta *secca* (dried). Dried pasta should be brittle not break easily. It comes in a variety of interesting and unusual flavors. Miller (2003) proposed that dried pasta can be stored in cool dry place for several months.

Fresh pasta can be made in the kitchen. However, it requires a great deal of labor or hard work to produce and also difficult of get consistent product (Guler *et al*., 2002). Sung and stone (2003) stated that fresh pasta can be purchased fresh or frozen. It comes in a variety of flavors, such as spinach, tomato garlic and whole wheat.

Fresh pasta must be tightly wrapped and kept refrigerated to prevent drying out and spoilage. Even when refrigerated fresh pasta should be used in a few days after it has been made (Wen and Martha, 2005).

Banana flour added to pasta and pasta products exhibit a low rate of carbohydrate enzymatic hydrolysis that could help broaden the range of low glycemic index foods available for consumers.

Jackfruit seed in noodles increased protein content and improved overall nutritional value of the noodles. Chemical composition in noodles substituted with jackfruit seeds indicated decrease in fat and moisture content compared to control noodles. Also, ash and crude fiber contents in 30 per cent substitution of jackfruit seed flour were higher than that of control noodles (Amin, 2009).

Brennan (2005) explains that pasta products can be fortified with protein sources such as fish protein concentrates, soy flours, soy isolates, milk and milk products, cotton seed meal, egg albumin, whey proteins, and yeast protein concentrates.

Altan *et al*. (2008) proposed that pasta products are normally high in starch but low in dietary fiber, minerals, vitamins, phenolic compounds, etc. With an increasing concern by the health conscious population, more nutritious pasta

products rich in minerals, phenolic compounds, and dietary fiber with low glycemic index, have become the subject of prior significance.

Pasta with moderately acceptable cooking and sensory quality can be prepared by incorporating 20 per cent level of banana and ragi flours in pasta formulation. The mineral content and dietary fiber content of pasta was considerably increased by substitution. Antioxidant activity was also considerably improved by their addition (Yagci and Gogus, 2008).

2.2.2. Intermediate Moisture Convenience Foods

Intermediate moisture foods (IMF) products are foods that have higher moisture content than dry foods and are ready to eat. They require no preparation or rehydration although they are high in moisture, they do not require refrigeration during distribution and storage and thus they are shelf stable. The moisture content is usually in the range of 10 per cent to 40 per cent and water activity is usually 0.60-0.90 (Charles *et al.,* 2003).

Intermediate moisture foods are food products of soft texture subjected to one or more technological treatments, consumable without further preparation and with a shelf stability of several months assured without thermal sterilization, no freezing or refrigeration, but an adequate adjustment of their formulation, composition, pH, additives and mainly water activity approximately between 0.60-0.90 measured at 25^0 C (NCCFN, 2005)

According to James (2003) IMF foods are semi dried foods with ideal water activity between 0.65 to 0.90. At this level of water activity the texture of the product is soft, moist, and more acceptable than conventional dried products.

Lowering of water activity to a level where most microorganisms cannot grow is one of the oldest methods of food preservation and forms the basis of the intermediate moisture foods. IMF has water activity reduced to approximately 0.65 to 0.90 that is moisture content of 15-40% are elastic enough to be consumed without rehydration. Other preservative factors act in association with water activity to ensure the shelf life of IMF (Sach, 2008).

Stewart (2009) reported that IMF products are semi moist foods that have some of their water bound by glycerol, sorbitol, salt, or certain organic acid, thus preventing the growth of many microorganisms.

Purvi *et al*. (2006) opined that IMF products are characterized by a semi moist consistency so these foods have enough moisture content to permit easy chewing but low enough water content to prevent spoilage.

FAO (2005) reported that IMF products have better retention of original flavour and texture compared to fully dried products, with concomitant reduction in bulk, weight and cost of packaging, transportation and storage. Such IMF products are more appropriate for developing counties in view of their minimal processing equipments, stability under ambient conditions, safety, convenience, ease of nutrient content adjustment, energy savings, and low capital investment. They are also eminently more suited than dehydrated or canned foods.

Work done by various food scientists approximately three decades ago in the search for convenient stable products through removal of water resulted in so called modern IMF foods. These foods rely heavily on the addition of humectants and preservatives to prevent or reduce the growth of microorganisms to make them shelf stable for longer period (Leistner *et al.,* 2009).

Sebastian (2009) experimented and showed that many foods can be successfully stored at room temperature by proper control of their water activity. These foods can be described as semi moist foods or intermediate moisture foods, which include fruit cakes, puddings, and sweet sauces as chocolate and caramel.

Granole *et al.* (2009) developed calorie restricted IMF candy without added sugar. The product is designed in such a way that the full fruit strawberry is filled with wheat flakes and oats and which is coated with yogurt. The product is fluffy, elastic, crispy, and soft and crunchy too. High fiber IMF was developed by Garrel (2010). In this wheat bran is added in the IMF fruit bar. The amount of sugar and salt are very less.

Taylor *et al.* (2010), reported that high fiber IMF have a significant role in weight reduction. Whole fruits, vegetables, nuts can be incorporated to such IMF, thus improving the nutritional value. Various IMF products such as fruit cakes,

bread, cookies, etc which is having shelf life more than 20 weeks have developed by DFRL scientists in India (Madura, 2003).

Cream and IMF fruit pieces are blended together for a variety of desserts. Strawberry, black berry, pomegranate, pineapple, mango etc commonly used fruits for making creamy desserts. Dried fruits are also used as ice-cream toppings along with roasted nuts which add variety to desserts (Potter, 2006).

IMF papaya chunks were developed by Baysal (2000) which had chewy texture. Nutritional analysis revealed that the product had great exotic energy, vitamins and minerals. The product was perfect for snacking or as incorporated ingredient to dessert.

Sialaja (2014) developed intermediate moisture papaya fruit bar which was nutritionally high in calories retaining the natural vitamins and minerals. The study also pointed out that the intake of phytosterols in papaya fruit bar could be efficacious for lipid profile modulation**.**

2.2.3. Ready to Eat Snack Foods

Vijayabaskaramansilamani and Sundaram (2012) opined that snack foods are commonly foods that are eaten between main meals. Snack foods have a tendency to have a lower nutritional value than natural food and are commonly viewed by many in this way.

Snacks come in a variety of types, ranging from raw to cooked foods, and some for example beans and nuts, provide significant amounts of protein and fat. Those snack foods prepared from fruits and vegetables also provide important vitamins and minerals (Rolls *et al.,* 2000).

Ouwens *et al.* (2003) stated that snack foods can be found in nearly every corner of the world and have been on sale for thousands of years. Such foods are inexpensive, provide a nutritional source based on traditional knowledge, mostly follow the seasonality of farm production and thus allow for variation in consumer diets, and are widely distributed and available in both urban and rural settings.

Stroebele (2004) opined that snack foods show great variation in terms of their ingredients, how they are prepared, and how they are sold and consumed. The nutritional value of snack foods depends on the ingredients used and how the

snack is prepared. It can provide important daily nutritional requirements, as long as appropriate ingredients and methods of preparation have been observed.

Young and Nestle (2002) proposed that with the rise of urban centers and growing urban populations demand for ready-to-eat affordable food is increasing. In many large cities ready-to-eat food is a necessity for many as they have little time for food preparation while at work or do not have the time to travel back home for their meals.

Recent trend in snack food industry is to develop value added fruit and vegetable incorporated bakery products.

Supplementation of jack fruit seed flour to the wheat flour in cookies increases fibers (Aziz, 2006). Development of reduced calorie chocolate cake was successful by partially replacing sucrose with polydextrose at 11 per cent and jackfruit seed flour at 16 per cent resulting in approximately 34 per cent calorie reduction as compared to the control cake (Amin, 2009).

Hernández *et al.* (2012) reported that when cookie flour is made up of partially fruit flour (in various levels) cookies contain higher dietary fiber and resistant starch and lower hydrolysis percentage and predicted glycemic index, rendering the cookies nutritious and aid consumers with health problems such as diabetes and obesity.

2.3 NEED FOR FOOD PROCESSING

Foods are perishable commodities and are therefore processed to preserve them from deterioration while providing the consumer with palatable, wholesome, nutritious and tasty foods in a convenient form throughout the year. Food processing adds value, enhances shelf life of the perishable agro food products and encourages crop diversification (Anand, 2000).

Maheshkumar (2009) opined that food industry is of enormous significance for India's development because of the vital linkages and synergies that it promotes between the two pillars of the economy, namely industry and agriculture.

Food processing is very important for the prosperity of India. Food processing industry help to avoid post harvest losses of agricultural produce. In

India, the value addition of food production is only 7 per cent compared to 23 per cent in china, 45 per cent in Philipines and 88 per cent in U.K. (Mallaya, 2003).

The national food processing policy aims to increase the level of food processing to 11 per cent by 2010 and 25 per cent by 2025. But attaining these targets would be difficult, unless research and development programmes are upgraded to reduce costs, improve quality and performance and tap opportunities in the food and beverage sector (Bhattacharya, 2009).

Food processing sector is an employment intensive and generates 1-8 direct employment per ten lack rupee of investment and 6.4 employments indirectly (Aswathi *et al.,* 2006).

Processing fruit based products is a method of reducing post harvest losses of perishable foods like fruits. Processing fruits can be defined as adding value to conventional and innovative fruit items, through various permutations and combinations providing protection, preservation, packaging, convenience, carriage and disposability.

Soong and Barlow (2004) reported that due to perishable nature of fruits and vegetables the post harvest loss of these commodities is four to five times higher than in food grains.

Processing of under exploited fruits can add value and find good business opportunities in India. Underutilized fruits which are not easily marketed in the fresh form should be processed into acceptable products so that the opportunity to enjoy the fruit in the form of its processed products (Santiago, 2011).

Lund and Smoot (2002) opined that many of the minor tropical fruits are completely unknown to consumers living in temperate climates. With the interest in exotic and unusual products growing in developed countries, real potential exists to cultivate an export market based on the production of tropical fruits.

The fruit and vegetable processing industry has been declared as a thrust area and is likely to takeoff in the near future as a potential earner of foreign exchange through export of processed fruits and vegetables. The food industry can provide processed food products at reasonable prices throughout the year, meeting

the requirements of defence forces in border area and earning foreign exchange for the country by development of exports (Crisosto, 2010).

Ajila and Naidu (2007) reported that fruit processing helps to imitigate the problems of underemployment during the off season in agriculture sector. Cultivation of new fruits and development of products from many of the notable fruits could bring benefit nutritionally and economically. If the fresh and processed fruits are evenly marketed from the places of abundance to the place of scarcity, not only will the consumers get the produce at a reasonable price but also the producer will not be forced to sell at throw away prices.

Fruits and fruit products are enigma of modern society. Fresh fruits are perishable and have limited shelf life. To prolong the shelf life various processing and preservation methods are being used. There are several methods of preserving food such as dehydration, irradiation, freezing, osmotic drying, and reduction of water activity, canning and smoking (Larrauri, 2009).

2.4. OSMOTIC DEHYDRATION OF FRUITS

Osmotic dehydration (OD) is a dehydration process of foods that involves soaking a food in hypertonic sugar and/or salt solution to reduce the moisture content of foods before actual drying process. OD is performed to reduce the moisture content of food products in minimal processing under ambient or modified environment conditions (Escriche *et al*., 2009).

During the osmotic process two simultaneous counter-current flows may occur; water flow out of the food into the solution, the simultaneous transfer of water soluble solutes from the solution into the food, and migration of natural solutes (sugars, organic acids, vitamins, reducing sugars, some flavour compounds, volatiles, minerals, etc.,) from the food into the solution (Beaudry *et al.,* 2004).

Since the hypertonic solution has higher osmotic pressure with reduced water activity, it serves as a driving force for water withdrawal from the cells solution to the osmo-active solution. The removal of water during osmotic process is mainly by diffusion and capillary flow, whereas solute uptake or leaching is only by diffusion (Rahman, 2007). All these mass exchanges between the osmotic

solution and foodstuff may have an effect on the overall yield and quality of the dehydrated product.

In perfectly semi-permeable membrane, the solution is unable to transfer through the membrane into cells, but it is hardly to obtain such type of membrane in food materials due to its complex internal structure and possible damages during processing (Shi, 2008). Hence, such conditions are important in osmotic dehydration processes to allow counter flow of solutes and water.

Osmotic dehydration got its attention due to its great importance in processing industry. This simple pretreatment prior to drying was governed by various factors such as type, concentration and time. Osmotic dehydration is mostly used as an initial processing prior to convention or vacuum drying, freeze drying or pasteurization (Piotrowski *et al.,* 2004).

Nowadays, fresh fruits and vegetables have been increasing in popularity for consumption compared to canned fruits. To satisfy the growing market demand for commodities in a fresh like state, minimal processing such as osmotic dehydration will be increasingly used. The active research in the area of osmotic dehydration of fruits is continuing all over the world (Allali *et al.,* 2010). It is reported that up to 50 per cent reduction in the fresh weight of fruits or vegetables can be achieved by osmotic dehydration (Varith *et al.,* 2007).

Zhang *et al.* (2007) described partial dehydration of banana by osmosis in 70 % sugar syrup. The fruit was reduced to about 50 % of its original weight by the process of osmosis. Flavour, colour, appearance and texture attributes were maximally retained in osmotically dried products.

Machado *et al.* (2003) evaluated the parameters of the osmotic dehydration process of banana and the influence of concentration of the osmotic solution over the chemical and physical characteristics of the fruit after osmosis and drying. It was concluded that it is possible to obtain banana by osmotic dehydration, where the chemical and physical characteristics are influenced by the concentration of the solute used as osmotic agent, mainly color and texture, after osmosis and drying, decreasing time of drying with the concentration increase.

Edson *et al.* (2006) studied the process of osmotic dehydration and followed by air- drying in papaya.

Tedjo *et al.* (2002) stated that the driving force for water removal is the concentration gradient between the solution and the intercellular fluid. It improves the quality of the product in terms of colour, flavor, aroma and texture, and is less energy intensive process than air or vacuum drying process.

Taiwo *et al.* (2003) opined that because of constant product immersion in the osmotic medium, the plant tissue is not exposed to oxygen; therefore, there is no need to use antioxidants (i.e., sulfur dioxide in case of fruits) for protection against oxidative and enzymatic discoloration.

Dehydration of foodstuffs by immersion in osmotic solutions before convective air-drying improves the quality of the final product since it prevents oxidative browning and/or loss of volatile flavouring constituents, reduces the fruit acidity (Corrêa *et al.,* 2010).

On the other hand, partial dehydration and solute uptake have advantages in preventing structural collapse during subsequent drying processes (Chiralt *et al*., 2001). Considering that heat is not applied in this stage, osmotic dehydration offers higher retention of initial food characteristics, such as colour, aroma, nutritional constituents, and flavour compounds (Beaudry *et al.,* 2004).

The use of osmotically dried fruits to make high quality chips is one application area to get good quality vacuum fried product. The best mango chip in vacuum frying was produced with an osmotic solution concentration of 65% (w/v) and temperature of 40oC, which resulted in the highest water loss to sugar gain and provided a good texture characteristic (Nunes and Moreira, 2009).

Osmotic drying has diverse application in fruit and vegetable processing industries. However this dehydration step generally does not produce product of low moisture content having long shelf life and stability. To get relatively stable product the technique should complement with other drying methods like; convective, freeze, microwave or vacuum drying steps (Erle and Schubert *et al.,* 2001).

By reducing the moisture content of a product to certain, extent either using mechanical or OD method, ultimately reduce the energy demand required to remove the moisture.

2.5. EXTRUSION COOKING

Brennan (2005) stated that a range of acceptable, quality ingredients and food products can be produced by extrusion cooking. These products had acceptable textural properties and were received favourably in consumer pre-test studies. According to Riaz (2007) extrusion cooking technology is defined as a process in which material is pushed through orifice or a die of given shape.

Sloane (2006) reported that extrusion cooking is defined as a unique tool to introduce the thermal and mechanical energy to food ingredients, forcing the basic components of the ingredients, such as starch and protein, to undergo chemical and physical changes.

Food extrusion is a form of extrusion used in food processing. It is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. The machine which forces the mix through the die is an extruder, and the mix is known as the extrudate (Karwe and Mukund, 2008).

Archibald (2006) proposed that food products manufactured using extrusion usually have high starch content. These include some pasta, breads (croutons, bread sticks, and flat breads), many breakfast cereals and ready-to-eat snacks, confectionery, pre-made cookie dough, some baby foods, full-fat soy, textured vegetable protein, some beverages, and dry and semi-moist pet foods.

Brennan (2005) opined that Extrusion has enabled the production of new processed food products and revolutionized many conventional snack manufacturing processes.

Extrusion processing of food materials has become an increasingly important manufacturing method, and its applications have broadened substantially in the last two decades (Sloane, 2006).

Extrusion combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming so it is a highly versatile unit operation that can be applied to a variety of food processes. Extrusion has for years provided the means of producing new and creative foods. One major advantage of extrusion cooking is the capability to produce a wide range of finished products with minimum processing times and by using inexpensive raw material (Riaz, 2007).

Extrusion is a popular means of preparing snack foods and ready to eat breakfast cereals using starch based raw materials. The raw materials such as flours of rice, wheat, corn oat can be incorporated in to the formulation (Jha and Prasad, 2003).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled "**Development and quality evaluation of fruit based instant snack and pasta product"** was undertaken in two parts viz, development of fruit based instant snack product and pasta products. Ready to eat nutritious snack and pasta product were developed by incorporating the ingredients such as fruits, cereals, pulses, tapioca and coconut.

PART- I

3.1. DEVELOPMENT OF FRUIT BASED INSTANT SNACK

A healthy snack includes whole grains, fruits and vegetables, nuts and low fat dairy products. The fruit based instant snack was formulated by selecting the food items such as locally available fruits (jackfruit, papaya, and banana), whole grains (rice and wheat), pulses (green gram and horse gram) and coconut.

3.1.1. Selection and Preliminary Processing of Fruits for Instant Snack

Good quality uniformly matured jack fruit (C V Koozha), papaya (Pusa Dwarf) and banana (Nendran) were the three fruits selected and procured from Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram and also purchased from super market for the formulation of fruit based instant snack..

3.1.1.1. Pre-preparation of Jackfruit

Semi ripened jackfruit was washed under tap water to remove dust and dirt, cut in to several pieces, bulbs were removed manually. As the fruit contain sticky latex, small quantity of vegetable oil was applied on hands and seeds were removed from bulbs. The selected bulbs were cut in to uniform cubes.

3.1.1.2. Pre- preparation of Papaya

Semi ripened papaya was washed in tap water, peeled, non edible portions were removed and cut in to uniform cubes.

3.1.1.3. Pre-preparation of Banana

Semi ripened banana was cleaned in tap water, peeled and cut into halves, removed the center portion and cut into uniform cubes.

3.1.2. Pretreatments of Fruits

Pre-treatments of fruits were done to improve the texture, firmness and keeping quality of fruits. Each fruit was subjected to eight pretreatment separately. The fruit cubes were directly soaked in pretreatment solutions for required time period and removed. All these process were done manually. The initial weight and weight after pretreatment were recorded.

3.1.2.1. Selection of Best Pretreatment for Fruits

The best pretreatment was identified by conducting organoleptic study. Organoleptic parameters such as colour, appearance, flavor, texture and taste were observed. A 6 point score card (Estaio *et al.,* 2009) (Appendix I) was prepared and the best acceptable pretreatment was selected based on the sensory judgment given by selected semi - trained 10 panel members.

The pre treatments and osmotic treatments given to fruits for the development of instant snack is as follows

Pretreatments

PT_1: 0.5 % citric acid solution for 5 minutes.

PT_2: 0.5 % citric acid solution for 10 minutes.

PT_3: 1 % citric acid solution for 5 minutes.

PT_4: 1% citric acid solution for 10 minutes.

PT_5: 10% lime water for 6 hours.

PT_6: 10% lime water for 12 hours.

PT_7: 15% lime water for 6 hours.

PT_8: 15% lime water for 12 hours.

Osmotic treatment

OT_1: Sugar solution 60◦ B 6 hours.

OT_2: Sugar solution 60◦ B 12 hours

OT_3: Sugar solution 70◦ B 6 hours.

OT_4: Sugar solution 70◦ B 12 hours

Fruits - 3

Pretreatments-8

Osmotic treatment -4

Replication – 2

Design - CRD

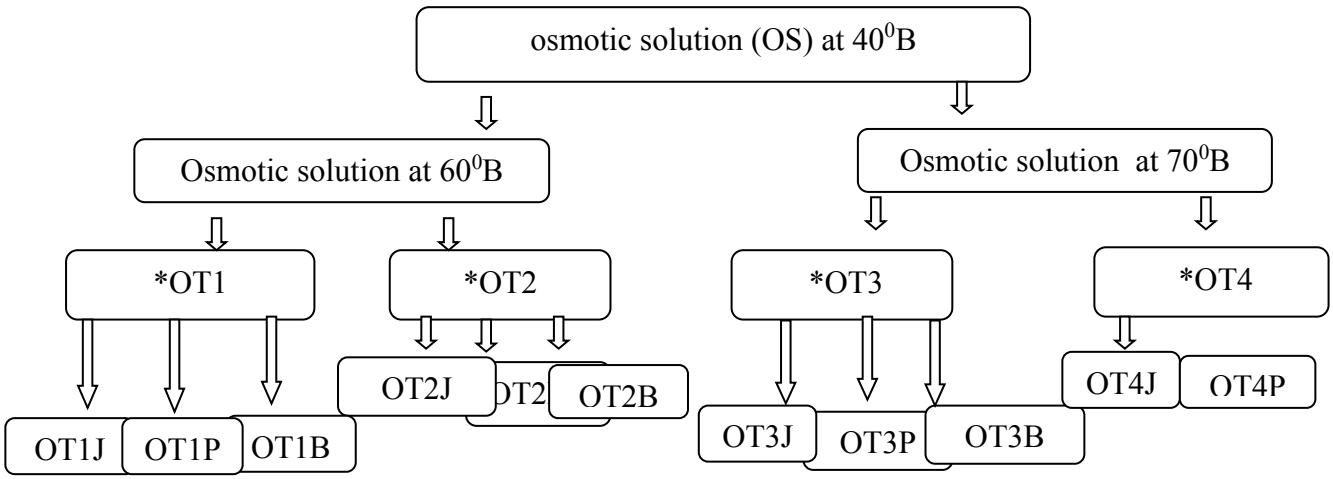
3.1.3. Osmotic Dehydration of Pretreated Fruits

Osmotic dehydration is less energy intensive than air or vacuum drying processes because it can be conducted at low or ambient temperature. It has potential advantages for the processing industry to maintain the food quality and to preserve the wholesomeness of the food. It involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent (osmotic concentration) and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable.

The selected pretreated fruits were further subjected to osmotic dehydration. Osmotic treatment for each fruit was conducted separately. Fruit cubes were washed thoroughly before osmotic dehydration. Sugar solution of two concentrations (60^0B and 70^0B) for 6 and 12 hours was used in osmotic treatment of fruit cubes.

Initially 12 l. of osmotic solution at 40^0 B was prepared and kept in glass bottles. In each glass bottle 1l. of osmotic solution was taken and 500 g fruit cubes (jackfruit, papaya and banana) were immersed separately and kept for 12 h. In this study concentration of osmotic solution was gradually increased so that the shape and size of the fruit cubes could be retained. After 12 h., the fruit cubes were drained out and the concentration of osmotic solution was raised to 60^0 B in 6 glass bottles. The other 6 bottles, concentration of osmotic solution was raised to 70^0 B as shown in Fig. 1.

The concentration of osmotic solution was raised by boiling solution and addition of sugar simultaneously. Using a hand refractometer, the concentration was checked. When the osmotic solution achieved the prescribed concentration of 60^0 B and 70^0 B, the solution was cooled to room temperature and fruit cubes of jackfruit, papaya and banana were immersed and kept for specified time durations. After the prescribed time periods, the drained out fruit cubes from each bottle separately. The initial and final weight after osmotic treatment was recorded.



*OT1, OT2, OT3 and OT4- osmotic treatments

*P, B, J – Papaya, Banana, Jackfruit

Fig. 1. Flow chart of osmotic dehydration of fruits

3.1.3.1. Selection of Best Osmotic Treatment for Fruits

The best osmotic treatment for fruits was selected by conducting organoleptic evaluation with the help of a 6 point score card (Estaio *et al.,* 2009) (Appendix II). Semi-trained panels of 10 members were selected for the sensory study. The colour, appearance, flavor, texture and taste of the osmotically dehydrated fruits were tested. The best acceptable osmotic treatment was selected based on the judgment.

3.1.3.2. Drying of Fruit Cubes

In order to prevent the adhesiveness and aggregation, osmotic treated fruit cubes were further subjected to drying in tray drier at 60^0 C for 4 hours. Each fruit was separately dried in the drier. Weight loss after drying was noted.

3.1.4. Selection and Optimization of Other Raw Ingredients for Instant Snack

Cereals, pulses and coconut were selected as the other ingredients for the development of instant snack. NIIR (2000) reported that wheat, rice, maize and barley are the cereals ideal for making shredded, granular, puffed or flaked products. Cereals such as rice and wheat and pulses such as green gram and horse gram were selected for the development of fruit based instant snack. The selected cereals and pulses except rice were sprouted. After sprouting, the ingredients were dried in tray drier. The time taken for drying and weight after drying was recorded. The ingredients were finally taken for roasting. Roasting was done till the ingredients acquire crisp texture, roasted flavor and acceptable colour.

3.1.4.1. Processing of Rice

The selected cleaned parboiled rice was roasted till rice grains attained enough crispiness and crunchiness (Fig. 2.). The crispiness of rice was randomly checked while roasting. Meantime in minutes required to complete the roasting procedure of half kg of parboiled rice was noted.

3.1.4.2. Processing of Wheat

Soaking, sprouting, flaking and roasting were the processing techniques applied to wheat. Wheat of two kilo gram quantity was soaked for an overnight in 3 l. of water. After overnight soaking excess amount of water was removed, wheat was tied in muslin cloth and kept in room temperature for germination.

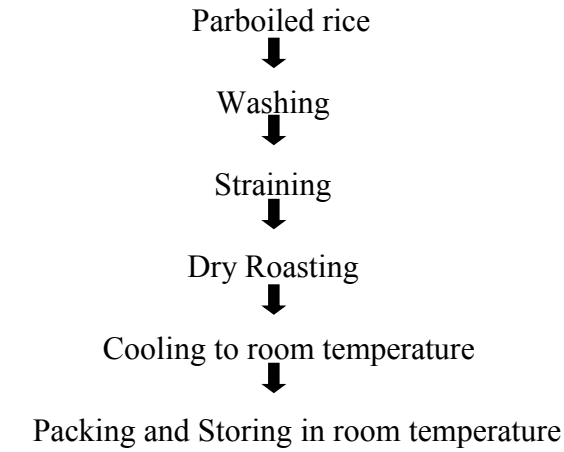


Fig. 2. Flow chart on processing of rice

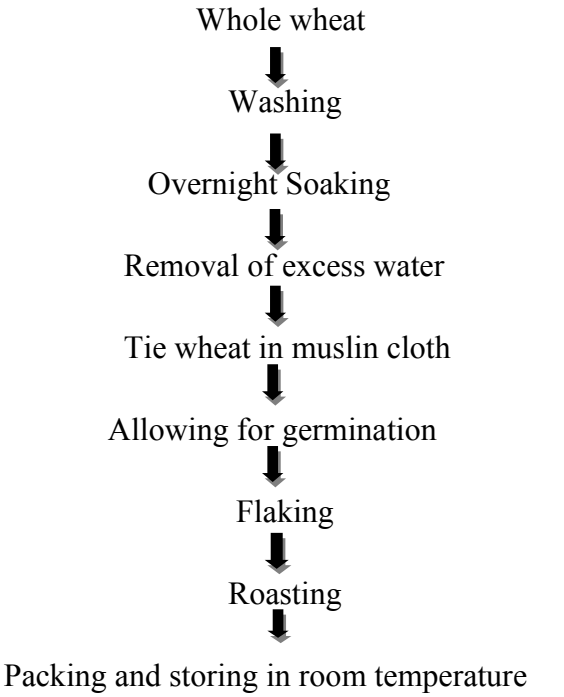


Fig. 3. Flow chart on processing of wheat

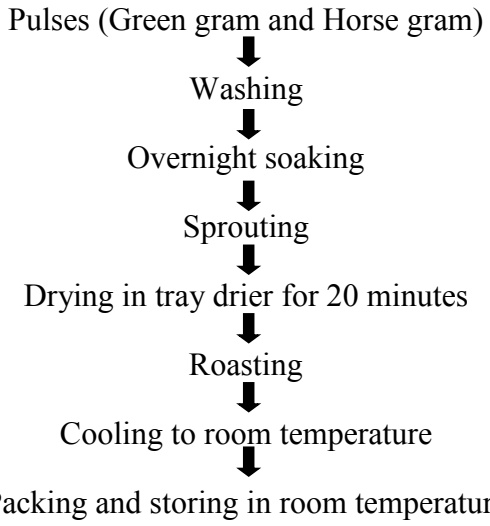


Fig. 4. Flow chart on processing of pulses

At an interval of two hour, the growth of sprouts was noted and the wheat was removed from tied cloth immediately when the germination started. The germinated wheat was flaked mechanically. The flaked wheat was then dry roasted till it became crisp and crunchy. The mean time required for roasting wheat was noted. Random checking was done to find out the complete roasting procedure (Fig. 3.).

3.1.4.3. Processing of Pulses

The pulses (green gram and horse gram) were cleaned in tap water, geminated, dehydrated and roasted. Initially one kilo gram of pulses was soaked in 2 l. of water for an overnight. The excess water was removed by draining out and the pulses were tied separately in muslin cloth, kept in room temperature for germination. At an interval of two hour duration, the growth of sprouts was noticed. The pulses were removed immediately when the germination started.

The germinated pulses were further subjected to tray drying for 10 minutes at 60^0 C, in order to remove excess water. Roasting of dried pulses was done. The mean time taken for roasting ingredients and weight losses after processing the ingredients were noted (Fig 4.).

Sprouting studies conducted in green gram and horse gram by Routelle *et al.* (2006) showed that the rate of germination for green gram is high than that of horse gram. Since the germination rate for green gram and horse gram are different both experiments were conducted separately for the instant snack development.

3.1.4.4. Processing of Coconut

Freshly harvested 6-8 months old coconut was selected for the study. Coconut kernel was separated from the shell, sliced in to pieces and dehydrated by osmosis in sugar solution at 60^0 B for 6 h. After osmotic dehydration the coconut pieces were uniformly spread in tray and dried at the temperature of 60^0 C for 8 h. in a tray drier (Santhi *et al.,* 2008). Initial and final weights of coconut were recorded.

Osmotic solution of 60^0 B using sugar was prepared, and the coconut pieces (500 g) were directly immersed in the hot solution. The solution along with

coconut pieces were kept for 6 h. After 6 hours the pieces were drained out and dried in tray drier at 60^0 C for two hours to obtain shelf stable coconut pieces.

3.1.5. Development of Instant Snack

Fruit based instant snack was formulated by mixing all the eight processed ingredients such as fruits (jack fruit, papaya, banana), cereals (rice and wheat), pulses (green gram and horse gram) and coconut in different combinations using a blender. Various combinations of snack were worked out and from that best combination was selected for further investigation.

The best combination was selected based on the nutritional content and organoleptic scores. The selected combination of snack was packed in laminated pouches and stored in room temperature for further analysis. The processing steps involved in the development of instant snack are detailed in Fig 5.

3.1.5.1. Bulk Production of Instant Snack

The selected combination of snack was produced in bulk amount of about 10 kg. in order to conduct various experiments such as quality evaluation, consumer study and shelf life study.

3.1.5.2. Yield Per cent of Instant Snack

Estimation of yield per cent in food processing will be helpful in determining cost of production. The yield per cent of the instant snack was calculated on dry weight basis. To determine the yield per cent for instant snack the following formula was used. Yield per cent= (Wt of snack obtained ÷ Wt of raw ingredients) ×100

3.1.6. Quality Evaluation of Instant Snack

Quality assurance in food is an ordered set of planned and systematic actions, necessary to provide adequate confidence regarding processed products and services, satisfying the requirement of quality. Sensory quality, nutritional and chemical composition and shelf stability of the formulated combination of instant snack product was carried out by using standard procedures.

3.1.6.1. Organoleptic Quality Evaluation of Instant Snack

Initial organoleptic assessment was performed for the snack immediately after formulation.

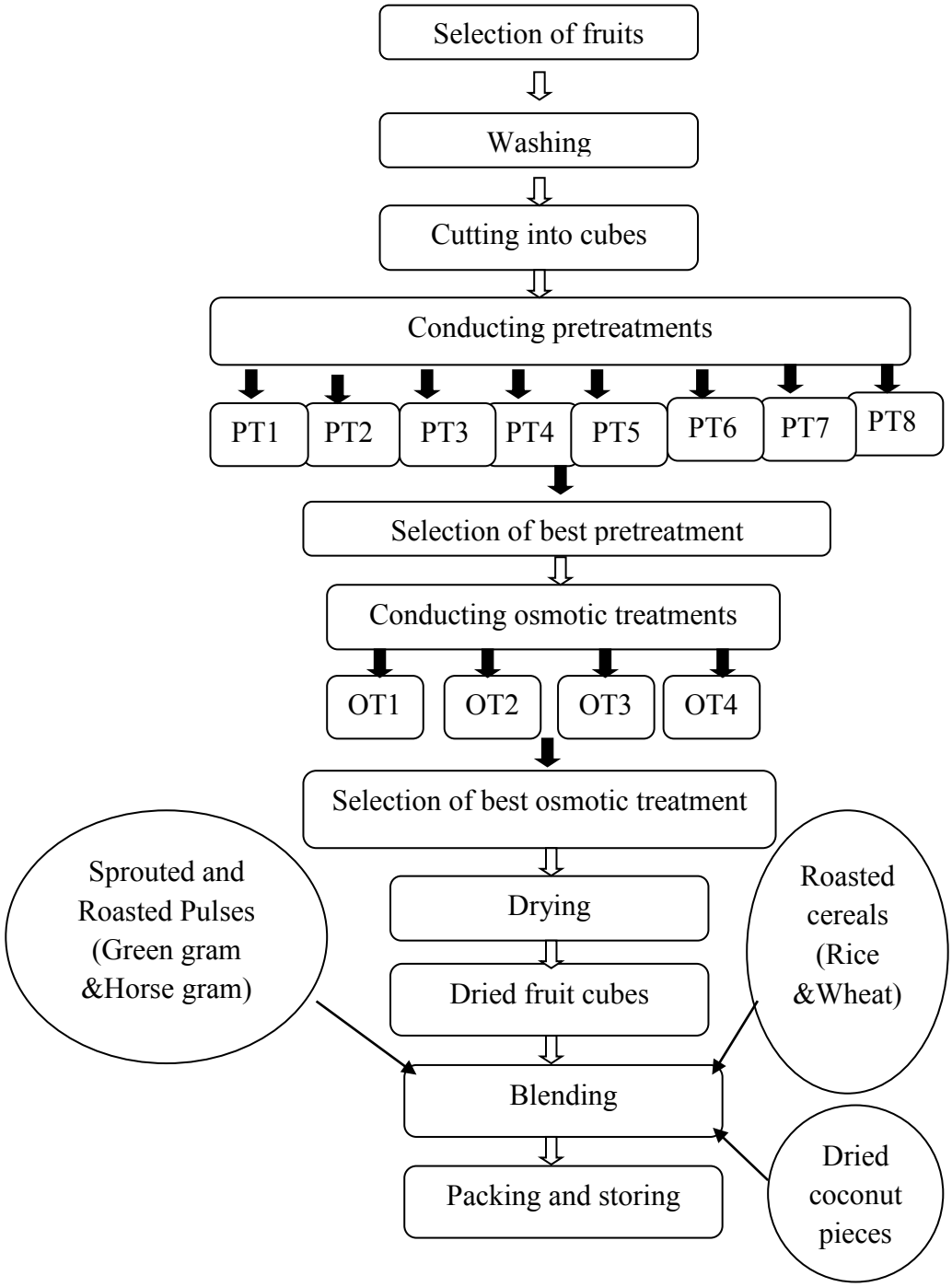


Fig. 5. Flow chart on development of instant snack.

The developed instant snack product uniformly prepared and presented to panelists. Judges recorded the product's sensory characteristics such as colour, appearance, flavour, texture and taste on a sensory evaluation sheet (Estaio *et al.,* 2009) (Appendix- III). A panel of 10 members semi-trained in different scientific methods of sensory analysis was charted for conducting the sensory analysis of the developed instant snack. The scores were decoded and analyzed by statistical procedures to obtain a suitable conclusion.

3.1.6.2. Nutrient Content and Chemical Composition of Instant Snack

Nutrient as well as chemical composition analysis refers to the process of determining the nutritional and chemical components in foods and food products. The developed combination of instant snack was analyzed for nutrients as well as chemical components using standard procedures (Tables 1 and 2).

3.1.7. Shelf Stability of Instant Snack

Shelf life studies are conducted in food products to determine the shelf life of the product that will retain qualities including acceptable appearance, flavor, taste, microbial counts and chemical components. The instant snack was packed in laminated pouches, kept in room temperature and analyzed for a period of three months. At an interval of one month the sample was analyzed in terms of organoleptic quality, chemical constituents and microbial growth.

3.1.7.1. Organoleptic Quality Evaluation of Stored Instant Snack

The stored instant snack was assessed for sensory attributes such as colour, appearance, texture, flavor and taste by selected ten semi-trained panel members using a score card during the storage period.

3.1.7.2. Chemical Composition of Stored Instant Snack

During the shelf life study, the chemical components such as moisture, peroxide, poly phenols and total minerals of the stored product were analyzed using standard procedures.

3.1.7.3. Microbial Evaluation of Stored Instant Snack

Microbiological load in packaged food has a significant effect on the quality of the final product. A high microbial load and temperature higher than recommended for a particular product can reduce the shelf life of a product by 50-

70 per cent. Presence of microbes above the particular limit leads to severe problems among the consumers, which directly affect the reputation of food. Therefore, analysis for microbial load is necessary in a product development study.

The developed and stored instant snack was analyzed for bacteria, fungi, yeast and actinomycetes infection by suitable and standard procedures. The procedures adopted were serial dilution technique. 1 ml from each of the sample was taken in conical flask containing 99 ml sterile water, making the dilution of $10^{-2.}$ From this 1 ml of the dilution was further transferred into test tube containing 9 ml of sterile water, so that dilution becomes 10^{-3}. Likewise further dilutions of 10^{-4}, 10^{-5}, and 10^{-6} were made. Kenights, nutrient agar, PDA, and YPDA (Appendix VII) were the medium selected for the microbial analysis. Plates were poured and allowed for solidification. 1ml of the suspension from 10^{-3}dilution was then transferred to Petri plates using a sterile pipette, medium poured and spread evenly. The whole procedure was done aseptically in a laminar airflow chamber. Plates were then kept for incubation at 28^{0} C. Colonies appearing in the plates were recorded after 2 days in the case of bacteria and after 4 days for fungi and yeast. The microbial load of the samples was then expressed as cfu/g of the product.

3.1.8. Consumer Acceptance of Instant Snack

The consumer acceptance and preference study of the developed instant snack were conducted among 50 subjects each among children, adolescents and adults. A 9 point hedonic rating scale (Appendix V) was used to derive data.

3.1.9. Cost Analysis of Instant Snack

` The cost analysis was carried out based on the input cost *i.e.* cost of different ingredients used for the preparation of instant snack, and output cost (the total input cost and added 15 per cent as overhead charges for fuel and labour).

3.2.10. Statistical analysis

In order to obtain meaningful interpretation, the generated data was subjected to suitable statistical analysis (Analysis of Variance).

Table 1. Nutrients analyzed in instant snack

Nutrients	Reference
Energy(Kcal)	Gopalan *et al.,* (1991)
Protein(g)	Sadasivan and Manikkam (1992)
Carbohydrate(g)	Sadasivan and Manikkam (1992)
Fat(g)	Sadasivan and Manikkam (1992)
Calcium(mg)	Jackson (1973)
Iron (mg)	Thimmaiah(1999)
Sodium (mg)	Thimmaiah(1999)
Potassium (mg)	Thimmaiah(1999)
β carotene (µg)	Ranganna (2001)

Table 2. Chemical components analyzed in instant snack

Chemical components	Reference
Moisture(g)	Sadasivan and Manikkam (1992)
Poly phenols(mg)	Ranganna (2001)
Total minerals(g)	Sadasivan and Manikkam (1992)
Fiber(g)	Sadasivan and Manikkam (1992)
Peroxide(meq)	Sadasivan and Manikkam (1992)

PART-II

3.2. DEVELOPMENT OF PASTA

Pasta is one of the most consumed foods in the whole world, and it is a traditional product obtained from semolina. The pasta product was formulated by incorporating items such as locally available fruits (jackfruit, papaya, and banana), wheat flour, green gram flour and tapioca flour.

3.2.1. Selection of Ingredients for the Development of Pasta

Locally available fruits were chosen for the study. Fully ripened and matured jackfruit (C V Koozha), papaya (Pusa Dwarf), and banana (Nendran) were selected for the pasta product formulation. The three fruits were procured from Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram and also purchased from super market. Wheat, green gram and tapioca, were the other ingredients, selected for the development of pasta and were purchased from super market.

3.2.2. Processing of Ingredients for the Development of Pasta

Processing provides availability of many food products that we are not able to eat otherwise, varieties of methods used in food processing are also very helpful in increasing the safety and the quality of the food, and many processed foods are even more nutritious than natural food.

In the present study, all the selected fruits and other ingredients were processed for the development of pasta.

3.2.2.1. Processing of Fruits

Uniformly ripened fruits (jackfruit, papaya and banana) were selected, cut in to halves, and the edible portions were collected manually. The collected portions were smashed into pulp using a fruit pulper. The pulp was collected in an air tight container and immediately used for pasta processing (Fig. 6.).

3.2.2.2. Processing of Wheat and Green Gram

Wheat flour is the basic component for the development of pasta. It provides excellent binding property and retains the texture of pasta. Wheat is an excellent source of protein.

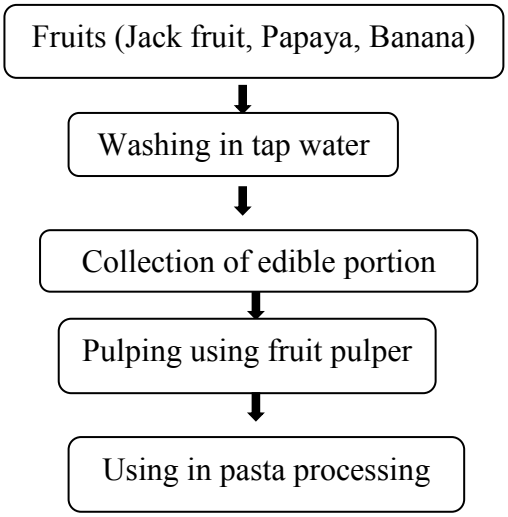


Fig.6. Flow chart on processing of fruits for the development of pasta

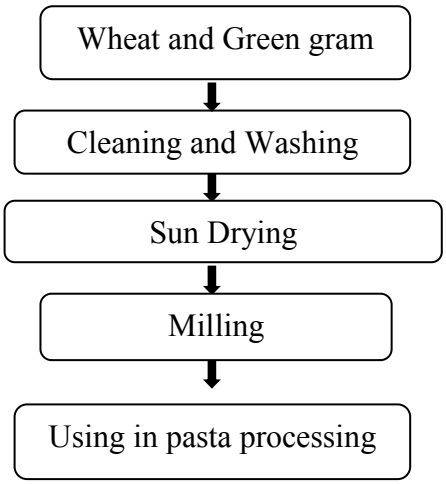


Fig.7. Flow chart on processing of green gram and wheat for the development of pasta

Whole wheat was purchased from the local market and cleaned in tap water and dried under sun. The dried wheat was further milled to flour and sieved. The flour was packed in laminated pouches and stored in room temperature for further use (Fig 7.).

Green gram is good source of protein as well as various other nutrients. For the improvement of biological value of protein of the developed pasta product, green gram was also incorporated. Green gram was purchased from the market, cleaned and washed, sun dried and milled into flour. The flour was sieved and packed in airtight containers and stored in room temperature (Fig 7.).

3.2.2.3. Processing of Tapioca

Tapioca is an important ingredient for the development of extruded snack foods because of its excellent binding property. Tapioca was purchased from the local market. It was washed in tap water to remove mud and dirt. The cleaned tuber was then peeled and cut in to small pieces with the aid of sharp knife.

The tapioca pieces were taken to mixer grinder for grinding. The ground paste was mixed with excess water, stirred well and strained through filter. This was allowed to settle to get tapioca starch. The excess water was drained out. The sediment was collected, dried in sun to get fine tapioca starch. This was used for the development of pasta.

3.2.3. Formulation of Pasta

All the processed ingredients along with the fruit pulp were taken to pasta making machine Dolly Mini (Plate 1.). The ingredients were mixed together for ten minutes and made to dough mechanically and then extruded. Fruit pulps individually as well as in combination were mixed together along with the other ingredients (Plate 2A.) in various proportions. Different proportions of the ingredients measured and blended (Plate 2B.) and were taken to the extruder, pasta making machine (Dolly mini).

The extrusion auger not only forces the dough through the die, but it also kneads the dough into a homogeneous mass, controls the rate of production, and influences the overall quality of the finished product. Uniform flow rate of the dough through the extruder is also important. Variances in the flow rate of pasta

through the die produce inferior quality product and products of non uniform size were discarded. The extruded pasta was shade dried. Standardization of pasta product was done based on trial and error method. The ideal proportion of the ingredients for the pasta product formulation was analyzed by working out different proportions (Fig. 8).

3.2.4. Selection of Best Proportion

Selection of best proportion was done based on the extrusion behaviour of pasta. The extrusion behavior of pasta was assessed based on MFR value (Mass Flow Rate, MFR). It is the maximum quantity extrusion in gram within the minimum time in seconds (Sigh *et al.,* 1996). The formula of MFR is given below

$$\frac{\text{Quantity extruded in g}}{\text{Time taken in seconds}}$$

Five proportions of each banana incorporated pasta, papaya incorporated pasta, and jack fruit incorporated pasta was worked out as well as four proportions of mixed fruit (Jackfruit pulp + papaya pulp + banana pulp) pasta were developed. Therefore total nineteen proportions of pastas were developed.

Banana pulp incorporated pasta	- 5
Papaya pulp incorporated pasta	- 5
Jack fruit pulp incorporated pasta	- 5
Mixed fruit pulp incorporated pasta	- 4
Total	- 19

From each group the best proportion was taken for further analysis.

3.2.5. Quality Evaluation of Selected Proportion of Pasta

Quality is the important feature in any category of industry so as to maintain reputation. As far as pasta is concerned the quality analysis for sensory, functional, nutritional and chemical characteristics are quiet essential. Selected proportions of pasta were analyzed for organoleptic quality, functional characteristics, and nutritional as well as chemical composition by adopting standard procedures.

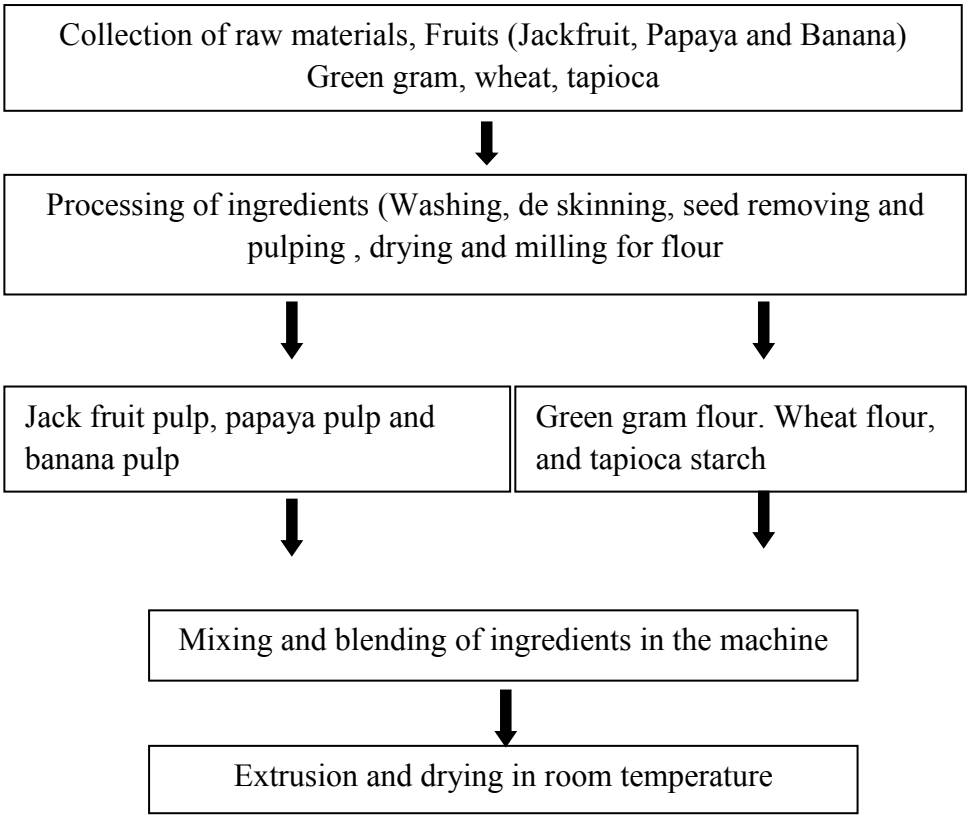


Fig 8. Flow chart on development of pasta product

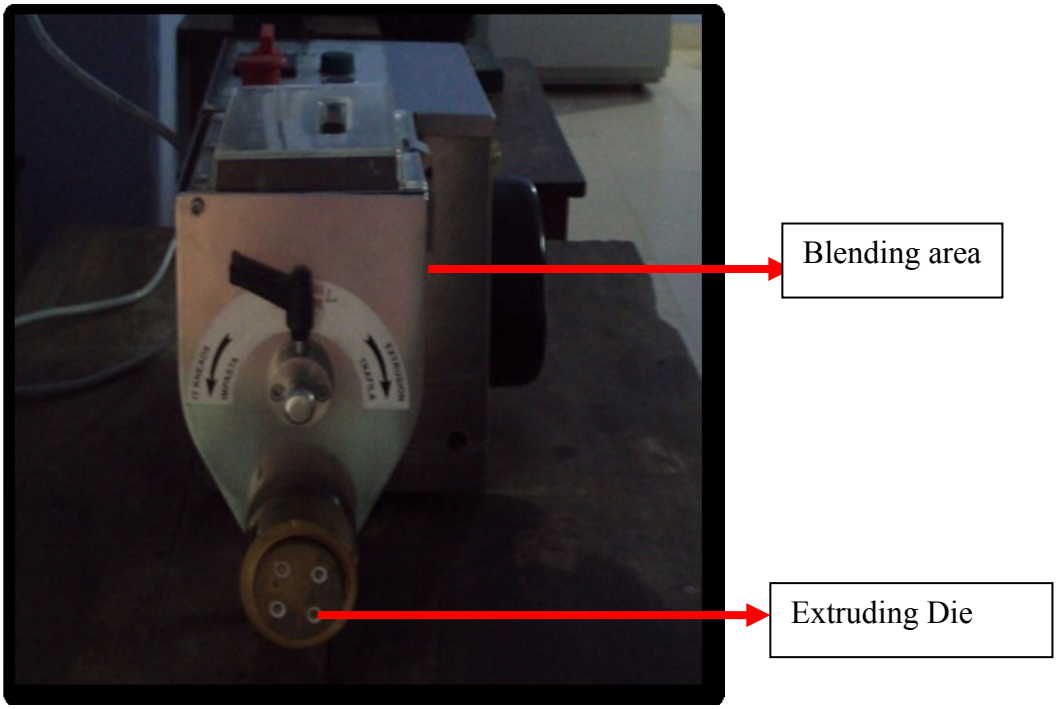


Plate 1. Pasta Making Machine (Dolly Mini)

Plate 2A. Addition of pulp for pasta processing

Plate 2B. Blending of pasta dough

3.2.5.1. Organoleptic Quality Evaluation

Sensory evaluation is designed to reflect common preference to maintain the quality of food at a given standard, for the assessment of process variation, cost reduction, product improvement, new market development and market analysis.

The sensory assessment of pastas was conducted within 48 hours after the production of pastas as initial sensory scoring. The pastas were cooked and reconstituted to recipes (Appendix VIII) by adding seasonings and flavorings and uniformly presented to semi-trained panel members. A panel of ten members semi-trained in different scientific methods of sensory analysis was charted for conducting the sensory analysis of the developed pasta product. A score card (Appendix IV) was used to conduct the organoleptic study.

3.2.5.2. Functional Characteristics Evaluation

Physical characteristics such as optimum cooking time (AACC, 2000), cooking loss (AACC, 2000), swelling index (AACC, 2000), water absorption index (AACC, 2000), texture and colour of the best extruded pastas were analyzed.

Optimum cooking time

The cooking time of the products was analyzed by cooking 25 g of pasta in 100 ml of water. The product was cooked till the white line disappears and the time taken was recorded. The end point was tested by pressing the cooked samples between two glass slides.

Water absorption index

Water absorption index is the quantity of water absorbed by a known quantity of the food sample. This is mainly used to assess the rehydration capacity of the extruded products. 50 g of raw pasta sample was taken in a glass beaker. 100 ml of water was added to it. The water was drained after 10 minutes. The weight of the hydrated sample was recorded. The water absorption index was calculated by weight of the hydrated sample minus weight of raw sample.

Cooking loss per cent

Cooking loss was determined by evaporating the pasta water to dryness overnight in a conventional oven at 100 ^{0} C. The initial weight and dried weight was recorded

Cooking loss (%) = [dried residue in cooking water (g)/noodle weight before cooking (g)] × 100.

Swelling Index

Swelling Index (SI) of cooked pasta (g water absorbed per g of dry pasta) was determined as (weight of cooked pasta-weight of dry pasta)/weight of dry pasta.

Texture

It is generally accepted that texture is the main criterion for assessing overall quality of pasta. The texture of the developed product was analyzed using a texture analyzer (stable micro systems, UK: Plate 3A.). The texture of the pasta is very important factor in shaping the consumers final evaluation of the product.

The instrument had a microprocessor regulated texture analysis system interfaced to a personal computer. The instrument consists of two separate modules; the test bed and the control console (keyboard). Both are linked by a cable which route low voltage signal and power through it.

The texture analyzer measures force, distance and time hence provide a three dimensional product analysis. Forces may be measured to achieve set distances and distances may be measured to achieve set forces.

The sample was kept on the platform of the instrument and was subjected to double compression by a cylindrical probe with 5mm diameter. The test was conducted at a speed of 10mm/s using 50 N load cell. The sample was allowed for a double compression of 40 per cent with trigger force of 0.5 kg during which various textural parameters were determined. From the force deformation curve, the firmness or hardness (peak force), and toughness (area under the curve) were determined.

Plate 3A. Texture Analyzer

Plate 3B. Colour Analyzer

Colour

Consumer prefers to buy pasta having yellow, translucent appearance. The colour of the developed pasta products were analyzed using a Hunter Lab Colourimeter (Mini Scan XE Plus, Plate 3B.).

It works on the principle of transmission of light and measures energy from the sample reflected across the entire visible spectrum. The meter uses filters and mathematical models which rely on standard observer curves that define the amount of green, red and blue primary lights required to match a series of colours across the visible spectrum and the mathematical model used in Hunter model.

It provides reading in terms of 'L', 'a' and 'b' recommended by the commission international de l' Eclairage (CIE). The 'L' coordinate measures the value or luminance of colour and ranges from black at 0 to white 100. The 'a' coordinate measures red when positive and green when negative and 'b' measures yellow when positive and blue when negative.

3.2.5.3. Nutritional and Chemical Composition of Pasta

The pastas were analyzed for its nutrients and chemical composition. The nutrients and chemical constituents analyzed and procedures adopted for developed pastas are listed in Table1 and 2.

3.2.6. Shelf Stability of Stored Pasta

By conducting shelf life study, the use by date for food products can be predicted. The pasta product was packed in laminated pouches and stored in room temperatures for three months. At an interval of one month, the stored sample was analyzed for sensory characteristics, chemical composition and microbial count using standard procedures.

3.2.6.1. Organoleptic quality of Stored Pasta

The stored pasta were cooked and reconstituted to recipes by adding flavorings and seasonings and uniformly presented to judges for sensory evaluation using score card. Experienced panel of ten members were selected for organoleptic study.

3.2.6.2. Chemical Composition of Stored Pasta

During the period of three months shelf life study, chemical components such as moisture, polyphenols, total minerals and peroxide content of stored pasta were analyzed by adopting standard procedures.

3.2.6.3. Microbial Study of Stored Pasta

Processed foods which are stored and consumed after a period of storage require certain microbiological criteria to be employed to ensure their quality and safety.

The developed and stored pastas were analyzed for bacteria, fungi, yeast and actinomycetes infection by suitable and standard procedures. The procedures adopted were serial dilution. 1 ml from each of the sample was taken in conical flask containing 99 ml sterile water, making the dilution of $10^{-2.}$ From this I ml of the dilution was further transferred into test tube containing 9 ml of sterile water, so that dilution becomes 10^{-3}.

Kenights, nutrient agar, PDA, and YPDA (Appendix VII) were the medium selected for the microbial analysis. Plates were poured and allowed for solidification. 1ml of the suspension from each dilution was then transferred to petri plates using a sterile pipette medium poured and spread evenly. The whole procedure was done aseptically in a laminar airflow chamber. Plates were then kept for incubation at 28^0 C. Colonies appearing in the plates was recorded after 2 days in the case of bacteria and after 4 days for fungi and yeast. The microbial load of the samples was then expressed as cfu/g of the product.

3.2.7. Consumer Acceptance of Pasta

The consumer acceptance and preference study of pastas developed were conducted among 150 subjects, (50 subjects from children, 50 subjects from adolescents and 50 subjects from adults) applying 9 point hedonic rating scale score card (Appendix VI).

3.2.8. Cost Analysis of Pasta

The cost analysis was carried out based on the input cost i.e. cost of different ingredients used for the preparation of instant snack, and output cost(the total input cost and added 10 per cent as overhead charges for fuel and labour).

3.2.9. Statistical Analysis

In order to obtain meaningful interpretation, the generated data was subjected to suitable statistical analysis such as Anova and split plot analysis.

RESULTS

4. RESULTS

The present study entitled "**Development and quality evaluation of fruit based instant snack and pasta product"** was conducted in two parts viz, development of fruit based instant snack product and development of pasta products. Ready to eat nutritious snack and pasta product were developed by incorporating the ingredients such as fruits, cereals, pulses, roots and tapioca and coconut.

PART-I

4.1. DEVELOPMENT OF INSTANT SNACK

4.1.1. Selection of Best Method of Pretreatment for Fruits

Among the eight pre-treatment methods followed individually for jack fruit, papaya and banana, best pre-treatment method was identified by observing the maximum sensory scores for parameters being appearance, texture, flavor, and taste of the fruit pieces (Table 3).

In papaya, PT_3, PT_4, PT_5 and PT_6 treatments were found on par with respect to colour and appearance. Texture scores showed that PT_2, PT_3, PT_4, PT_5 and PT6 were on par in relation while the other treatments were significantly different. Significant difference was noticed in flavor and taste scores of pretreated papaya cubes. Among pretreatments, PT_7 showed maximum scores for all parameters and was significantly different from other treatments.

In jack fruit, colour and appearance scores of PT_1 to PT_6 were found on par in relation while PT_7 and PT_8 showed considerable difference. Significant difference in texture, flavor and taste scores were observed and the maximum scores were found in PT_7 followed by PT_8.

In banana, considerable difference in sensory scores was noticed in all parameters. Among all the pretreatments, PT_7 showed maximum scores for colour, texture, taste and flavor, and was found significantly different from other treatments.

Table 3. Sensory score of pretreated fruits

Selection of pretreatment in papaya				
***Pretreatments**	**Colour & appearance**	**Texture**	**Flavor**	**Taste**
PT1	1.4^{d}	2.1^{d}	2.4^{c}	1.8^{d}
PT2	2.0^{cd}	2.5^{cd}	2.3^{c}	2.2^{cd}
PT3	2.6^{bc}	2.6^{cd}	2.1^{c}	2.8^{bc}
PT4	2.5^{bc}	2.3^{cd}	3.3^{b}	3.5^{b}
PT5	2.7^{bc}	2.9^{cd}	3.7^{b}	2.7^{bd}
PT6	2.7^{bc}	2.4^{cd}	3.7^{b}	2.9^{bc}
PT7	5.7^{a}	5.7^{a}	5.9^{a}	5.8^{a}
PT8	3.4^{b}	3.2^{b}	4.1^{b}	3.1^{bc}
CD (0.05)	0.87	0.87	0.82	0.93
Selection of pretreatment in jackfruit				
PT1	1.6^{c}	1.3^{c}	1.4^{cde}	1.5^{c}
PT2	1.2^{c}	1.5^{cd}	1.1^{e}	1.3^{c}
PT3	1.2^{c}	1.7^{cd}	1.3^{de}	1.5^{c}
PT4	1.5^{c}	1.6^{cd}	1.4^{cde}	1.5^{c}
PT5	1.4^{c}	1.7^{cd}	1.9^{c}	1.7^{c}
PT6	1.6^{c}	2.1^{c}	1.7^{cd}	1.8^{c}
PT7	5.5^{a}	5.7^{a}	5.4^{a}	5.6^{a}
PT8	4.2^{b}	4.0^{b}	4.2^{b}	3.8^{b}
CD (0.05)	0.48	0.54	0.56	0.54
Selection of pretreatment in banana				
PT1	2.7^{c}	2.3^{cd}	2.7^{bc}	2.1^{c}
PT2	2.1^{bc}	1.9^{d}	2.1^{c}	2.1^{c}
PT3	2.7^{bc}	2.3^{cd}	2.3^{bc}	2.9^{bc}
PT4	2.4^{bc}	2.5^{bcd}	2.4^{bc}	3.0^{bc}
PT5	3.1^{b}	2.8^{bcd}	2.8^{bc}	2.6^{bc}
PT6	3.0^{bc}	3.1^{bc}	3.0^{bc}	3.5^{b}
PT7	5.7^{a}	5.4^{a}	5.6^{a}	5.4^{a}
PT8	2.8^{bc}	3.3^{b}	3.2^{b}	3.4^{b}
CD (0.05)	0.90	0.3	0.94	0.90

* PT_1: 0.5 % citric acid solution for 5 minutes. *PT_5: 10% lime water for 6 hours.
*PT_2: 0.5 % citric acid solution for 10 minutes. *PT_6: 10% lime water for 12 hours.
*PT_3: 1 % citric acid solution for 5 minutes. *PT_7: 15% lime water for 6 hours.
*PT_4: 1% citric acid solution for 10 minutes. *PT_8: 15% lime water for 12 hours.

The study revealed that there was significant difference in sensory scores of pretreated fruit cubes. The scores for PT_7 (above 5 out of 6) treatment were considerably high in all fruit cubes while other treatments were scored less. Thus, PT_7 (lime water at 15% concentration for 6 hours) selected as the best pretreatment method for all the three fruits (Jackfruit, Papaya and Banana).

4.1.2. Osmotic Dehydration of Pretreated Fruits

Weight loss per cent (Table 4) was calculated after conducting osmotic treatment of selected fruit cubes. The result showed that the maximum loss of weight occurred for OT_4 fruit cubes which were treated at 70^0B for 12 h. immersion in sugar solution. As the concentration of osmotic solution increases weight loss also increases.

Among the fruit cubes, weight loss per cent of papaya cubes was high ranging from 3.6 per cent to 8.6 per cent. The weight loss of jackfruit and banana cubes were ranged from 2.6 per cent to 7.8 per cent and 2.4 per cent to 7 per cent respectively.

Table 4. Weight loss per cent of fruits on osmotic treatment

*OT	Jack fruit	Papaya	Banana
OT_1	2.6	3.6	2.4
OT_2	4.2	5.2	3.8
OT_3	6.4	7.4	5.2
OT_4	7.8	8.6	7.0

* OT_1: Sugar solution 60◦ B 6 hours.*OT_2: Sugar solution 60◦ B 12 hours

*OT_3: Sugar solution 70◦ B 6 hours. *OT_4: Sugar solution 70◦ B 12 hours

4.1.2.1. Selection of Best Method of Osmotic Treatment for Fruits

Among the four different osmotic treatments the best osmotic treatment was selected based on the high organoleptic scores obtained for appearance, flavor, texture and taste of the osmotic treated fruits (Table 5).

In papaya, OT_1, OT_2 and OT_3 treatments were found insignificant with respect to sensory parameters being texture, flavor and taste. Significant difference was observed in colour and appearance scores of all four treatments. Among all osmotic treatments, OT_4 showed maximum scores for all parameters and was significantly different from other three treatments.

Colour and appearance, texture and flavor scores of OT_1, OT_2 and OT_3 treated banana cubes were found insignificant. Significant differences in taste scores were observed. Among all the treatments, OT_4 showed maximum scores for colour, texture, taste and flavor, and was found significantly different from other treatments.

In jack fruit, the scores were found significantly different with respect to flavor parameter. Significant difference was not observed in colour and texture scores of OT_1, OT_2 and OT_3 treatments. Taste scores showed significant difference between OT_3 and OT_4 while on par relation was observed for OT_1 and OT_2 treatments. OT_4 showed maximum scores for colour, texture, taste and flavor, and was found significantly different from other treatments.

Results revealed that significant difference was observed in the sensory scores of osmotic treated fruits. The scores obtained for OT_4 treatment (70^0 B of sugar solution for 12 hours immersion duration) was maximum whereas less scores were found in OT_1, OT_2 and OT_3 treatments, thus OT4 treated fruits were selected.

4.1.3. Drying of Fruit Cubes

The selected osmotically (OT_4) treated fruit cubes were dehydrated in a tray drier for 60^0 C for 4 hours. Weight loss per cent of dried fruit cubes were calculated (Table 6). The mean time requirement for jackfruit to get the final dried product was four hours. Papaya and banana took mean time of two hours and two and half hours respectively. The dried product was cooled and stored in airtight containers and used for the development of instant snack. The study revealed that OT_4J cubes had highest loss in weight (8.02%). The percentage of weight loss of OT_4P and OT_4B were 4.37 per cent and 3.65 per cent respectively. The loss per cent was less in banana compared to other fruit cubes.

Table 5. Sensory scores for osmotic treated fruits

Osmotic Treatment	Best osmotic treatment for papaya			
	Colour & Appearance	**Texture**	**Flavor**	**Taste**
*OT_1	2.0^{c}	3.3^{b}	2.6^{b}	2.7^{b}
*OT_2	3.4^{b}	3.3^{b}	2.9^{b}	2.8^{b}
*OT_3	3.1^{b}	3.5^{b}	3.1^{b}	3.0^{b}
*OT_4	5.5^{a}	5.9^{a}	5.3^{a}	5.5^{a}
CD(0.05)	1.08	0.66	0.77	1.02
Best osmotic treatment for banana				
*OT_1	2.6^{b}	2.7^{b}	2.7^{b}	2.7^{c}
*OT_2	2.6^{b}	3.2^{b}	2.6^{b}	2.5^{c}
*OT_3	2.8^{b}	2.9^{b}	3.1^{b}	3.8^{b}
*OT_4	5.6^{a}	5.4^{a}	5.4^{a}	5.8^{a}
CD(0.05)	1.05	1.12	0.85	0.90
Best osmotic treatment for jack fruit				
*OT_1	2.9^{b}	2.5^{b}	2.0^{d}	2.3^{c}
*OT_2	3.0^{b}	2.3^{b}	3.0^{c}	2.9^{c}
*OT_3	3.7^{b}	3.0^{b}	3.8^{b}	4.0^{b}
*OT_4	5.7^{a}	5.7^{a}	5.0^{a}	5.7^{a}
CD(0.05)	0.89	0.89	0.58	0.81

* OT_1: Sugar solution 60◦ B 6 hours.*OT_2: Sugar solution 60◦ B 12 hours

*OT_3: Sugar solution 70◦ B 6 hours. *OT_4: Sugar solution 70◦ B 12 hours

4.1.4. Selection and Optimization of Other Raw Ingredients for Instant Snack

In order to boost the nutritional quality of the developed instant snack, cereals (parboiled rice, wheat) pulses (green gram, horse gram) and coconut were also used for the processing of instant snack.

These ingredients were subjected to various degrees of processing techniques as mentioned in methodology. The weight loss per cent and roasting time required for the ingredients was calculated (Table 7).

The results indicated that among cereals, the weight loss per cent of roasted rice (RR) was found to be less (5.2%), despite the fact that roasted wheat (RW) had high per cent of weight loss (7.8%). Roasted horse gram (RHGM) and roasted green gram (RGM) had weight loss per cent of 8.9% and 7.3% respectively amid pulses.

The results of osmotic dehydration of coconut indicated that the average weight loss per cent of osmotically treated coconut (9.2 %) was higher to dried loss per cent (4.8 %).

4.1.5. Development of Instant Snack

Using the eight processed ingredients different combinations of the snack were formulated in order to develop standardized quality product (Table 8 and 9). In each combination the quantity of the eight ingredients varied. Formulated combinations were analyzed for nutrients such as energy and protein content and also for organoleptic studies.

Eight different combinations of instant snack were formulated (C1-C8). The content of fruit (OT_4J, OT_4P, and OT_4B) ranged from 5 g to 20 g, cereals (RR, RW) content was from 10 g to 20 g, pulses (RGM, RHGM) 10 g to 20 g and the amount of coconut (ODC) was from 5 g to 20 g, in different combinations per hundred grams. The proportion of each combination is also given.

Being a fruit based product, proportions of different items of ingredients should be wisely incorporated to derive maximum energy and protein. The formulated combinations should be acceptable and consumable. It should also have storage stability. The energy and protein content of different combinations were computed (Table 10) and also sensory acceptability (Table 11) study of the

combinations was carried out by a group of semi trained panel members with the help of hedonic rating scale.

The results illustrate that combination (C2) comprised of higher energy and protein content than the other seven combinations of instant snack. Among the eight combinations, energy and protein content of C6 was very low. The quantity of cereals (RR, RW) and pulses (RGM, RHGM) in the combination C6 was low and the fruits quantity was high. Since the study aims to develop high energy and protein snack, C6 was not selected for further investigation.

Significant differences in sensory scores of formulated eight combinations of instant snack were noticed. Results revealed that the average mean scores and rank obtained for the combination number 2 (C2) was highest (8.8/9) while sensory scores for all other combinations were found less, ranged from 2.6 - 4.9 out of 9.

The rank column specifies that the first rank obtained for the combination C2 and the eighth rank obtained for the combination C5. Study indicated that combination number 2(C2) was the best of all formulated combinations with respect to nutrient content and sensory quality. Thus C2 was taken as developed instant snack for the further study (Plate 4).

4.1.5.1. Bulk Production of Instant Snack

Instant snack was produced in bulk amount for 10 kg using the selected combination (C2). The developed product was then utilized for various analyses being chemical, nutritional, organoleptic, storage studies and also consumer acceptance studies. Quantity of each ingredient required for production of 10 kg instant snack is given in Table 12.

4.1.5.2. Yield Per cent of Instant Snack

The yield for the instant snack was calculated using the formula as described in methodology (Table 13). The yield percentage is the ratio of the edible portion of food to the amount of food purchased. Many times foods lose volume or weight as they are processed. Results indicate that among the eight ingredients the yield per cent was high for RR (96.6%) where as less for OT_4J, only (12 %).

Plate. 4. Developed instant snack product

Table 6. Weight loss per cent of fruits after drying

Fruit cubes	Osmotically treated fruit weight (g)	Dried weight (g)	Weight loss %
*OT_4J	461	424	8.02
*OT_4P	457	437	4.37
*OT_4B	465	448	3.65

*OT_4 J: Sugar solution 70◦ B 12 hours treated Jackfruit *OT_4 P: Sugar solution 70◦ B 12 hours treated Papaya *OT_4 B: Sugar solution 70◦ B 12 hours treated Banana

Table 7. Weight loss per cent of other ingredients

Ingredients	Quantity roasted (g)	Mean time in minutes	Weight loss per cent
*RR	500	10	5.2
*RW	500	12	7.8
*RHGM	1000	13	8.9
*RGM	1000	10	7.3
Coconut (ODC*)			
Osmotic loss	-	-	9.2
Dried loss	-	-	4.8

*RR- Roasted Rice * RW- Roasted Wheat *RGM-Roasted Green gram
*RHGM- Roasted Horse gram*ODC- Osmotically Dried Coconut

Table 8. Formulated combinations of instant snack

	Quantity in grams							
Components	***C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
*OT_4J	5	10	10	10	20	20	20	20
*OT_4P	5	10	10	10	20	20	20	10
*OT_4B	5	10	10	10	20	20	20	20
*RR	20	20	10	20	5	5	5	10
*RW	20	10	20	20	5	5	5	10
*RGM	20	20	10	10	5	10	10	10
*RHGM	20	10	20	10	5	10	10	10
*ODC	5	10	10	10	20	10	10	10

*RR-Roasted Rice *RW-Roasted Wheat *RGM- Roasted Green gram *RGHM- Roasted Horse gram *ODC- Osmotically Dried Coconut *OT_4 J: Sugar solution 70◦ B 12 hours treated Jackfruit *OT_4 P: Sugar solution 70◦ B 12 hours treated Papaya *OT_4 B: Sugar solution 70◦ B 12 hours treated Banana *C1- C8 Combinations

Table 9. Proportions of ingredients

Combination	OT4J	OT4P	OT4B	RR	RW	RGM	RHGM	OCD
C1	0.5	0.5	0.5	2	2	2	2	0.5
C2	1	1	1	2	1	2	1	1
C3	1	1	1	1	2	1	2	1
C4	1	1	1	2	2	1	1	1
C5	2	2	2	0.5	0.5	0.5	0.5	2
C6	2	2	2	0.5	0.5	1	1	1
C7	2	2	2	0.5	0.5	1	1	1
C8	2	1	2	1	1	1	1	1

Table 10. Computed nutritional quality of the combinations

Combinations	Energy (kcal)	Protein (g)
*C1	304.0	10.5
C2	311.5	10.8
C3	289.7	10.8
C4	289.3	10.1
C5	213.5	9.9
C6	203.5	5.5
C7	279.5	9.4
C8	223.4	7.8

*C1-C8- Combinations

Table 11. Organoleptic quality evaluation of formulated combinations

*Combinations	Mean Score	Rank
C1	2.6	7
C2	8.8	1
C3	4.9	2
C4	4.3	4
C5	2.4	8
C6	3.5	6
C7	4.0	5
C8	4.6	3
CD (0.05) -1.30		

*C1-C8- Combinations

Table 12. Bulk production of instant snack

Components	Quantity (Kg)
*OT4J	1
*OT4P	1
*OT4B	1
*RR	2
*RW	1
*RGM	2
*RHGM	1
*ODC	1

*RR- Roasted Rice *RW- Roasted Wheat *RGM- Roasted Green gram *RGHM-Roasted Horse gram *ODC- Osmotically Dried Coconut *OT_4 J: Sugar solution 70◦ B 12 hours treated Jackfruit *OT_4 P: Sugar solution 70◦ B 12 hours treated Papaya *OT_4 B: Sugar solution 70◦ B 12 hours treated Banana

Table 13. Yield per cent of instant snack

Components	Wt as purchased(Kg)	Wt after drying (Kg)	Yield per cent
OT4J	10	1.2	12
OT4P	8	3.6	45
OT4B	5	2.7	54
RR	6	5.8	96
RW	6	4.9	81.6
RGM	6	3.4	56.6
RHGM	6	4.6	76.6
OCD	15	4.3	28

*RR- Roasted Rice *RW- Roasted Wheat *RGM- Roasted Green gram *RHGM- Roasted Horse gram *ODC- Osmotically Dried Coconut *OT_4 J: Sugar solution 70◦ B 12 hours treated Jackfruit *OT_4 P: Sugar solution 70◦ B 12 hours treated Papaya *OT_4 B: Sugar solution 70◦ B 12 hours treated Banana

4.1.6. Quality Evaluation of Instant Snack

Quality assessment with respect to organoleptic characteristics, chemical composition, nutritional composition and shelf stability of the developed instant snack was conducted.

4.1.6.1. Organoleptic Quality Evaluation of Instant Snack

Sensory assessment was conducted on developed instant snack using score card by selected semi trained panel members. Assessment of sensory characteristics was based on the criteria such as colour, appearance, flavour, taste and texture (Table 14).

The results revealed that the mean scores obtained for colour, appearance, texture, flavor, and taste of the product were 5.1, 5.5, 5.6, 5.8 and 5.6 respectively. Close observation of mean scores denotes that maximum mean score was obtained for the flavor parameter because of its pleasant aroma. Texture and taste of product was highly acceptable with a score of 5.6. In short for the selected instant snack, the mean scores obtained were above 5 out of 6 which were the maximum score.

4.1.6.2. Nutrient Content and Chemical Composition of Instant Snack

Nutritional components and chemical composition of the selected instant snack was analyzed with respect to major nutrients such as energy, protein, fat and carbohydrates, calcium, iron, sodium, potassium and beta carotene. Chemical components such as moisture, polyphenols, peroxide value, fiber and total minerals were also evaluated using standard procedures. Each nutrient and chemical constituent was analyzed in triplicate (Table 15 and Table 16).

The results showed that the product obtained an energy value of 350 (kcal/g), which indicates the product have sufficient amount of energy to maintain health of consumers. Carbohydrate is the major energy source of diet. The developed product has got 66.96 g of carbohydrate per 100 g of the product. Proteins are vital to the living process and carry out a wide range of functions essential for the sustenance of life. The developed product obtained 10.83 g of protein per 100 g of the product.

Fat content of the product was 4.95 g/100 g of the product. The instant snack obtained calcium of 70.18 g/100g, Iron of (3.96 mg/100 g), Sodium (16.46 mg/100 g), Potassium (280.86 mg/100 g), Beta carotene (115.46 µg/100 g). The study also revealed that the developed instant snack was adequate in micro nutrients.

The instant snack had a moisture content of 13 g per 100 g of the product. Peroxide content of processed foods determines the shelf stability of the product. As the peroxide value increases the shelf stability of the product decreases. Peroxide value of the developed instant snack was 0.65. Poly phenols, fiber and total minerals content of the developed instant snack were 1.27 mg, 2.9 g and 2.28 g respectively.

4.1.7. Shelf Stability of Stored Instant Snack

The shelf-life of a food is the period for which it remains safe and suitable for consumption. This means that the food has not deteriorated in quality or spoiled in any way that the consumer would find unacceptable. Shelf life study is a series of regularly schedule tests of product held under controlled packaging and storage conditions.

At an interval of one month the instant snack was analyzed for its quality such as organoleptic parameters, chemical composition, and microbial evaluation.

4.1.7.1. Organoleptic Quality of Stored Instant Snack

Periodical examination of the sensory characteristics of the selected combination of instant snack was carried out using score card by the selected semi trained panel members to understand the sensory quality changes in the stored product (Table 17). Sensory evaluations to determine the shelf life of food products are routinely conducted in food experimentation as a part of each product development program, whether it includes a new product, product improvement or a change in type or specification of an ingredient.

The result revealed that there was no significant difference observed with respect to colour, appearance, texture, flavor and taste scores during three months storage study of instant snack. The study noticed a slight decrease in the mean values for each criterion across the months, while it was not significant.

4.1.7.2. Chemical Composition of Stored Instant Snack

Chemical composition of the selected combination of instant snack was investigated at prescribed time periods to observe the effect of storage on keeping quality. Statistical analysis showed that there was no significant change in the chemical composition of selected combination of instant snack during the storage period (Table 18). Moisture content of the product was below 14 g per 100 g of the product in all the three months. No significant change was observed in total minerals content, peroxide content and poly phenol content of stored instant snack.

4.1.7.3. Microbial Evaluation of Stored Instant Snack

The developed instant snack product was tested during storage period for the presence of microbes. Each month 1g of the sample was taken from the stored product for microbial analysis. Dilution plating technique and counting live microbial colonies was adopted to detect the growth of microbes.

By counting the number of colony forming units (CFU) formed, the presence of viable microorganisms was detected. Kennights, nutrient agar, potato dextrose agar, and yeast potato dextrose agar (YPDA) were the medium selected for detecting actinomycetes, bacteria, fungi and yeasts respectively. Dilutions up to 10^{-5} were made and 10^{-3} and 10^{-4} dilutions were selected for plating.

Three replications were done for each medium and dilutions. After plating, the microbial count was taken for five consecutive days. Each day the microbial count was observed. The results revealed that there was no growth of actinomycetes, bacteria, fungus and yeast in any of the plates during the 5 days of the study in fresh sample as well as in stored sample (Plate 5A, 5B, 6A and 6B).

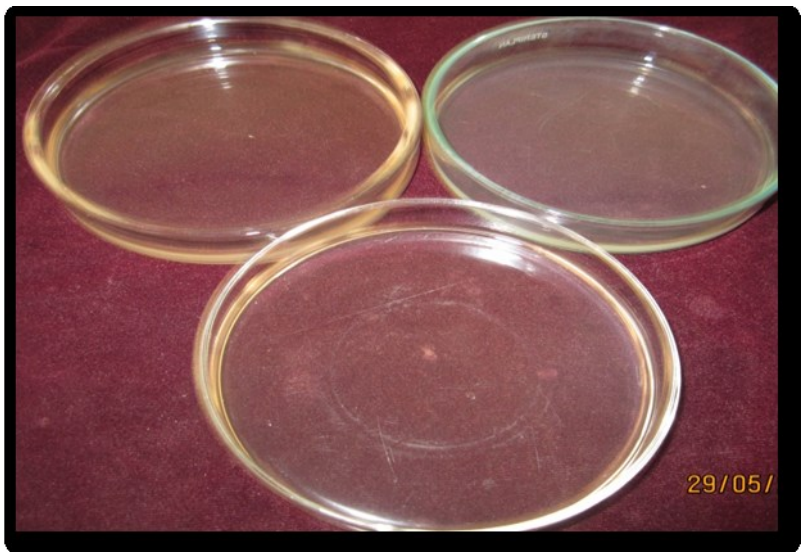


Plate 5A. Microbial growth in Nutrient Agar

Plate 5B. Microbial growth in Yeast Potato Dextrose Agar

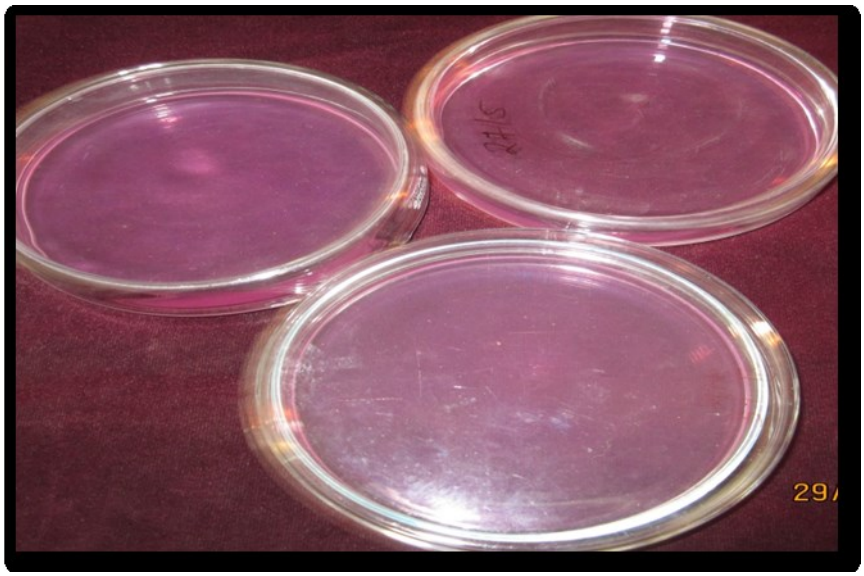


Plate 6A. Microbial growth in Potato Dextrose Agar

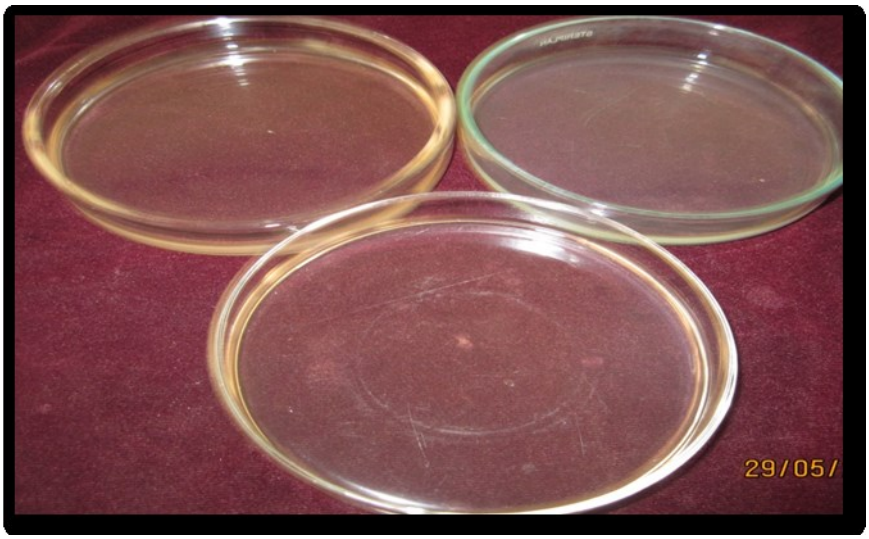


Plate 6B. Microbial growth in Kennights

Table 14. Organoleptic quality of instant snack

Sensory Parameters	Mean Scores
Colour	5.1
Appearance	5.5
Texture	5.6
Flavor	5.8
Taste	5.6
Overall Acceptability	5.5

Table 15. Nutrients content of 100 g instant snack

Nutrients	Mean value
Energy (k cal)	349
Carbohydrates (g)	66.96
Protein (g)	10.83
Fat (g)	4.95
Calcium (mg)	70.18
Iron (mg)	3.96
Sodium (mg)	16.46
Potassium (mg)	280.86
β carotene (µg)	115.46

Table 16. Chemical components of 100 g instant snack

Chemical components	Mean value
Moisture (g)	13.00
Peroxide (meq)	0.65
Poly phenols (mg)	1.27
Fiber (g)	2.9
Total minerals (g)	2.28

Table 17. Organoleptic quality of stored instant snack

Criteria	Month 1	Month 2	Month 3	CD (0.05)
Colour	5.2	5.0	4.8	NS*
Appearance	5.1	4.9	4.8	NS
Texture	4.9	4.9	4.7	NS
Flavor	5.8	5.6	5.3	NS
Taste	5.4	5.2	5.0	NS

Table 18. Chemical composition of 100 g of stored instant snack

Chemical constituents	Month 1	Month 2	Month 3	CD (0.05)
Moisture(g)	12.9	13.02	12.9	NS*
Total minerals(g)	2.25	2.20	2.27	NS
Peroxide(meq)	0.65	0.67	0.67	NS
Poly phenols (mg)	1.26	1.55	1.21	NS

*NS- Non Significant

4.1.8. Consumer Acceptance Study of Instant Snack

A large sample size (150 people - 50 from children, 50 from adolescents and 50 from adults) were selected as representative of the target population or potential users to obtain information on consumer attributes and their preferences towards the developed product. 9 point hedonic score card was used to conduct the study. Scores obtained were further critically evaluated and results were drawn with the application of statistics (Table 19).

The results proved that there was no significant difference in the acceptance pattern of the product among the three selected groups. The study portrayed that all the three selected groups such as children, adolescents and adults equally preferred the developed instant snack product. The likeness of the

product showed a higher rating score of 7.78 to 7.84. The maximum rating score was 9.

Table 19. Consumer acceptance study of instant snack

Groups	Means
Children	7.78
Adolescents	7.82
Adults	7.84
CD - NS	

4.1.9. Cost Analysis of Instant Snack

The economy of the product depends much on the cost of ingredients used for the preparation of products. The cost of the developed snack was calculated by taking into account of the expenses incurred in raw materials, packaging accessories, labour charges and fuel cost. Cost analysis of the selected instant snack was computed taking into consideration of the pre market price of the ingredients used and cost involved in processing.

From the observation the cost of production for selected combination of instant snack was Rs 170 /- per kilo gram of the product, which is affordable for any class of people.

Part II

4.2. DEVELOPMENT OF PASTA PRODUCT

Pasta is a universally accepted staple food which is made with wheat flour. Various scientific evidences showed the incorporation of fruits, vegetables, aloevera, honey and egg in to wheat flour and developed healthy and nutritious pasta. The nutritional quality of pasta can be improved by incorporating fruits, vegetables, meat, fish, egg to the pasta dough.

4.2.1. Formulation of Pasta Product

Nineteen different proportions of pastas were formulated (Table 20 and Table 21). In each proportion of pasta the quantity of both pulp and wheat flour varied, while the amount of green gram and tapioca starch remained invariable. The well extruded pastas (Plate 7A) were allowed for drying under shade for 24-48 h. in order to improve and retain the texture of pasta whereas poor extruded pastas (Plate 7 B) were discarded. Dried pastas were packed in laminated pouches for further investigation. The best proportions of pastas were subjected to quality analysis.

4.2.2. Selection of Best Proportion

By judging the extrusion behavior and blending time the best extruded pastas were selected for further investigation. Mass Flow Rate (MFR) study was done to examine the extrusion behavior of pasta. In MFR, maximum quantity in grams extrusion of pasta through the die within minimum time in seconds is considered as the best extrusion behavior.

Blending time is the time taken by pasta dough to get thoroughly mixed. Increment in blending time denotes the inferior selection of raw materials or proportions used in pasta processing. The best proportions were selected based on high MFR value and low blending time (Table 22).

Results revealed that most of the proportions of pasta took the average blending time ten minutes as described in international standards of pasta. On close observation it was clear that proportion 19 had the maximum blending time of 13 minutes and all other proportions worked out had minimum blending time of 10 minutes.

Plate 7A. Well extruded pasta

Plate 7B. Poor extrude pasta

Table 20. Quantity of ingredients in pasta

Proportion	*JP	*PP	*BP	*WF	*GF	*TS
P 1	-	-	200	600	100	100
P 2	-	-	300	500	100	100
P 3	-	-	400	400	100	100
P 4	-	-	500	300	100	100
P 5	-	-	600	200	100	100
P 6	-	200	-	600	100	100
P 7	-	300	-	500	100	100
P 8	-	400	-	400	100	100
P 9	-	500	-	300	100	100
P 10	-	600	-	200	100	100
P 11	200	-	-	600	100	100
P 12	300	-	-	500	100	100
P 13	400	-	-	400	100	100
P 14	500	-	-	300	100	100
P 15	600	-	-	200	100	100
P 16	200	200	200	200	100	100
P 17	100	100	100	500	100	100
P 18	150	150	100	400	100	100
P 19	100	150	150	400	100	100

*JP- Jack fruit pulp*PP- Papaya pulp*BP- Banana pulp*WF- Wheat Flour

*GF- Green gram Flour*TS- Tapioca Starch

Table 21. Proportions of pasta

Proportion	*JP	*PP	*BP	*WF	*GF	*TS
P 1	-	-	2	6	1	1
P 2	-	-	3	5	1	1
P 3	-	-	4	4	1	1
P 4	-	-	5	3	1	1
P 5	-	-	6	2	1	1
P 6	-	2	-	6	1	1
P 7	-	3	-	5	1	1
P 8	-	4	-	4	1	1
P 9	-	5	-	3	1	1
P 10	-	6	-	2	1	1
P 11	2	-	-	6	1	1
P 12	3	-	-	5	1	1
P 13	4	-	-	4	1	1
P 14	5	-	-	3	1	1
P 15	6	-	-	2	1	1
P 16	2	2	2	2	1	1
P 17	1	1	1	5	1	1
P 18	1	1.5	1.5	4	1	1
P 19	1.5	1.5	1	4	1	1

*JP- Jack fruit pulp*PP- Papaya pulp*BP- Banana pulp*WF- Wheat Flour

*GF- Green gram Flour*TS- Tapioca Starch

Table 22. Mass Flow Rate (MFR) study of pasta

Proportions	Wt of sample (gm)	Extrusion Time (secs)	MFR	CD (0.05)	Blending time (min)
Banana pulp					
P1	850	480	1.72^{b}	0.07	10
P2	**950**	**420**	**2.27^{a}**		**10**
P3	720	600	1.24^{c}		10
P4	600	660	0.90^{d}		11
P5	530	840	0.62^{e}		10
Papaya Pulp					
P6	870	420	2.04^{b}	0.14	11
P7	**980**	**360**	**2.72^{a}**		**10**
P8	740	660	1.18^{d}		11
P9	650	720	0.91^{d}		10
P10	620	780	0.75^{e}		10
Jack fruit Pulp					
P11	840	510	1.59^{b}	0.11	10
P12	**860**	**480**	**1.84^{a}**		**10**
P13	700	600	1.08^{c}		12
P14	660	630	1.03^{c}		12
P15	540	720	0.52^{d}		11
Mixed fruit pulp					
P16	440	840	0.51^{d}	0.11	12
P17	**890**	**420**	**2.11^{a}**		**10**
P18	880	510	1.65^{c}		12
P19	860	480	1.80^{b}		13

Plate 8A. Developed pasta (P3J)

Plate 8B. Developed pasta (P1B)

Plate 8C. Developed pasta (P4MF)

Plate 8D. Developed pasta (P2P)

MFR value was found significantly different in each proportion of pastas formulated. The study portrayed that the extrusion behavior of pasta varied depending on proportion. The value was observed high in proportion number 2 from banana pulp, proportion number 7 from papaya pulp, proportion number 12 from jack fruit pulp and proportion number 17 from mixed fruit pulps. Thus these proportions were selected as the best extruded pastas. These selected proportions here after termed as P1B (Plate 8B), P2P (Plate 8D), P3J (Plate 8A), and P4MF (Plate 8C) respectively in this study.

The statistical evaluation of data revealed that as the quantity of fruit pulp increases or decreases from 300 grams per kilo gram, the mass flow rate was affected which directly influence the extrusion behavior. The mass flow rate was maximum when the fruit pulp quantity was at 300 grams.

Among the fruits selected, papaya fruit pasta had maximum mass flow rate followed by mixed fruits pasta, banana fruit pasta and jack fruit pasta. The selected four proportions of pasta were allowed for shade drying in room for 24 – 48 h. in order to enhance and retain the textural property of pasta which then packed in laminated pouches and kept in room temperature.

4.2.3. Quality Evaluation of Pasta Product

Quality evaluations such as functional characteristics (Table 23), sensory characteristics (Table 26), nutritional (Table 27) and chemical composition (Table 28) of the selected four proportions of pasta (P1B, P2P, P3J and P4MF) were conducted. The developed pastas were compared with the control (commercially available pasta) with respect to all quality parameters.

4.2.5.1. Functional Characteristics of Pasta Product

Swelling index, cooking loss, cooking time, water absorption index, colour (Table 24) and texture (Table 25) were the prime functional characteristics analyzed for the selected proportions of pasta. The study also compared functional characteristics of developed pastas with the control (commercially accepted).

Swelling Index (SI)

Swelling Index (SI) of pasta is an indicator of the water absorbed by the starch and proteins during cooking, which is utilized for the gelatinization of

starch and hydration of proteins. During cooking of pasta, starch absorbs water and swells and the granular structure collapses leading to the leaching of amylose.

Result indicated that there was significant difference in swelling indices of different fruit pasta with the control. Among the developed pastas, the maximum swelling index was observed for P2P (1.387) followed by P1B (1.322), P3J (1.267) and P4MF (1.2). Control sample made only with wheat had the highest swelling index. Non-wheat ingredients lead to discontinuity within the gluten matrix and results in weak swelling index.

Cooking Loss per cent

The quantity of solids going into water during cooking of pasta is a determinant of pasta quality and compact textured pasta leads to lower cooking loss. Statistical analysis showed that there was significant difference in cooking loss of selected proportions of pasta. The result showed that the cooking loss percent for P3J (4.10) and P4MF (4.0) were found to be high. P2P (1.10) had least cooking loss per cent followed by P1B (2.17) pasta. The cooking loss per cent of control sample was 0.67. High cooking loss per cent is expected as lack of textural integrity.

Cooking time

There was a continuous white line visible at the centre of a pasta strand. This visible white line would be disappeared during cooking and the cooking time is the time taken by the pasta to disappear the visible white colour.

It could be concluded that the developed pastas P1B, P2P and P4MF had showed on par relation with respect to cooking time limit. Statistical interpretation showed that there was significant difference in cooking time amongst the selected proportions of pasta. The results revealed that cooking time was found to be significantly high in P3J, where as optimum in other three developed pastas.

The cooking time of control sample was 11 minutes, which is the average cooking time limit for pasta as per international standard. Only P2P showed exact 11 minutes of cooking time as that of control.

Water absorption Index (WAI)

The study showed that there was significant difference in water absorption index for all the pastas. Lowest water absorption index was observed for P3J (8.5) pasta. Water absorption index of control was 20.16 which were followed by P2P pasta (17). Water Absorption Index of P1B and P4MF were 12.5 and 11.25 respectively.

Colour analysis

The colour of developed pastas was compared with the ordinary pasta (control) available in the market. The ordinary pasta is termed as control in this study. 'L', 'a' and 'b' values were observed for all the pastas.

The L values of developed pastas were considerably less compared to control. Among the fruit pulp incorporated pasta, P4MF had maximum 'L' value of 58.63 followed by P1B (48.38), P2P (45.95) and P3J (39.79). 'a' value was high for P2P (7.96) which indicates the degree of redness. It was observed that control sample with less 'a' value of 2.37. 'b' value (yellowness index) was approximately comparable for the developed fruit incorporated pasta products and the control ranging from 20.38 to 22.97.

Texture analysis

The developed pastas were subjected to texture analysis using a laboratory texture analyzer. The firmness or hardness test was conducted and compared with the hardness of commercially available pasta which was taken as control. Texture Analyzer utilizes uni-axial compression and tension forces in combination with a selection from extensive list of probes, grips and fixtures to test a wide variety of food. The result of texture analysis indicated that P3J had low hardness compared to other fruit pulp incorporated pastas. The hardness of control sample was 15682.97 (gf) which was noticeably high.

Addition of fruit pulps will soften the texture of the products. It was showed that the formulated pastas with fruit pulp had less hardness compared to control with no fruit pulp. Fig. 9, 10, 11, 12 and 13 represents the results of texture analysis. The X axis represents the time taken and Y axis represents the force applied to break the pasta

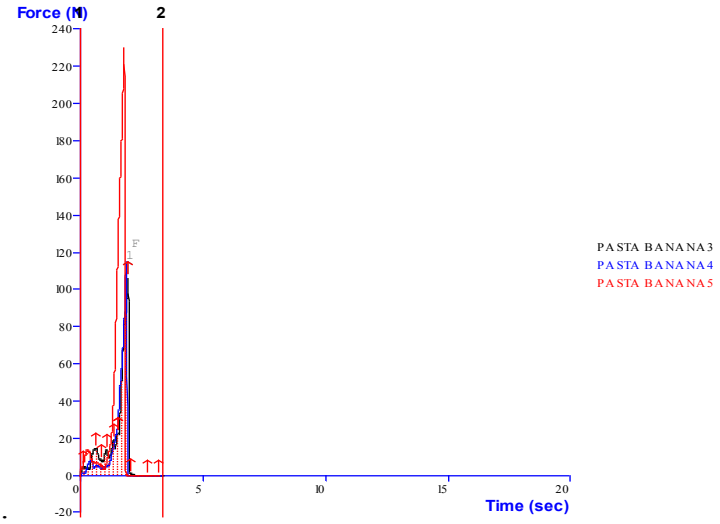


Fig 9. Texture analysis of pasta (P1B)

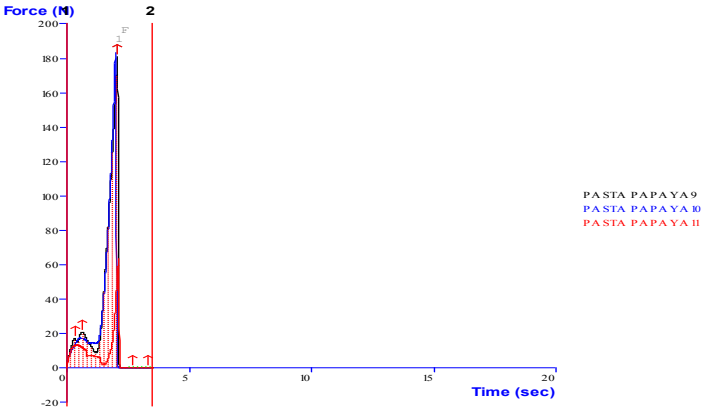


Fig 10. Texture analysis of pasta (P2P)

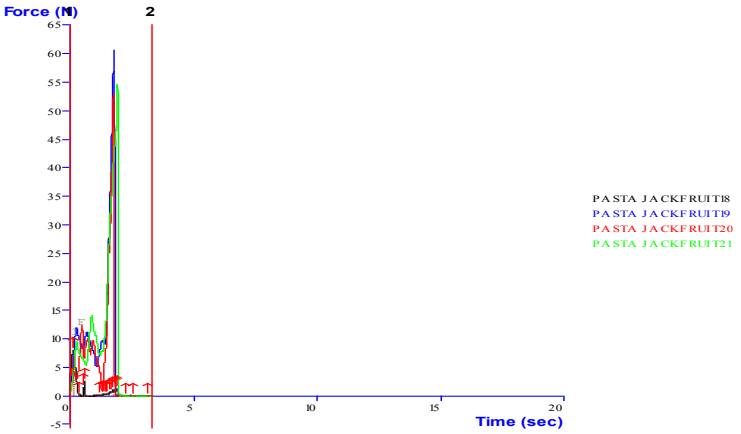


Fig 11. Texture analysis of pasta (P3J)

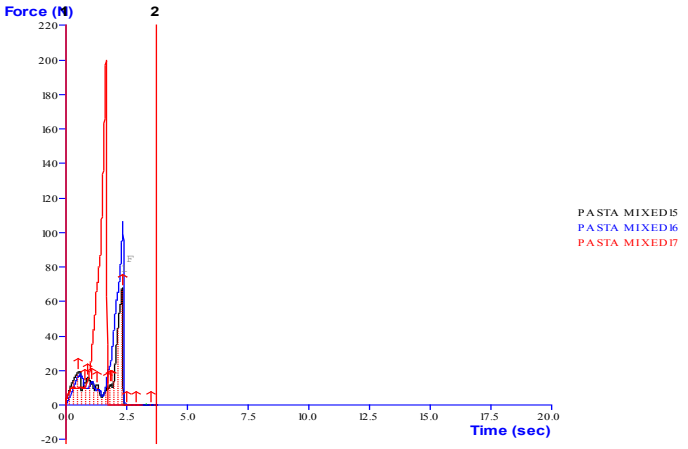


Fig 12. Texture analysis of pasta (P4MF)

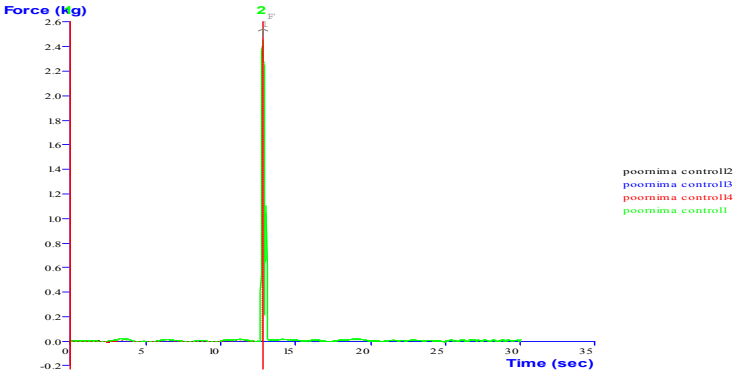


Fig 13.Texture analysis of pasta (Control)

4.2.5.2. Reconstitution and Sensory Evaluation of Pasta

Pasta's sensory quality is determined mainly by its behavior during cooking. Sensory evaluation study of a new product is obligatory which settle on the prime quality status of a food product. The sensory test was conducted within 48 hours after the pasta production. The recipe of pasta preparation is given in Appendix VIII. A comparison study of developed pastas and control was done.

The results noticed that high scores for appearance was observed for P1B (5.6) followed by control (5.3), P2P (5.2) and P4MF (5.1). Least score for appearance was observed for P3J (4.8). With respect to colour, no significant difference was noticed between P1B, P2P and control, were as significant difference was observed for P3J and P4MF. Both P1B (5.7) and control (5.7) shows highest scores for colour.

Highest score was obtained for control (5.9) with respect to texture assessment. The statistical interpretation proved that there was significant difference among the pastas regarding texture. Least score for texture was shown by P3J (4.7). With in the developed pastas highest score was obtained for P2P (5.6).

Significant difference was noticed with respect to flavor assessment of pastas. The developed pasta P1B (5.8) had shown maximum scores for flavor followed by P2P (5.4), control (5.4), P4MF (5.2) and P3J (5.0). Highest taste score was found in P1B (5.8), followed by control (5.7), P2P (5.4), P3MF (5.3) and P3J (5.0). The results revealed that all the sensory scores were less in P3J whereas high in P1B. P1B and P2P were found on par in the study.

4.2.5.3. Nutritional Quality and Chemical Composition of Pasta Product

Food nutritional quality appears to be the major concern for the consumers. In recent years, there have been significant changes in the preferences of consumers for foods that are healthier, higher nutritional quality, and more exotic. Individual food manufacturers must respond rapidly to these changes in order to remain competitive within the food industry.

Table 23. Functional characteristics of pasta product

Criteria	*P1B	*P2P	*P3J	*P4MF	Control	CD (0.05)
*SI	1.32^{bc}	1.38^{ab}	1.26^{c}	1.20^{c}	1.78^{a}	0.29
*CL (%)	2.17^{b}	1.10^{c}	4.10^{a}	4.00^{a}	0.67^{d}	0.25
*CT(minutes)	11.50^{b}	11.0^{b}	12.50^{a}	10.75^{b}	11.00^{b}	0.53
*WAI	12.5^{c}	17.0^{b}	8.5^{e}	11.25^{d}	20.16^{a}	0.81

*SI- Swelling Index,*CL- Cooking Loss Per cent,*CT- Cooking Time,*WAI-Water Absorption Index,* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

Table 24. Colour analysis of pasta

Pasta	Mean tri-stimulus color values		
	L*	a*	b*
P1B	48.38	6.53	20.38
P2P	45.95	7.96	23.36
P3J	39.79	5.86	21.03
P4MF	58.63	6.14	22.10
Control	82.81	2.37	22.97

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,
* P4MF-Mixed fruit pasta, *L- Lightness Index, *a- Redness Index,
*b- yellowness index

Table 25. Texture analysis of pasta

Pasta	Mean Hardness (gf)
P1B	11982.28
P2P	12458.71
P3J	10945.10
P4MF	11982.22
Control	15682.97

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,
* P4MF-Mixed fruit pasta

Table 26. Sensory scores of pasta

Criteria	P1B	P2P	P3J	P4MF	Control	CD (0.05)
Appearance	5.6^{d}	5.2^{bc}	4.8^{a}	5.1^{b}	5.3^{bc}	0.16
Colour	5.7^{e}	5.6^{c}	4.8^{a}	5.3^{b}	5.7^{c}	0.21
Texture	5.5^{bc}	5.6^{c}	4.7^{a}	5.2^{b}	5.9^{c}	0.41
Flavor	5.8^{d}	5.6^{cd}	5.0^{a}	$5.^{2ab}$	5.4^{bc}	0.35
Taste	5.8^{c}	5.4^{b}	5.0^{a}	5.3^{b}	5.7^{c}	0.27

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta, * P4MF-Mixed fruit pasta

The study showed that P1B pasta provides 383 Kcal which was the highest energy content when compared with the other selected proportions of pasta. The calorie content for P2P, P3J and P4MF pastas were 338, 368 and 368 respectively.

There was significant difference for carbohydrate content among the selected proportions of pasta. Carbohydrates were found high in P1B (58.56) pasta followed by P3J (56.91) and P4MF (54.46). P2P (51.56) pasta had the lowest carbohydrate content.

The amount of protein in pasta depends on the type of raw materials used to manufacture it. Pasta based on wheat contain on an average of 11g of protein per hundred grams. In the current study, the results indicate that there was significant difference in protein content of selected proportions of pasta. The highest protein content was observed for P1B (8.19) and P3J (8.05) pasta followed by P4MF (7.98) and P2P (7.72).

Pasta is a low fat food and preferred by diet loving people. From the study, it could be concluded that all the three selected proportions of pasta such as P2P (0.94) , P3J (0.88) and P4MF (0.89) had a fat content less than one per cent and P1B pasta was observed with a fat content of 1.05g as represented in the table.

Calcium is important for overall health. Almost all cells in our body utilize calcium in some way. Various studies signify the health benefits of calcium. Pasta made with wheat as the basic component contains calcium about 2%. Calcium content was high for all the developed pastas. Result emphasizes that there was significant difference in calcium content in selected proportions of pasta. P1B (46.87) was found with highest calcium content followed by P3J (44.03), P4MF (43.73) and P2P (43.3).

Iron is an important mineral having a considerable role in blood production. It was observed that iron content of P1B (2.95) pasta was high. The lowest iron content was for P4MF (1.1) pasta. *Sodium* plays a diverse and *important* role in many physiological processes. The major source of sodium that people get from processed and packed foods. The result elucidates that P1B pasta (24.4) had highest sodium content followed by P4MF (18.23) pasta. The lowest sodium content was observed for P3J pasta (12.78) as represented in the table.

Potassium is an important mineral necessary for normal functioning of many of our body systems. Ordinary pasta made only with wheat, consist an average amount of 223 mg of potassium. Potassium content was high for P1B (344.7), P2P (314.5), and P4MF (310.4) pastas. Low amount of potassium was observed in P3J (29.422) pasta.

Beta carotene is an essential antioxidant, thus analysis was done for beta carotene in the developed pastas. The result shows that high amount of beta carotene was observed in P2P (150.6) and P4MF (150.6) pasta. Lowest amount of beta carotene was observed in P1B (47.25). P3J had beta carotene content of 97.76 as represented in the table.

The study indicated that all the developed pastas were equally good. Results emphasizes that there was significant difference in nutrients in the selected proportions of pasta. All the analyzed nutrients (energy to potassium) were found significantly high in P1B pasta except for beta carotene. The analyzed nutrients were found comparatively less in P2P pasta except for beta carotene. With respect to calcium, fat and protein content P3J and P4MF was found on par.

4.2.5.4. Chemical Composition of Pasta Product

Since chemical constituents have a definite role in food property, determination of chemical components in developed pasta is crucial. Thus the major chemical components such as moisture, poly phenols, peroxide, fibre and total minerals of the selected proportions of pasta were analyzed by adopting standard procedures (Table 28).

The results elucidate that the chemical constituents in selected four proportions of pastas were significantly different. Moisture content of foods affects the physical, chemical aspects of food which relates with the freshness and stability. Moisture content of P2P (19.65) was low and P3J (24.52) was high. Significant difference was noticed with respect to moisture content of pasta.

Table 27. Nutritional composition of 100 g pasta product

Criteria	P1B	P2P	P3J	P4MF	CD (0.05)
Energy (Kcal)/100g	383	338	368	368	-
Carbohydrate(g)/100 g	58.56^{bc}	51.56^{a}	56.91^{c}	54.46^{b}	2.11
Protein(g)/100g	8.19^{b}	7.72^{a}	8.05^{ab}	7.98^{ab}	0.42
Fat(g)/100g	1.05^{b}	0.94^{a}	0.88^{a}	0.89^{a}	0.06
Calcium(mg)/100g	46.87^{c}	43.3^{a}	44.03^{b}	43.73^{b}	0.40
Iron(mg)/100g	2.95^{b}	2.60^{b}	2.10^{b}	1.10^{a}	0.95
Sodium (mg)/100g	24.40^{d}	14.03^{b}	12.78^{a}	18.23^{c}	0.73
Potassium(mg)/100g	344.70^{d}	314.50^{c}	29.42^{a}	310.40^{b}	0.78
Beta Carotene (micro gram)/100g	47.25^{b}	150.6^{c}	97.76^{a}	150.6^{c}	4.11

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

Table 28. Chemical composition of 100 g of pasta product

Chemical components	Mean value				CD (0.05)
	*P1B	*P2P	*P3J	*P4MF	
Moisture (g)	21.70^{b}	19.65^{a}	24.52^{c}	21.17^{b}	0.53
Total minerals (g)	3.22^{b}	2.22^{a}	3.25^{b}	3.20^{b}	0.28
Peroxide (meq)	0.62^{a}	0.36^{a}	0.96^{a}	0.73^{a}	*NS
Poly phenols(mg)	2.10^{b}	1.42^{a}	2.10^{b}	1.48^{a}	0.34
Fiber(g)	1.51^{b}	1.49^{b}	1.61^{b}	0.63^{a}	0.50

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta, *NS- Non significant

The total mineral content of P3J pasta (3.25g) was high followed by P1B (3.22), P4MF (3.2) and P2P (2.22). P3J, P4MF and P2B were found on par. Peroxide gives evidence of rancidity in both fresh and processed foods. Peroxide value for P3J (0.96) was high compared to other three selected proportions of pastas. P2P had least peroxide value (0.36) as represented in table.

The total polyphenol content of both P1B and P3J (2.1) were high followed by P4MF (1.48) and P2P (1.42). The result showed that P1B and P3J were on par in relation. The fiber content of developed pastas was found to be high evidently. P3J (1.61) pasta was found with high fiber content followed by P1B (1.51), P2P (1.49) and P4MF (0.63) as represented in the table. The study indicated that there was significant difference among developed pastas with respect to all chemical components except for peroxide content.

4.2.5.5. Comparative study of nutrients with control pasta

The developed pastas were compared with the control (commercially accepted pasta) with respect to certain nutrients such as energy, protein, fat, carbohydrate and fiber (Table 29). Result showed significant difference in the nutrient content of developed pastas and control. All the developed pastas except P2P (338 Kcal) showed high energy content than control (360 Kcal).

Protein was seen high in control followed by P1B (8.19 g), P3J (0.88 g), P4MF (7.90 g) and P2P (8.19 g). Control pasta (2.30 g) observed with high fat content followed by P1B (1.05 g). Least fat content was obtained for P3J (0.88 g). Carbohydrate content was noticeably high in control pasta. All the developed pasta showed carbohydrate value in a range of 51.50 g to 58.50. Fiber was significantly high in developed pastas when compared with control (0.02 g).

The results indicate that the nutritional composition of developed pastas and control were significantly different. Protein, fat, carbohydrate was found to be high in control whereas fiber content was less compared to developed four pastas.

4.2.6. Shelf Stability of Stored Pasta

Food products that do not spoil under ordinary unrefrigerated temperature and humidity conditions are called shelf stable products. Shelf stability of a

product depends upon many factors like chemical composition of the product and raw materials used in the product.

The shelf life of a food is the time period within which the food is safe to consume and/or has an acceptable quality to consumers. During storage episode chemical and physical changes and microbial growth may be observed in perishable food items. The rate of spoilage during storage period is directly proportional to the perishability nature of the food.

Shelf-life studies can provide important information to product developers enabling them to ensure that the consumer will see a high quality product for a significant period of time after production. Shelf life studies up to three consecutive months were conducted. At an interval of one month selected proportions of pastas were analyzed for its sensory quality parameters, chemical composition changes and microbial content.

4.2.6.1. Organoleptic Quality of Stored Pasta

Sensory study during the storage period of a food product is important as far as food manufacturer is concerned. Sensory appeal is the key standard for a new food product in the market. The interpretation of chemical and physical measurements is often easier and more meaningful when combined with sensory data (Table 30 to Table 34).

Colour of stored pasta

Consumers are conscious for food colour. Appealing colour for food product magnetize consumers. Colour is the primary quality criteria judged by the people**.** In shelf life study, colour was analyzed for each month.

The statistical analysis showed that there was significant change in colour of stored pasta products during the storage period. The colour scores were found decreased in each month for all four developed pastas. P1B and P2P produced no significant difference with respect to colour scores during the storage period where as P3J and P4MF showed considerable difference.

Table 29. Comparison study of nutrients with control per 100 g

Nutrients	*P1B	*P2P	*P3J	*P4MF	*Control	CD (0.05)
Energy (Kcal)	383	338	368	368	360	-
Protein (g)	8.19^{c}	7.72^{a}	8.05^{bc}	7.90^{b}	9.90^{d}	0.16
Fat (g)	1.05^{a}	0.94^{a}	0.88^{a}	0.89^{a}	2.30^{b}	0.32
Carbohydrate (g)	58.50^{d}	51.50^{a}	56.90^{c}	54.40^{b}	71.00	0.82
Fiber (g)	1.51^{c}	1.48^{b}	1.61^{d}	0.63^{d}	0.02^{a}	0.01

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta * Control- Commercially available pasta

Table 30. Colour score of stored pasta

Pasta	Month			Pasta mean
	1	2	3	
P1B	5.9^{a}	5.7^{a}	5.6^{a}	5.7
P2P	5.9^{a}	5.7^{a}	5.6^{a}	5.7
P3J	5.5^{b}	5.3^{a}	5.1^{a}	5.3
P4MF	5.5^{b}	5.3^{a}	5.1^{a}	5.3
	Pasta	Month	Pasta * Month	
CD (0.05)	0.4	0.2	0.4	

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit

Table 31. Appearance score of stored pasta

Pasta	Month			Pasta mean
	1	2	3	
*P1B	6.0[b]	5.5[a]	5.4[a]	5.6
*P2P	5.9[a]	5.8[a]	5.6[a]	5.7
*P3J	5.7[b]	5.5[ab]	5.3[a]	5.5
*P4MF	5.9[a]	5.7[a]	5.6[a]	5.7
	Pasta	Month	Pasta * Month	
CD (0.05)	0.37	0.16	0.32	

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit

Table 32. Texture score of stored pasta

Pasta	Month			Pasta mean
	1	2	3	
P1B	5.8[b]	5.6[ab]	5.4[a]	5.6
P2P	5.9[a]	5.7[a]	5.6[a]	5.7
P3J	5.2[a]	5.2[a]	5.1[a]	5.2
P4MF	5.2[a]	5.1[a]	5.1[a]	5.1
	Pasta	Month	Pasta * Month	
CD (0.05)	0.4	0.1	0.3	

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit

Table 33. Flavor score of stored pasta

Pasta	Month			Pasta mean
	1	2	3	
*P1B	5.8[a]	5.7[a]	5.6[a]	5.7
*P2P	5.8[b]	5.6[ab]	5.4[a]	5.6
*P3J	5.6[b]	5.5[b]	5.2[a]	5.4
*P4MF	5.6[b]	5.5[b]	5.2[a]	5.4
	Pasta	Month	Pasta * Month	
CD (0.05)	0.4	0.2	0.3	

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

Table 34. Taste score of stored pasta

Pasta	Month			Pasta mean
	1	2	3	
P1B	6.0[a]	5.9[a]	5.8[a]	5.9
P2P	5.4[a]	5.2[a]	5.2[a]	5.2
P3J	5.5[c]	5.1[b]	4.8[a]	5.1
P4MF	5.4[b]	5.3[ab]	5.1[a]	5.1
	Pasta	Month	Pasta * Month	
CD (0.05)	0.4	0.2	0.5	

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

The results revealed that pastas P1B and P2P were on par in relation. The scores obtained for P1B and P2P were significantly different from scores of P3J and P4MF. Differences in scores were noticed between first and second month of storage while the scores for second and third month were found to be on par.

Appearance of stored pasta

The study revealed that a decrease in the scores for appearance was observed in developed pasta. P2P and P4MF pastas (5.7) obtained high scores in all the three months of storage study which was followed by P1B (5.6).

The scores acquired by the P3J pasta was low (5.5) compared to other three pastas. There were reductions in sensory scores of appearance for the products in each month. For P1B pasta, significant difference in the scores was noticed during the first month and second months of storage. In the case of P2P pasta considerable difference was not observed. With respect to P3J pasta scores were significantly different from first month.

Texture of stored pasta

As far as pasta is concerned texture plays a noteworthy role. It was observed that there was significant change in texture scores during the storage period. P2P (5.7) showed high score for texture followed by P1B (5.6), P3J (5.2) and P4MF (5.1). Among the developed pastas maximum scores for texture was observed for P2P whereas less scores was found in P4MF.

The results revealed that considerable difference was not found in stored P2P, P3J and P4MF in all three months whereas stored P1B produced significant difference in all three months with respect to texture scores. Least scores were found in third month and high scores were observed in first month of storage period.

Flavor of stored pasta

Sensory scores for flavor were reducing at a significant level across the months. Similar scores were observed for P3J and P4MF (5.4). Highest score for flavor was shown by P1B (5.7). Significant difference in scores for flavor parameter was not noticed in P1B, while all the other pastas showed difference in scores during the storage period.

The results revealed that the scores were found decreased in pastas (P2P, P3J and P4MF) during the storage period except for P1B pasta. Significant differences in scores were found in second and third month of storage while scores for first and second month found to be on par.

Taste of stored pasta

The taste score was appreciably high for P1B (5.9) than other pastas followed by P2P (5.2). Lowest score for taste was observed for P3J (5.1) and P4MF (5.1). Results indicated that significant difference in taste scores of pasta products (P1B and P2P) were not found, while significant difference were observed in P3J and P4MF pastas. In pasta P3J, the taste scores were considerably decreasing in each month. The scores were found different in first and second month of storage period.

4.2.6.2. Chemical Composition of Stored Pasta

Just as microorganisms can grow during storage, other changes in the composition of the food may occur. This deterioration may make the food unacceptable to the consumer. In such cases the changes in the food during storage may make it unsafe due to the nature of the compounds formed. The chemical components will have an impact on the shelf-life requirements. Hence chemical constituents in developed proportions of pasta were analyzed using standard procedures (Table 35 to Table 38).

Chemical composition of stored P1B

The statistical analysis showed that moisture content remained constant in all the three months study. Peroxide content of P1B pasta had no significant change during the storage period. A slight change was observed in poly phenol content of stored P1B pasta, even though no significant change was produced. Total mineral content of P1B pasta remained unchanged during the storage period.

On the whole, there was no significant difference observed in any of the chemical constituents during the storage study of pasta. If there were no changes in chemical constituents in food product during storage, that food product can be considered to be shelf stable.

Table 35. Chemical composition of stored P1B

Chemical constituents	Month 1	Month2	Month 3	CD (0.05)
Moisture (g)	21.7	21.7	21.7	*NS
Peroxide (mg)	0.62	0.62	0.62	NS
Poly phenols(meq)	2.10	2.17	2.25	NS
Total minerals(g)	3.20	3.20	3.20	NS

*Non Significant

Table 36. Chemical composition of stored P2P

Chemical constituents	Month 1	Month2	Month 3	CD (0.05)
Moisture (g)	16.65	19.6	19.6	*NS
Peroxide (mg)	0.36	0.36	0.37	NS
Poly phenols(meq)	1.42	1.45	1.44	NS
Total minerals(g)	2.22	2.30	2.25	NS

*Non Significant

Table 37. Chemical composition of stored P3J

Chemical constituents	Month 1	Month2	Month 3	CD (0.05)
Moisture (g)	24.5	24.6	24.6	*NS
Peroxide (mg)	0.96	0.97	0.98	NS
Poly phenols(meq)	2.10	2.20	2.17	NS
Total minerals(g)	3.25^{a}	3.25^{a}	3.55^{b}	0.25

*Non Significant

Table 38. Chemical composition of stored P4MF

Chemical constituents	Month 1	Month2	Month 3	CD (0.05)
Moisture (g)	21.17	21.80	22.55	*NS
Peroxide (mg)	0.65	0.67	0.66	NS
Poly phenols (meq)	1.48	1.50	1.48	NS
Total minerals(g)	3.20	3.10	3.03	NS

*Non Significant

Chemical composition of stored P2P

The moisture content of P2P (16.65- 19.6) had a slight increase during the storage study. An increase in moisture content can lead to potential quality loss of the product. However, there was no significant difference. A meager increment in peroxide content of stored P2P (0.36-0.37) pasta was observed. The increased value was seen in the third month of the study without producing significant change.

There was change in poly phenol content in each month observation, but statistical interpretation showed no significant difference. The study revealed that there was no significant change in total minerals content during the storage study of P2P pasta. Thus the results revealed that there was no significant change in any of the chemical constituents (Moisture, peroxide value, polyphenols and total minerals) of stored P2P.

Chemical composition of stored P3J

The moisture content of P3J pasta was ranged from 24.5 - 24.6 during the storage study. The product had a tendency for increase in moisture. Anyway, there was no significant change. There was slight increment in peroxide content of P3J pasta (0.96-0.98). But statistical analysis proved that there was no significant change.

Phenolic content of pasta was found be decreased during the study, nevertheless there was no noteworthy change observed during the storage study which unambiguously states the product is shelf stable. The results indicate that all the chemical components showed no significant difference except for total minerals content.

Chemical composition of stored P4MF

The results showed that there was no significant changes occurred for the P4MF pasta during the storage study of three months. From the table it could be concluded that moisture content of pasta varied from 21.17 to 22.55 during the storage period.

A slight change in peroxide value was observed without producing any significant difference. Poly phenol content of pasta also had no difference during

the storage study. The storage study revealed that the total mineral content of P4MF pasta (3.2 – 3.03) was diminishing, but there was no significant difference.

4.2.6.3. Microbial Study of Stored Pasta Product

Microbial population in processed foods is an important factor, which determines the quality and safety of the product. Microbial contamination of the pasta products developed in the study was ascertained to determine the keeping quality of the products. When foods are processed, there are chances of contamination through various means and also during storage of the products. These microbes multiply and cause spoilage of the products. Hence assessment of microbial population of the pastas is an essential step in the development of new products.

The selected proportions of pastas were analyzed for the presence of bacteria, fungi, yeast and actinomycetes using specific medias. Microbial study was conducted in the four pastas for consecutive three months. Serial dilution technique was adopted for the study as described in methodology. 10^{-3} dilution was plated in the four selected medias and observations for the presence of any microflora in the pasta product was taken up to one week (Table 39).

Microbial study of P1B pasta

Microbial observations were taken for the first six days of plating. Study was conducted for the three consecutive months and there were no microflora detected in the first two months in any of the media. During the third month, presence of yeasts (0.66 cfu/g × 10^{-3}) and fungi (1.33 cfu/g× 10^{-3}) were observed on the fourth and fifth days respectively in the corresponding media. The study indicated that no bacteria and actinomycetes in P1B pasta were observed. Fungal and yeast growth were noticed during the third month of the study.

Microbial study of P2P pasta

No bacterial or actinomycetes growth were observed in the product, during the conduct of the study. In the third month of study, fungal growth (1.66 cfu/g × 10^{-3}) was noticed in PDA media from fifth day onwards. Growth of yeasts (2.10cfu/g × 10^{-3}) was noticed from sixth day onwards in YPD media as represented in table.

Microbial study of P3J pasta

Presence of any microflora was not detected in the first month of study. In the second and third month, fungal as well as yeast growth were examined. Yeast growth (0.66 cfu/g× 10^{-3}) was observed in the fourth day of third month storage study. Fungal growth was observed both in the second and third month of the study. Presence of yeast was detected in the sixth day of second month (3.2 cfu/g× 10^{-3}) as represented in table. The presence of bacteria as well as actinomycetes was nil (0) during the storage study.

Microbial study of P4MF pasta

Yeast and fungal growth were examined in the study. No microbial growth was observed in the first month of storage study. During the second and third month of the study, presence of microbes in PDA and YPD was examined. On the fifth day of observation, fungal population was noticed in the second (1.33 cfu/g× 10^{-3}) and third month (1.98 cfu/ g× 10^{-3}) storage study. Yeasts growth was observed (1.6 cfu/gm× 10^{-3} and 3.9 cfu/gm× 10^{-3}) from fifth day onwards as represented in table, in both second and third month. The growth of both bacteria and actinomycetes were nil in all the three months of storage study.

4.2.7. Consumer Acceptance of Pasta Product

A new product development study ends only when consumer acceptance and preference study is conducted. A pilot study of a new product among consumers must be done before introducing it in the market. Hence consumer acceptance and preference study was conducted for the developed pastas.

The study was carried out among three different groups such as children, adolescents and adults. Sample sizes of 50 members were selected from each group. 9 point hedonic score card was used for the study starting from like extremely to dislike extremely (Table 40).

From the results it could be concluded that there was difference in preference pattern among the selected groups as well as in the pastas. The study revealed that P2P was the most preferred pasta with a mean score of 8.7 out of 9 followed by P4MF (8.0) and P1B (7.4). The lowest preferred pasta was P3J with a score of 6.7 out of 9.

Table 39. Microbial count of stored pasta product

Pasta	Month	Media							
		*NA (cfu/g X 10^{-3})	*PDA (cfu/g X 10^{-3})			Kennights (cfu/g X 10^{-3})	*YPD (cfu/g X 10^{-3})		
			4	5	6		4	5	6
*P1B	1		0	0	0		0	0	0
	2	NIL	0	0	0	NIL	0	0	0
	3		0	1.33	3.10		0.66	1.6	1.6
*P2P	1		0	0	0		0	0	0
	2	NIL	0	0	0	NIL	0	0	0
	3		0	1.66	2.10		0	0	1.33
*P3J	1		0	0	0		0	0	0
	2	NIL	0	0.66	1.33		0	0	3.2
	3		0	2.10	3.10		0.66	1.6	3.2
*P4MF	1		0	0	0		0	0	0
	2	NIL	0	1.33	1.98	NIL	0	1.6	3.9
	3		0	2.10	3.96		0	3.2	3.2

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

* NA- Nutrient agar, * PDA- Potato dextrose agar, * YPD- Yeast potato dextrose

Both children and adults highly preferred the P2P pasta with a score of 8.3 and 9 respectively, while preference of adolescents was for P4MF pasta with a score of 8.9. All the developed products were highly scored by the selected subjects indicating that the products were preferable for the consumers. On the whole, the product pasta was highly preferred by adolescents followed by adults and children. Results revealed that children and adolescents equally preferred P1B pasta where as the preference rate was found less among adults. All the selected groups equally preferred pasta P2P.

There was no significant difference in the acceptance of P3J pasta among all the selected groups, but the scores were found less compared to other three developed pastas. Significant difference in the acceptance and preference of P4MF pasta was noticed. Both adults and adolescents scored well for the P4MF pasta whereas children preferred less.

4.2.8. Cost Analysis of Pasta Product

The cost of the developed proportions of pasta was calculated by taking into account of the expenses incurred in raw materials, packaging accessories, labour charges and fuel cost. Cost analysis of the selected four proportions of pastas were computed taking into consideration of the pre market price of the ingredients used and cost involved in processing.

Table 41 clearly shows that the cost for P3J (265/ kg) was high followed by P4MF (261/ kg), P1B (248 / kg) and P2P (240 / kg). As the cost of the food product increases the demand decreases. As India is not a developed country, high cost for foods is not affordable for Indian population especially middle and low income groups. The developed pastas products had affordable cost.

Table 40. Consumer acceptance of pasta product

Pasta	**Groups**			
	Children	**Adolescents**	**Adults**	**Pasta mean**
*P1B	7.9^{b}	8.5^{b}	6.0^{a}	7.4
*P2P	8.3^{a}	8.8^{ab}	9.0^{b}	8.7
*P3J	6.7^{a}	6.9^{a}	6.5^{a}	6.7
*P4MF	6.9^{a}	8.9^{b}	8.4^{b}	8.0
	Pasta	Group	Pasta * Group	
CD (0.05)	0.79	0.68	1.4	

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

Table 41. Cost of pasta product

Pasta	Price in rupees/Kg
*P1B	248
*P2P	240
*P3J	265
*P4MF	261

* P1B-Banana pasta,* P2P-Papaya pasta,* P3J-jackfruit pasta,* P4MF-Mixed fruit pasta

Discussion

5. DISCUSSION

PART I

5.1 DEVELOPMENT OF FRUIT BASED INSTANT SNACK

A snack is a portion of food often smaller than a regular meal, generally eaten between meals. Snacks come in a variety of forms including packaged and processed foods and items made from fresh ingredients. Traditionally snacks have been considered to be primarily indulgent foods eg., energy dense foods, nutrient poor, where as today there is an increased demand for and availability of healthier nutrient – dense snack choices. Survey reports shows that snacking pattern of people increased than ever before (Subramaniam *et al.,* 2008). According to Neil (2009) the snacking frequency of people is almost 1-5 times per day. Girge *et al.* (2009) opined that about 90% of snacks available in the market are unhealthy, which are rich in trans fats, sugar, sodium and low in fiber and other nutrients. Anderson *et al.* (2011) reported that, consumption of unhealthy snacks leads to various life style disorders. According to ADA (2010) people must shift from unhealthy snacking pattern to smart snacking pattern. Sami *et al.* (2012) reported that smart snack consists of fruits, vegetable, nuts, whole grains and pulses. Recent consumers are more health and nutritious conscious, thus they prefer healthy smart snacks. Thus in the present investigation an instant snack product, which could be considered as a healthy smart snack was developed by incorporating whole cereals, pulses, fruits and coconut.

5.1.1. Selection and Preliminary Processing of Fruits for Instant Snack

The selected fruits for the study were Jackfruit (cv Koozha), Papaya (Pusa Dwarf) and Banana (Nendran), which was obtained from instructional farm College of Agriculture, Vellayani.

Jackfruit is an excellent fruit used for processing. Ukkuru and Pandey (2005) developed varieties of jackfruit products being clarified juice, fruit nectar, fruit bars, health drink mixes, bakery and confectionary products. Various convenient value added food products were made from jack fruit. For instance, jackfruit leather and jackfruit chips can be made from dried jackfruit pulp

(Nakasone and Paull, 2008). Pureed jackfruit is also manufactured into baby food, juice, jam, jelly, and base for cordials (Roy and Joshi, 2005). Jackfruits are made into candies, fruit-rolls, marmalades, and even ice cream. Other than canning, advances in processing technologies too, have pushed toward more new products (Narasimham, 2000).

Khader (2006) opined that as jackfruit is a seasonal fruit, it should be utilized for processing so that extension of shelf stability can be achieved and the fruit can be enjoyed all the year around. Justin and Jaison (2010) reported that jack fruit is a wonderful fruit having various nutritional, health and medical benefits, which when incorporated in the daily diet numerous health problems can be alleviated. Study conducted by Sukumari (2001) stated that consumers prefer to eat jackfruit snacks to whole fruit as such. In Kerala, two types of jackfruit predominate : varikka and koozha. Varikka as a slightly hard inner flesh when ripe, while the inner flesh of the ripe koozha fruit is very soft and almost dissolving. Varika jack fruit is more preferred by consumers than Koozha, which is being wasted. Thus in the present investigation, koozha variety of jack fruit of semi ripened stage was selected and processed for the formulation of instant snack.

Papaya is called "the fruit of the angels" by Christopher Columbus. Chinoy *et al.* (2004) opined that papayas are a great source of antioxidants; recent studies have shown that they may aid in preventing diabetic heart disease. Various health and medicinal studies done in papaya revealed that consumption of this fruit either in the form of recipes or fruit as such can reduce life style disorders (Thor *et al.,* 2008). Papaya is a powerhouse of nutrients and is available throughout the year which effectively treats and improves all types of digestive and abdominal disorders (Adebiyi *et al.,* 2003).

Fedrick (2009) opined that due to its characteristic flavor and aroma, people prefer processed papaya. Various processed papaya products are now available such as papaya jam, puree, IMF papaya cubes, etc. Chandran and Cheriyan (1999) developed jelly product from papaya pulp which was shelf stable and organoleptically superior. Krishna *et al.* (2008) reported that papaya is an

excellent fruit suitable for applying various processing techniques. Processed papaya products are in demand because of its appealing colour and appearance. Thus in the present investigation, papaya fruit (Pusa Dwarf) was selected and applied various pre treatments and osmotic dehydration technique, and was incorporated in the formulation of instant snack.

Banana is the largest produced and maximum consumed amongst the fruits cultivated in India. It is known as the 'common man's fruit'. It is highly nutritive and very delicious (Surendranathan *et al.,* 2004). The bananas provides with antioxidants as well as a greater nutritional boost, including fiber, potassium and Vitamin B6, in addition, bananas have a healthier blend of sugars (Subramaniam *et al.,* 2008). Suman (2011) stated that banana is a harmless fruits which is tolerable to children to geriatric.

Andrews and Fiesta (2011) reported that banana is an estimable fruit that can be used for preparation of homemade snacks and also commercially available products such as bars, beverages, ice cream and even for extrusion. Various bananas based as well as banana incorporated snacks and convenient shelf stable foods were developed by DFRL for military purpose (Sharmila *et al.,* 2007). Nasheeda and Nirmala (2006) developed multipurpose convenient mix from banana (Robusta and Rasakadali) which were rich in nutrients with good shelf life. Various varieties of bananas are available in Kerala, of which Nendran variety of semi ripened stage was selected. Because of its peculiar characteristics such as nutritional quality, colour, and aroma, banana (Nendran) was selected for the development of instant snack.

Fruits are a high-moisture, generally acidic food that is relatively easy to process and that offers a variety of flavour, aroma, colour, and texture to the diet. As fruits are rich in moisture they are highly perishable. Processing of fruits will improve the shelf stability of fruits. Consumers are now more health and nutrition conscious, thus the demand for processed fruits incorporated convenient shelf stable foods are in rise (Hui, 2008). Jolly *et al.* (2009) stated that, because fresh fruits are both bulky and get spoilt rapidly, it is better to process for developing value added convenient healthy smart snacks. For the instant snack

development, the selected fruits (Jack fruit, Papaya and Banana) were processed as described in methodology.

5.1.2. Pretreatments of Fruits

Pretreatments help in improving the quality of the products and extend their shelf life. Pretreatments like dipping treatments increase the nutrient retention during subsequent drying (Jagadesh *et al.,* 2009). According to the study conducted by Lee and Lim (2011) on pretreated pumpkin and non pretreated pumpkin revealed that, the pretreated pumpkin had better retention of aroma, colour and nutrients where as the non-pretreated pumpkin was of inferior in quality.

Pre-treating fruits is an important step in preserving the produce. It helps the food product keep its natural colour, and kills off enzymes that can cause food spoilage. The pretreatment media used were citric acid and lime water solutions, at two different concentrations and immersion time. Pretreatment has also been reported to enhance the mass transfer kinetics during osmotic dehydration (Rastogi and Niranjan, 2008).

Eight different pretreatments (PT1,PT2, PT3, PT4, PT5, PT6, PT7 & PT8) using citric acid solutions at 0.5 and 1% concentrations for 5 and 10 minutes immersion time, while lime water at 10 % and 15 % concentrations for 6 and 12 hours immersion time were given. Pretreating fruits and vegetables for storage, regardless of method used is an important step in preserving the produce. It helps the food product keep its natural colour, and kills off enzymes that can cause food spoilage (Aravind, 2001).

After preliminary processing of selected fruits (jackfruit, papaya and banana) the edible portion was collected and cut into cubes for each fruit were given with eight pretreatments separately and the best pretreatment was selected based on high sensory scores given by the selected panel of ten judges. The study indicated that PT_7 (Limewater solution at 15 per cent concentration for 6 hours immersion duration) as the best pretreatment method in all selected fruit cubes. Similar observation was found in the study conducted by Jessi *et al.* (2007), were

lime water was selected as the best dipping pretreatment for apples, potato and pineapple.

5.1.3. Osmotic Dehydration of Pretreated Fruits

Osmotic dehydration (OD) is one of most important complementary treatments and food preservation techniques in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decrease the energy costs (Torres *et al.,* 2006). The different types of osmotic agents such as glucose, sorbitol, sucrose and salts are used according to the final products (Singh *et al.,* 2008).

Four different methods of osmotic treatments (OT_1, OT_2, OT_3 & OT_4) were conducted to selected pretreated fruits. Sugar solution at 60°B and 70°B concentration and immersion duration of 6 hours and 12 hours were applied. The best osmotic treatment was selected based on the sensory judgment provided by the selected ten panel members.

In all selected pretreated fruit cubes, OT_4 treatment resulted in maximum sensory scores. In OT_4 treatment, 70^0 B concentration of sugar solution for 12 hours immersion duration was applied. Jaeger (2003) stated that as the concentration of osmotic solution increases the quality of osmotically dried fruits also increases. Osmotic dehydrated apples at 70^0 B sugar solution for 12 hours immersion duration had the maximum keeping quality (Kaeini *et al.,* 2010).

Rodrigues and Fernandes (2007) opined that osmotic dehydration using sugar solution at 70^0 B concentration significantly improves the texture and taste of melons. This technology promotes partial removal of water from food by immersion in a concentrated hypertonic solution leaving a material that will need shorter drying times than the original food material, making this process more economical.

Furthermore, increased sugar content in the final product improves the organoleptic qualities of the end product because some of the acids are removed from the fruit during osmotic dehydration, so a sweeter product than ordinary dried fruit is obtained (Falade and Aworh, 2005). A longer contact time of the

samples with the sugar solution gives a higher solids gain and a higher moisture loss (Nieuwenhuijzen *et al.,* 2001).

OT_4 treated fruit cubes were dried in tray drier, in order to remove excess osmotic solution. The drying temperature was 60^0 C for 4 hours. Drying is one of the most energy intensive unit operations in food and non-food products processing industries. Ramasamy *et al.* (2011) reported that drying extends the shelf stability of fruits. In osmotic dehydration technique, a significant amount of water is removed in liquid form which demands little or no external energy supply (Lazarids, 2001). By reducing the moisture content of a product to certain extent either using mechanical or osmotic dehydration method, ultimately reduce the energy demand required to remove the moisture.

Tray drying of osmotically treated pine apple was found to be successful with respect to sensory and nutritional characteristics (Tsami and Katsioti, 2008). Lewicki and Lukaszuk (2009) reported that, shelf stability extension was made possible by tray drying of osmotically treated apple slices at 60^0 C for 2 hours.

Weight loss per cent of the fruit cubes were calculated and found that OT4J had the highest weight loss followed by OT_4P and OT_4B. The study also pointed out that time required for drying was high for OT_4J. The drying time was observed less for OT_4P. Drying studies of fruits and vegetables showed that utmost weight loss was observed for conventional drying while weight loss was less for osmotically treated products. Weight loss rate is specific for each fruit (Taiwo *et al.,* 2003).

5.1.4. Selection and Optimization of Other Raw Ingredients for Instant Snack

In this context, to improve the nutritional quality of the instant snack other ingredients being parboiled rice and wheat from cereals, green gram and horse gram from pulses, and fresh matured coconut were selected. Various degrees of processing technologies were applied and then incorporated in the instant snack formulation.

Rice is the most popular cereal worldwide, serving as a staple food for 39 countries and nearly half of the world's population (Juliano, 2003). Ludwig (2007) indicated that rice is an excellent addition in processed food preparations

because it is versatile, has lots of calories, and good shelf life. Iron, niacin, thiamin, and folic acid content of rice parboiled are not diminished. Heather *et al.* (2009) stated that rice is high in starch and fiber in addition, it is low in sodium and a good source of protein. Vaidehi (2005) reported that rice is a nutritious food that can be utilized for food processing.

Prasad *et al.* (2012) reported that rice being rich in carbohydrates contributes to about 60 to 70 % of the daily energy needs and also can be extensively used as convenience food such as breakfast cereals, multigrain flakes, puffed, popped, and extruded products.

In the case of parboiled rice, roasting was done until the product obtain crunchy and crispy texture. Mridula *et al.* (2007) opined that due to the changes in chemical components, roasted rice have high sensory attribute. Vasundhara and Parihar (2010) reported that addition of roasted rice in food improves the sensory qualities with its tempting roasted flavor and aroma. Wide variety of convenience foods can be developed by integrating roasted rice.

Alvarez *et al.* (2006) reported that many health and nutritional benefits of whole wheat incorporated processed food products are being recognized more and more by consumers. The demand for whole wheat products has actually increased during the recent years (Suzuki *et al.,* 2008). A survey has concluded that whole wheat diet slows down the progression of life style diseases, as well as reducing the frequency of heart attacks and strokes. Nelson and John (2011) stated that wheat is a resourceful food item which is valuable for healthy snack preparation.

Germination, flaking and roasting were the processing techniques applied for wheat. The germination is a simple method of food processing that result in increased nutritive value and decreases the phytates, tannin level and increases the availability of iron and calcium (Borade *et al.,* 2011).

Yang *et al.* (2009) reported that germination of wheat augment the vitamin and mineral content. Zandan and Asli (2012) stated that daily intake of sprouted wheat improves the physical health and helps in maintaining healthy body weight.

Saied *et al.* (2014) developed steam flaked wheat and incorporated in cookies, biscuits and breads. The consumer acceptance study of wheat flakes

revealed that the product is highly acceptable by the selected two hundred subjects.

Both the pulses green gram and horse gram were germinated and roasted. Germination and roasting are the usual processing steps conducted to pulses in India, for extending the nutritional quality as well as shelf stability (Pomeranz, 2003).

Green gram is one of the important pulse crops in India which is a protein rich staple food (Willett, 2004). Wong *et al.* (2006) opined that green gram contains about 25 percent protein. It supplies protein requirement of vegetarian population. Green gram is consumed in the form of split pulse as wells as whole pulse, which is an essential supplement of cereal based diet. Studies indicate that rise in micronutrient content was observed for sprouted green gram (Khader and Rao, 2009).

Mesallam and Hamza (2011) indicated that incorporation of roasted and sprouted green gram in convenience foods particularly designed for vegetarians is the emerging trend in food industries. Ginson and Kin (2010) developed sprouted green gram ready to eat mix.

Sawant (2007) stated that in traditional ayurvedic cuisine, horse gram is considered a food with medicinal qualities. Horse gram is a cheapest source of protein and excellent source of iron and molybdenum. It is prescribed for persons suffering from water retention and as part of a weight loss diet.

Ismail *et al.* (2003) reported that horse gram is an important crop must be used in various food preparations. It is useful in iron deficiencies and is considered helpful for maintain body temperature in the winter season. Sprouted horse gram is considered to be nutritious. Utilization of horse gram in the daily diet is poor, thus it could be transformed to other form by applying processing techniques, without losing the nutrients.

Kadam and Salunkhe (2007) pointed out that horse gram seeds have higher trypsin inhibitor and hemagglutinin activities and polyphenols. Dehusking, germination, cooking, and roasting have been shown to produce beneficial effects on nutritional quality of the legume. Sawant (2007) developed value added

extruded products using germinated horse gram flour with shelf stability and extremely nutritious.

Coconut was the eighth ingredient selected for instant snack formulation. In recent years, delicious snacks have been produced from coconut (Lattanzio *et al.,* 2008). One of these snacks consists, basically, in the removal of water of the coconut pulp, previously cut into small slices (Da Silva *et al.,* 2013). After the removal of water from the slices of mature or semi-mature coconut, the snack "dry coconut", cooled up to room temperature, is ready for consumption. However, the use of hot air to remove water of coconut slices is expensive due to the phase change of this substance from liquid to vapor, once its latent heat of vaporization within the product is very high. Thus, in general, a pre-treatment is accomplished before tray drying. An example of inexpensive pre-treatment is the osmotic dehydration (Arballo *et al.,* 2012).

In this scenario, fresh matured coconuts were osmotically pretreated and tray dried to develop coconut chips. The developed coconut chips were further mixed with the other ingredients for the development of instant snack.

5.1.5. Standardization and Formulation of Instant Snack

Eight different combinations of instant snack using selected processed ingredients were worked out. Nutritional and sensory aspects of each combination were worked out. The combination with high energy and protein content and sensory scores was selected as the developed instant snack.

Xue (2012) stated that nutritional value is an important attribute of foods whose benefits can only be experienced by repetitive consumption in long run. Consumers' knowledge about the importance and usefulness of specific nutrients in a food product may influence their subjective expectation of the product's health benefits which in turn is translated into their perception of the product's value. At the same time, the sensory characteristics of food products affect consumers' immediate consumption gratification.

Gomez (2009) proposed that making snacks nutritious is very important for healthy living. Bieber and Justin (2008) reported that energy and protein content in snack food plays a significant role than any other nutrient. According to

Marshell (2010), the energy and protein values of snacks must be labeled before marketing.

In the present study the energy and protein content of formulated C2 combination was recorded maximum and also obtained a sensory score of 8.8 (hedonic rating). Therefore the combination C2 selected as the developed instant snack. Fig. 14. and Fig. 15. represents the energy content and protein content of formulated combinations of instant snack respectively. Fig. 16. shows the results of sensory evaluation using hedonic rating scale.

The developed snack was produced in bulk quantity of 10 Kg for chemical and nutritional studies, shelf stability studies and consumer acceptance and preference studies.

5.1.7. Quality Evaluation of Instant Snack

Organoleptic quality, chemical composition, nutritional quality and shelf life of the instant snack product were evaluated.

5.1.7.1. Organoleptic Quality Evaluation of Instant Snack

The quality of a food is identifiable through those attributes of a food product that can be assessed sensorically. The sensory impressions were recorded using score card. The organoleptic evaluation (score card) of developed instant snack is given in Fig. 17.

Sensory evaluation is defined as a scientific discipline used to evoke measure, analyze, and interpret those responses to products that are perceived by the senses of sight, smell, touch, taste, and hearing (Stone and Sidel, 2003). Starting from product development, products are evaluated in terms of their sensory attributes to get their profile and to know if their target consumer would prefer to buy it.

In studies reported by Brunnschweiler (2004), taste, texture and appearance as the primary quality criteria for determining the choice of a product while flavor and colour is the secondary quality criteria. Sensory Evaluation is necessary for the quality assessment of foods (Akbarali and Maharaj, 2014). Various parameters of the instant snack being appearance, colour, flavor, texture and taste were assessed.

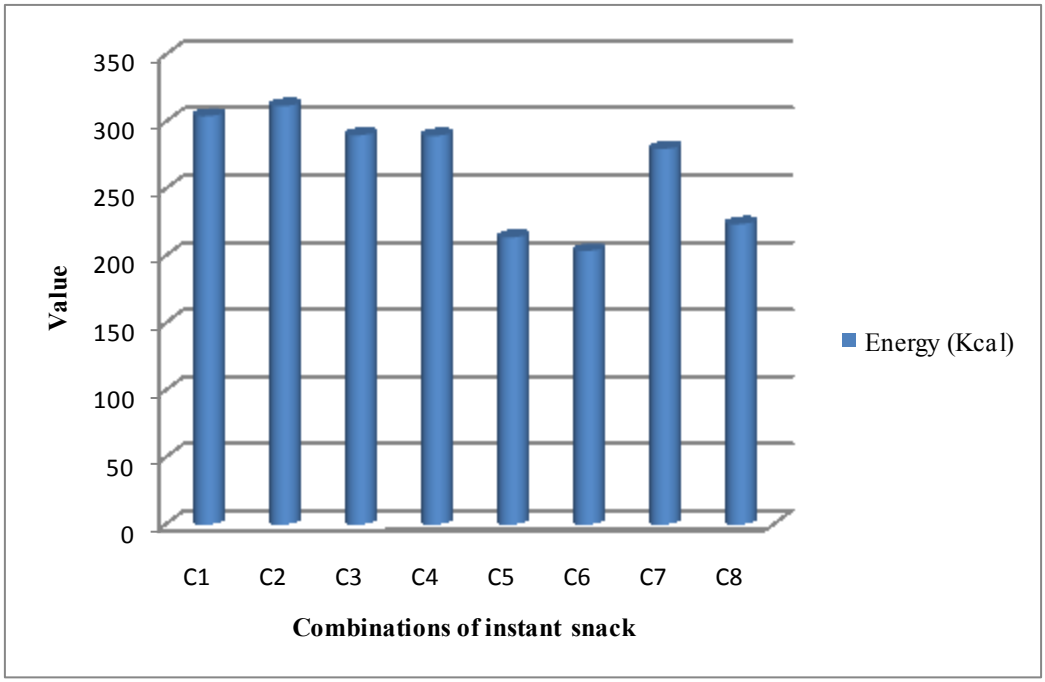


Fig. 14. Energy content of instant snack

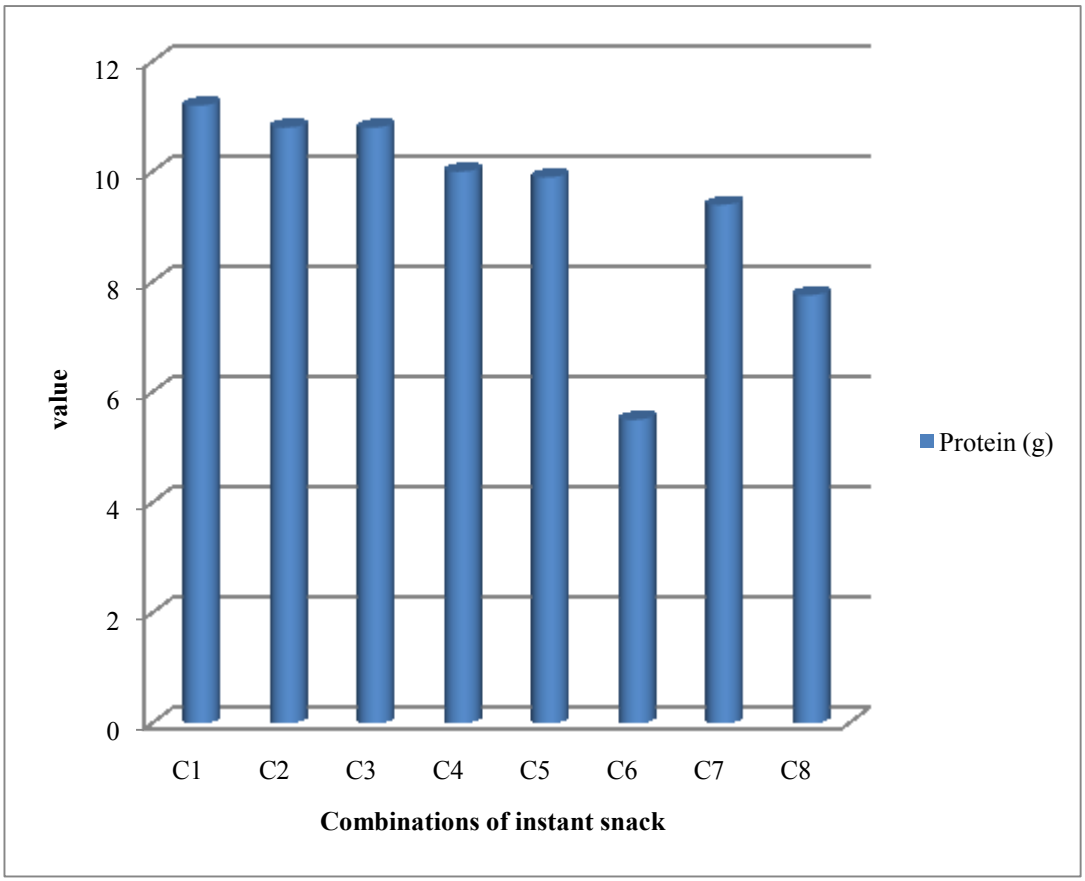


Fig. 15. Protein content of instant snack

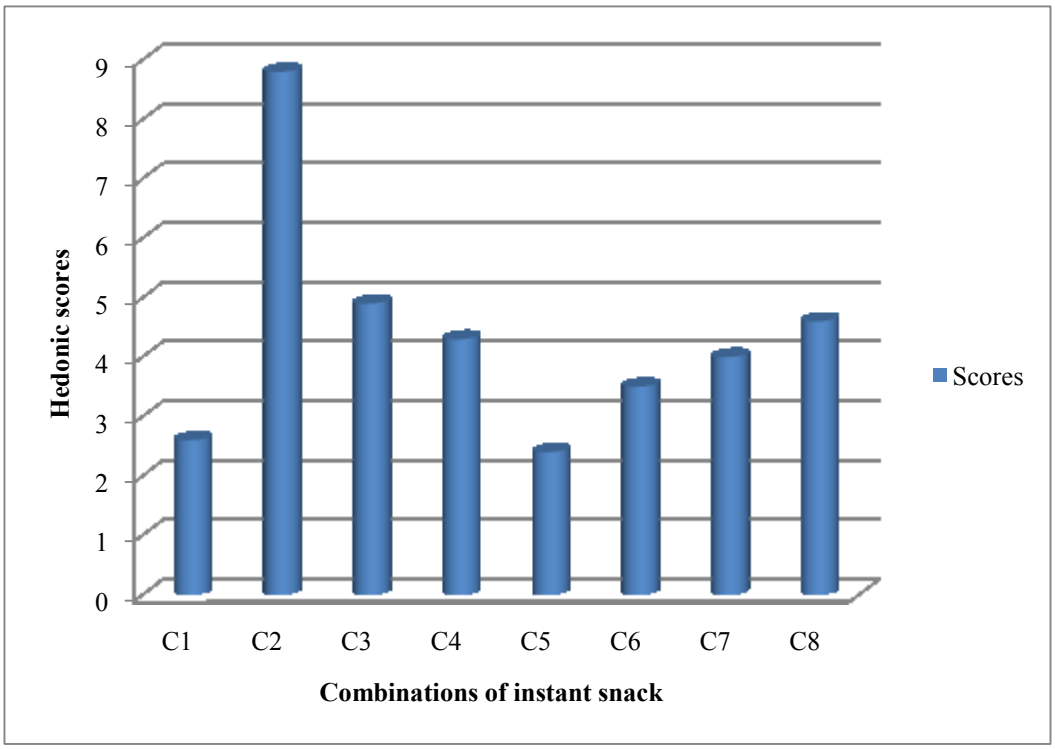


Fig. 16. Sensory evaluation of instant snack

The study results showed that all the parameters were well scored above 5 out of 6. Flavor was the parameter which was highly scored (5.8) contrast to other sensory characteristics.

5.1.7.2. Nutrient Content and Chemical Composition of Instant Snack

Processing including preparation makes food healthier, safer, tastier and more shelf stable. While the benefits are numerous, processing can also be detrimental, affecting the nutritional and chemical quality of foods. Thus the nutritional and chemical evaluations are inevitable for the study. Bothwell *et al.* (2002) opined that even though various snack foods are increasing in the market, healthy nutrient rich snacks are very few.

Chapelot (2011) stated that snacks are empty calorie foods. Calcium, iron and beta carotene are not found in many highly processed snack foods (Isabel, 2005). Damon *et al.* (2007) indicated that snacks with macro and micro minerals and vitamins considered being smart snacks.

Ferna *et al.* (2010) reported that food industries are trying to make healthy smart snacks. In recent years, simple snacks were replaced with nutrient rich smart snacks. A nutrient rich smart snack must supply major as well as minor nutrients.

The developed instant snack provide energy (349.8 K cal/100 g), protein (10.83 g/ 100 g), fat (4.95 g/ 100 g), calcium (70. 18 mg/ 100 g), iron (3.96 mg/ 100 g) sodium (16. 46 mg/ 100 g), potassium (280.86 mg/ 100 g) and beta carotene (115.46 µg/ 100 g). Consequently, the developed instant snack could be well thought-out to be a smart snack.

Chemical analysis of hundred gram of developed instant snack endow with 13 g of moisture, 0.65 meq of peroxide, 1.27 mg of poly phenols, 2.9 g of fiber, 2.28 g of total minerals.

Moisture content of the food material is important since it affects the physical, chemical aspects of food which relates with the freshness and stability for the storage of the food. Labuza (2009) defined that moisture occurs in food systems in both the free and bound states. In the bound state, water is not

available to participate in any reactions as it is tied up by water-soluble compounds such as sugar, salt and gums termed osmotic binding.

The moisture in the concentrated phase becomes kinetically immobilized and therefore does not support or participate in reactions (Rahman, 2009). Roos (2005) opined that moisture content from 12 per cent to 40 per cent regarded as intermediate moisture foods, were the water activity is less and the available water is in the bound state. In the present study, the moisture content was 13 per cent, which indicate that the developed instant snack can be described as an intermediate moisture food.

Afokowa *et al.* (2004) proposed that peroxide value is an indicator of keeping quality of food. Low peroxide values are preferred for processed foods. Only 0.65 meq of peroxide content was observed for the instant snack signifying that the product's shelf stability.

The polyphenols include different types of chemical compounds. Manach (2004) reported that food manufacturers have become increasingly interested in polyphenols because of the recognition of the antioxidant properties and their probable role in the prevention of various diseases associated with oxidative stress. Vallverdu *et al.* (2011) reported that the polyphenol content of processed foods are a lesser amount compared to unprocessed foods. The developed snack provides 1.27 mg/100g of poly phenols was moderately less.

Ludwig *et al.* (2009) projected that fiber content of processed foods is equivalent to zero per hundred grams. At least 15 g of fiber must be there in the daily diet (Greger, 2009). Chandalia (2007) stated that processed food with minimum 1.5 g of fiber can be labeled as smart snack. Accordingly, the developed instant snack which gives 2.9 g of fiber could be considered as a smart snack.

5.1.8. Shelf Stability of Stored Instant Snack

The common problems associated with snacks during storage are rancidity, loss of crispiness, colour and also breakage. Therefore storage study is essential for the developed instant snack. Shelf life study for consecutive three months was conducted with respect to organoleptic characters, chemical constituents and microbial growth.

5.1.8.1. Organoleptic Quality of Stored Instant Snack

The study produced no significant difference with respect to organoleptic study conducted in three consecutive months. The shelf life of osmotic dehydrated and roasted food stuffs is high (Steele, 2004). A storage study conducted by Man (2002) proved that osmotically dried mango pieces had storage stability more than 4 months. Campden, (2004) proposed that roasted cereals and pulses can be kept without organoleptic changes for up to one year. Osmotically dried coconut chips had a shelf life for 3 months**.** Hence it could be concluded that osmotic dehydration and roasting techniques helps in maintaining the sensory qualities of developed instant snack packed in laminated pouches. Fig. 18. represents the organoleptic quality of stored instant snack.

5.1.8.2. Chemical Composition of Stored Instant Snack

Monthly observations of moisture, total minerals, peroxide and polyphenols were observed and found no significant difference in their values. Similar results were shown in the study conducted by Roukos (2008) in fruit incorporated nutri-bar. Fig. 19. and Fig. 20. shows the chemical composition of stored instant snack.

5.1.8.3. Microbial Evaluation of Stored Instant Snack

No microbes were observed during the period of study, emphasizing that the developed snack was shelf stable for three months. Microbial analysis of osmotic dried jackfruit cubes, mango cubes, papaya cubes and pumpkin cubes showed no microbial count (Linda and Haris, 2003).

5.1.9. Consumer Acceptance Study of Instant Snack

Consumer awareness and preference decide the success of food products standardized. Acceptance and preference are consumer oriented tests. The study was carried out in 150 selected subjects 50 from each children, adolescents and adults using hedonic rating scale. Result indicated that all the selected subjects equally preferred the developed instant snack. Grunert *et al.* (2003) suggests that there is hike in the consumption of ready to eat snacks. Consumer acceptance study conducted in ready to eat fruit mixture developed by Gaskell *et al.* (2003) showed that all the subjects well scored and extremely liked the product.

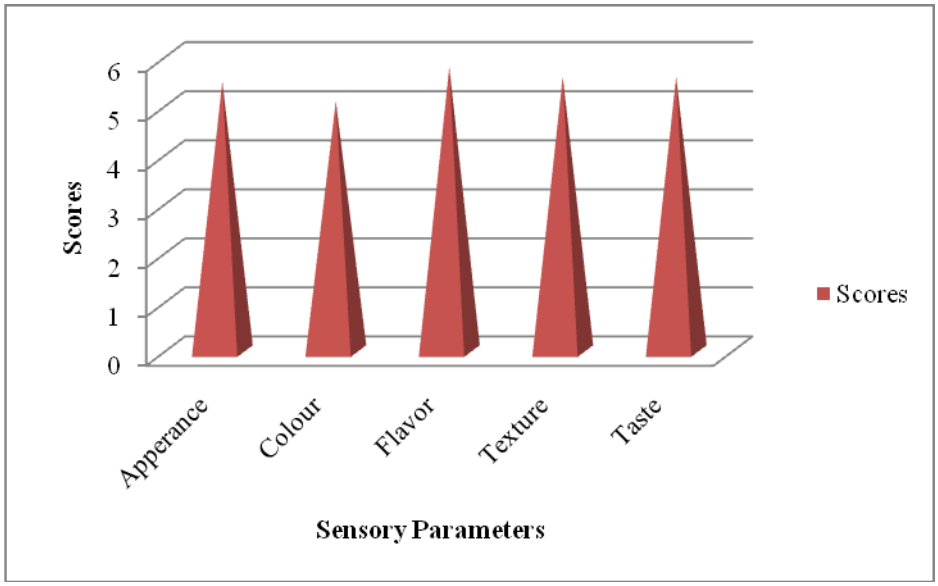


Fig. 17. Mean sensory scores of instant snack

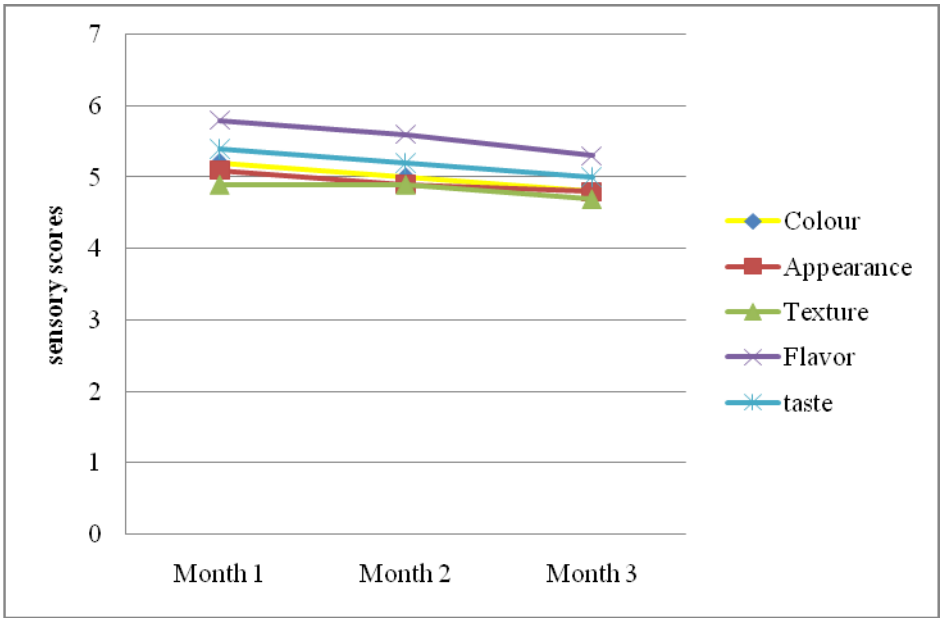


Fig. 18. Organoleptic quality of stored instant snack

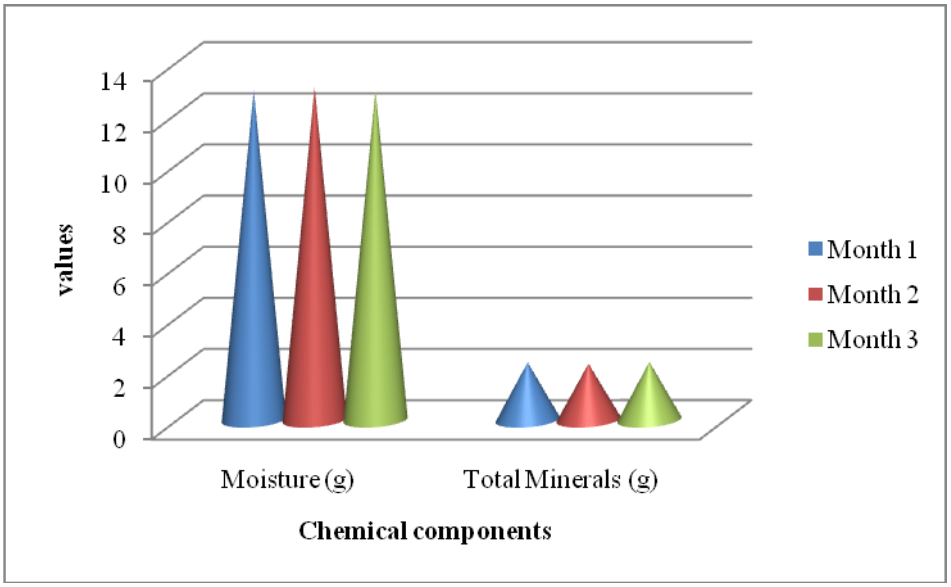


Fig. 19. Moisture and total mineral content of stored instant snack

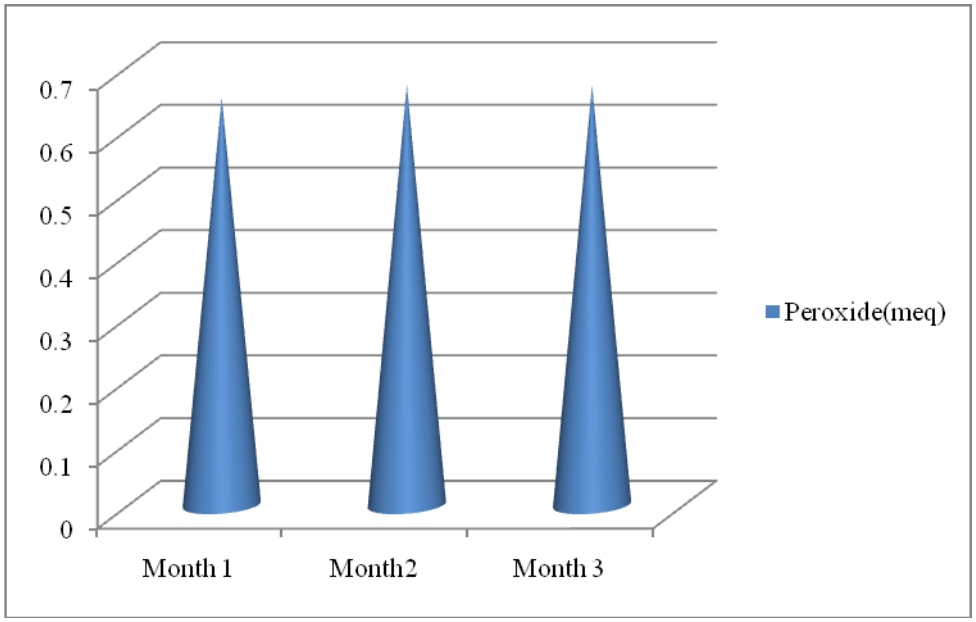


Fig. 20. Peroxide content of stored instant snack

Interestingly survey report evidences suggests that busy life of people having today demands convenient ready to eat food. The present study reveals the evidence of people's support for processed and convenient food products. Fig.21 to Fig. 23. represents the consumer acceptance study of instant snack.

5.1.10. Cost Analysis of Instant Snack

Costing is very important as the cost of a product can decide its profit or loss. The cost of a product depends on the purchase of raw materials, cost involved in processing, packaging and marketing and profit margin set by the industry (Kumbhar and Singh, 1991).

In order to realize the economic feasibility of developed instant snack, cost per kg of product was computed. The snack developed under this study was found to be reasonable in price. The cost of the snack was Rs 170/ Kg.

The cost of similar product (Museli) in which combination of fruit and cereals available in market is 470/250 g. When comparing the cost with the developed product it could be concluded that the developed instant snack is quiet reasonable.

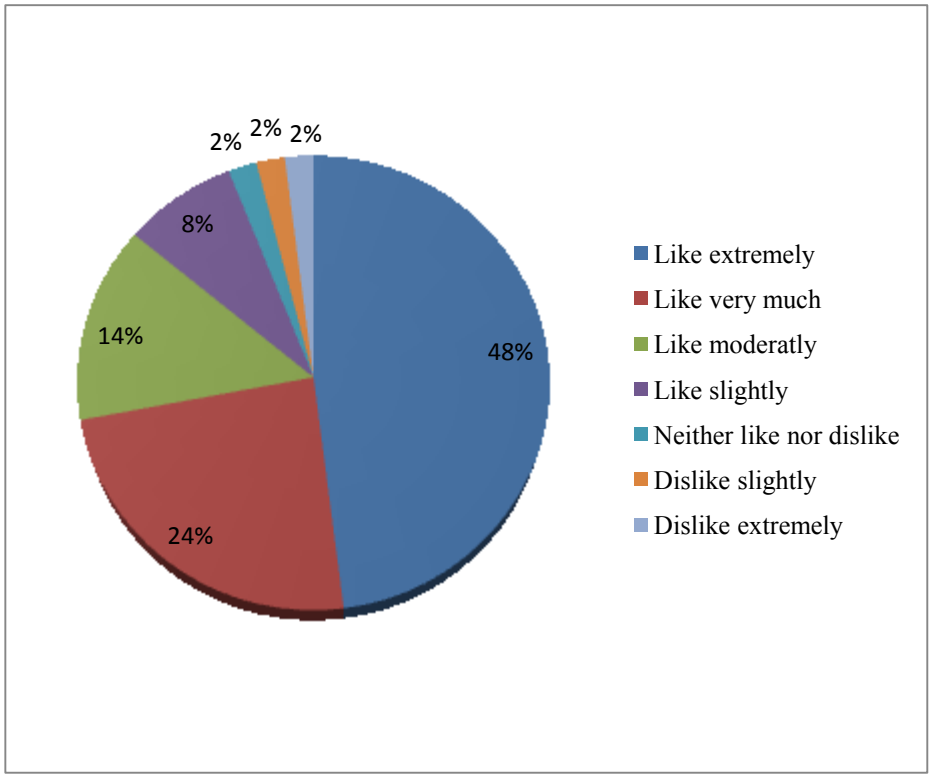


Fig. 21. Consumer acceptance study in children

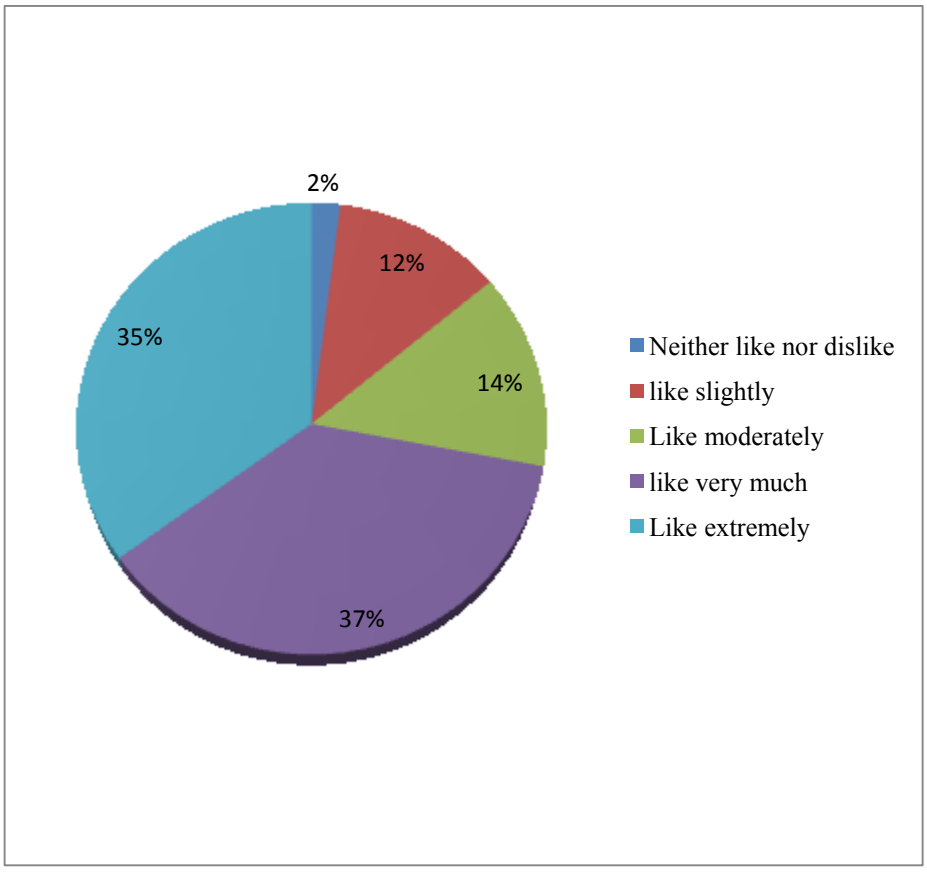


Fig. 22. Consumer acceptance study in adolescents

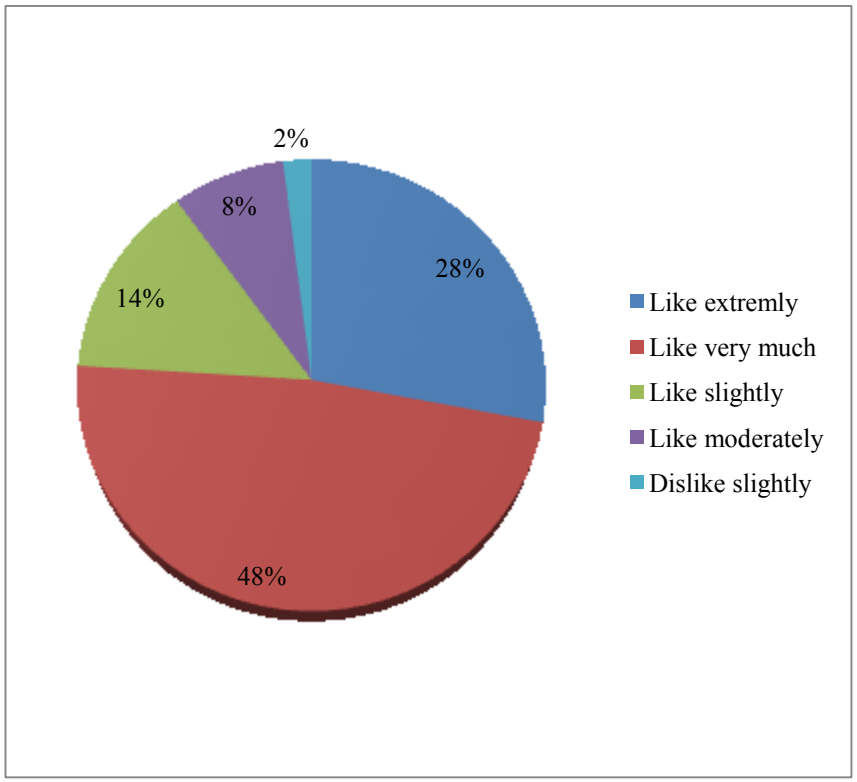


Fig. 23. Consumer acceptance study in adults

PART II

5.2. DEVELOPMENT OF PASTA PRODUCT

Pasta is a popular food because of its ease of preparation, sensory appeal, low cost and storage stability (Martinez *et al.,* 2007). Jessi (2005) reported that the nutritional quality of pasta can be improved by incorporating fruits, vegetables, meat, fish, and egg to the pasta dough.

5.2.1. Selection of Ingredients for the Development of Pasta

Jack fruit (CV Koozha), papaya (Pusa Dwarf), banana (Nendran), green gram, tapioca and wheat were the ingredients selected for pasta development. Jackfruit, is a seasonal fruit, has been reported to contain antioxidant. Samata (2007) reported that as the Koozha variety jackfruit is being wasted it could be utilized and processed to develop various value added convenient food products.

Papaya works magic on strengthening the immune system preventing the recurrent colds and flu. Papain the proteolytic enzyme in papaya, attacks intestinal parasites and causes parasite to die (Ayoola, 2010). But survey reports indicate that many people show reluctance to consume whole papaya because of its flavor. Chavez (2011) proposed that value added convenient product development using papaya is the right resolution for this problem.

Loganayaki (2010) opined that bananas are great as snacks, when combined with peanut butter, yogurt, and dark chocolate for a more creative treat. Along with the nutritional quality bananas have long been recognized for their antacid effects that protect against stomach ulcers and ulcer damage (Jahan, 2010).

Green gram has both medical and nutritional properties. The epidemiological evidence indicated that the consumption of dietary antioxidant such as green gram proteins provide protective effects for several chronic diseases (Petchiammal and Hopper, 2014). Consumption of whole green gram in daily diet is less. Lakhanpaul *et al.* (2000) stated that transforming whole green gram to a range of convenient food products can enable progress in intake.

Wheat is the basic component preferred for making pasta. Extrusion quality as well as nutritional quality can be enhanced in wheat pasta. Partial

substitution of wheat in the ready to eat food can be undertaken in order to improve the nutritional value of the product (Klava, 2004).

Liang *et al.* (2002) proposed that cassava is an important starch-rich crop grown in many parts of the world that contributes to economic development and food security, most especially in low income food deficient countries. Meanwhile, it is obvious that cassava as a crop is not popular for the production of extruded foods. Characteristics of cassava starch is good for extrusion process thus new products development/formulation using cassava starch can be done in developing countries (Patil *et al.,* 2007).

5.2.2. Processing of Ingredients for the Development of Pasta

The fruits (Jack fruit, papaya and banana) were processed to pulp using a fruit pulper whereas other ingredients (tapioca, wheat and green gram) were processed to flours in flour mill**.**

5.2.3. Formulation of Pasta Product

The processed items were further utilized for pasta manufacturing using the machine Dolly Mini. In this study,total nineteen proportions of pastas were developed in which 5 proportions of each jackfruit pulp, papaya pulp, banana pulp incorporated pasta and 4 proportions of mixed fruit pasta(Jackfruit pulp + Papaya pulp + Banana pulp). In each proportion the quantity of fruit pulp and wheat flour varied from 200 g to 600 g while the quantity of green gram and tapioca were kept constant (100 g).

5.2.4. Selection of Best Proportion

From the nineteen proportions worked out the best extruded pastas were selected based on the high MFR (Mass Flow Rate) value and low blending time. Kulkarni (2008) opined that Mass Flow Rate (MFR) assessment in pasta is inevitable in a pasta production industry. Quality pasta can be produced with the help of MFR study.

Chatterji *et al.* (2009) stated that MFR study basically deals with two main variables they are quantity extruded and time taken for extrusion. Maximum extrusion of pasta through the die within minimum time is considered as the best extrusion behavior.

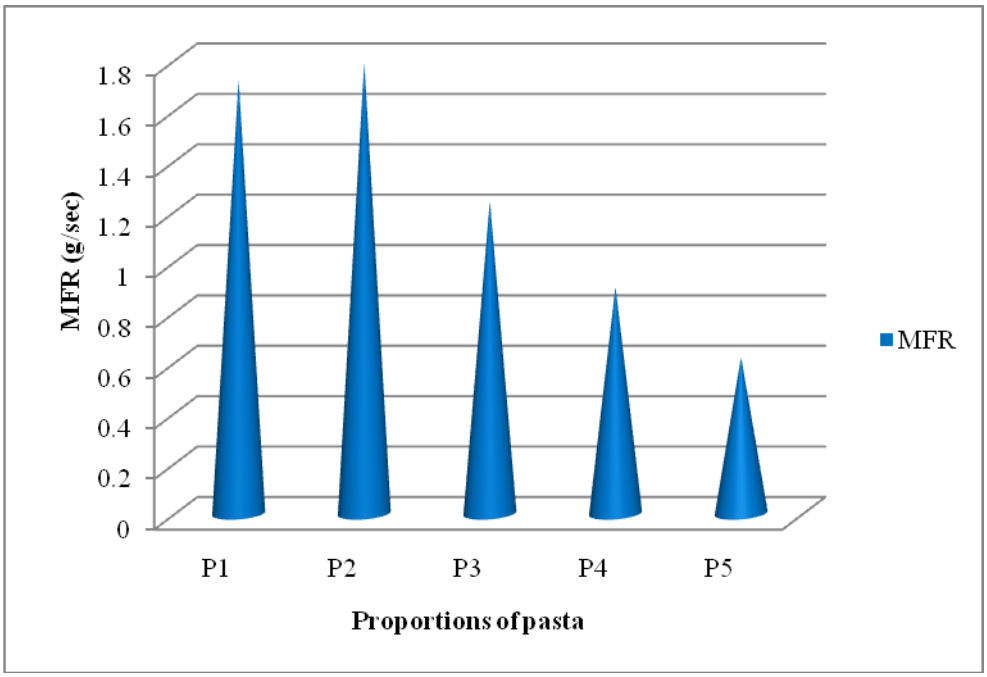


Fig. 24. Mass flow rate of banana pasta

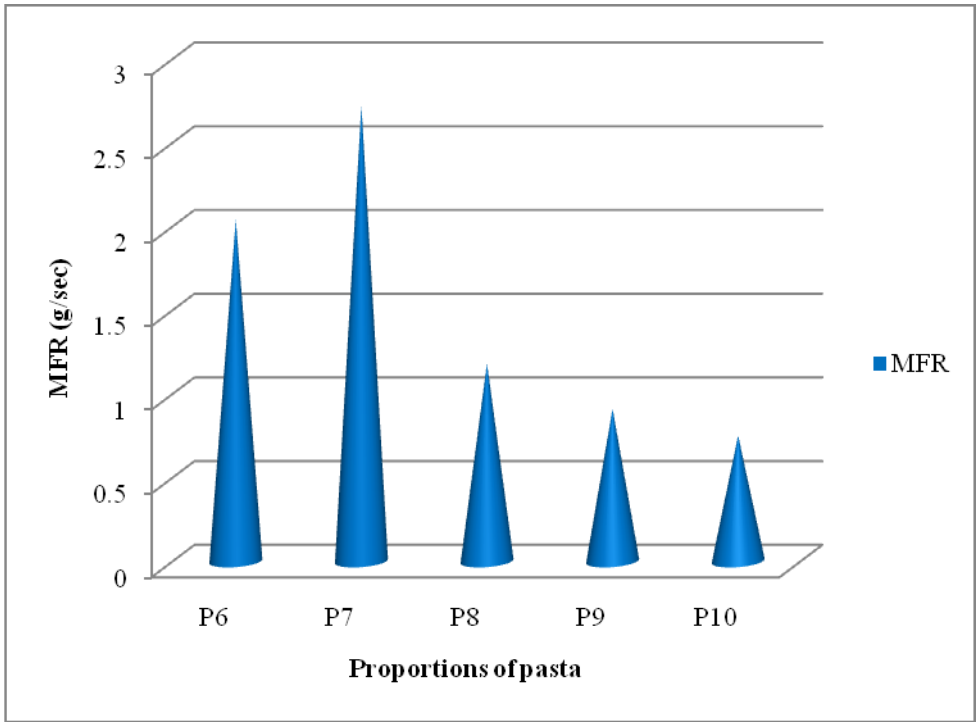


Fig. 25. Mass flow rate of papaya pasta

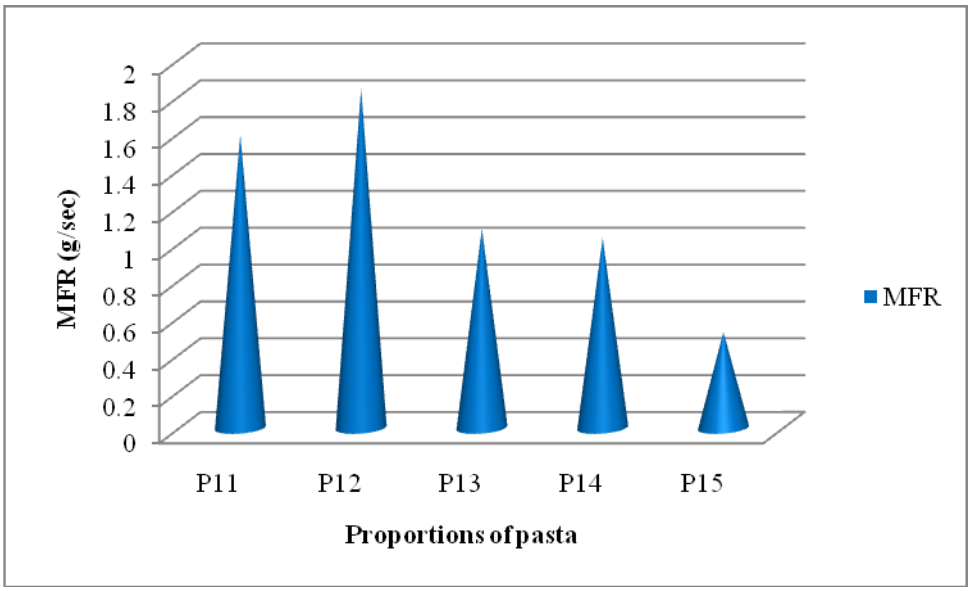


Fig. 26. Mass flow rate of jack fruit pasta

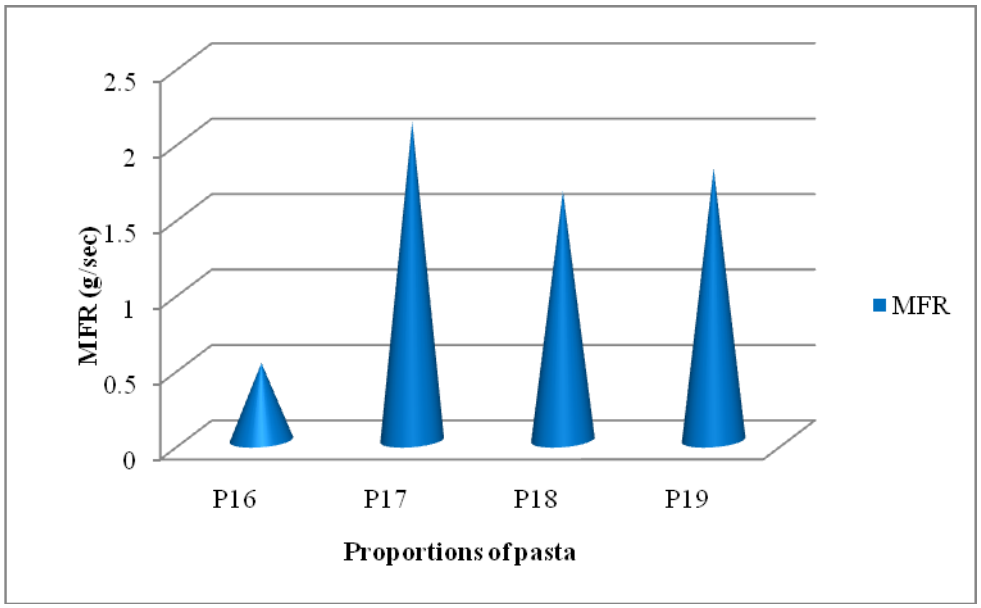


Fig. 27. Mass flow rate of mixed fruit pasta

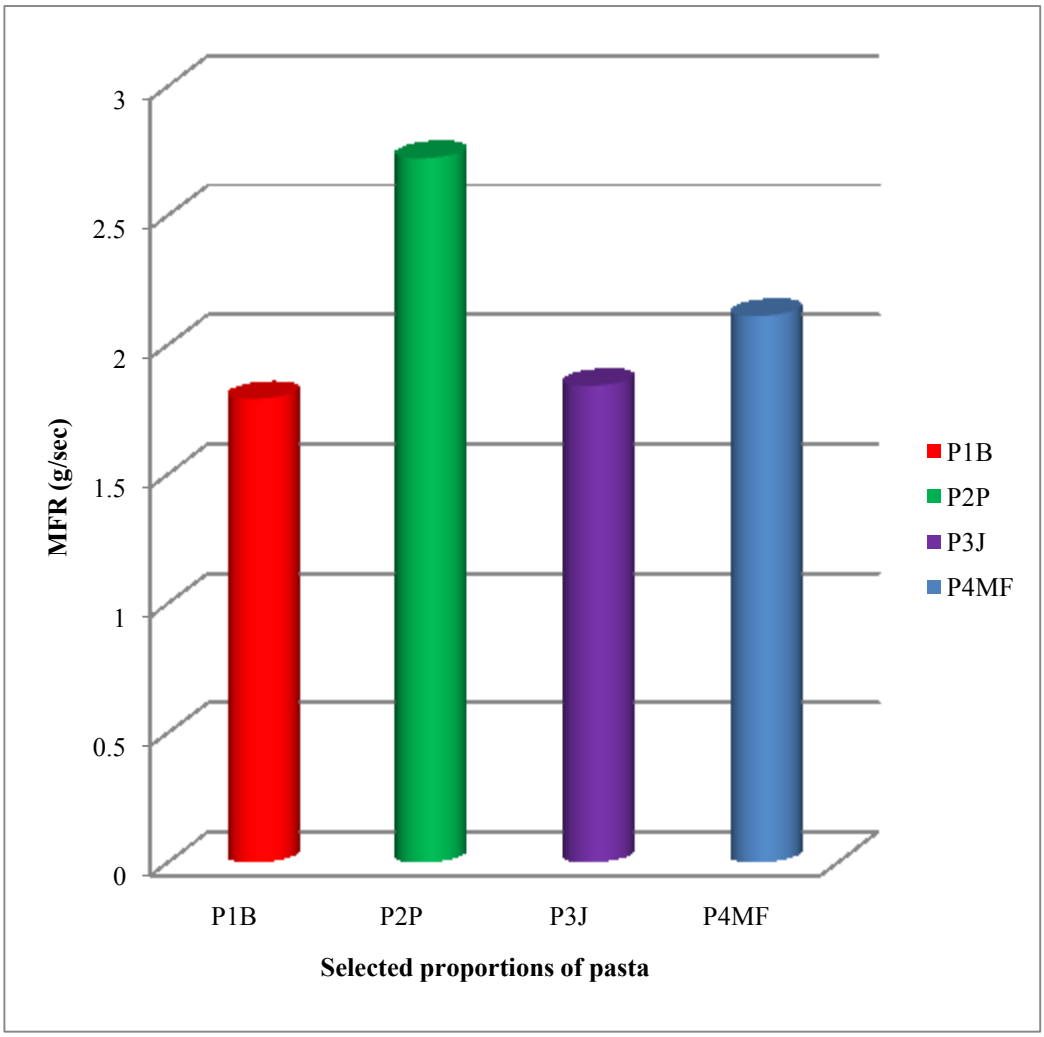


Fig. 28. Mass flow rate of selected proportions of pasta

According to international pasta standards the normal blending time for pasta is 10 - 12 minutes (Fabri *et al.,* 2007). Kris *et al.* (2009) opined that blending dough for pasta making is an inevitable feature in the pasta production point of view.

In this context, proportion number 2 (P1B), proportion number 7 (P2P), proportion number 12 (P3J), and proportion number 17 (P4MF) from banana pulp, papaya pulp, jack fruit pulp, from mixed fruit pulps respectively were selected as the best proportions of pasta. Among the selected pastas, P2P showed higher MFR value highlighting that papaya can extrude satisfactorily than the other selected fruits.

The developed pastas were shade dried for 24 to 48 hours. Oreal *et al.* (2011) proposed different methods of pasta drying techniques such as oven drying and freeze drying but among the various drying methods, slow drying by keeping in shade is the best method. Moreover, drying intensely also affect the textural integrity of pasta.

In normal ambient conditions dried pasta has a long shelf life without adding any preservatives or particular storage requirements (Taylor *et al.*, 2007).

In all the selected proportions of pasta, the quantity of fruit pulp was 300g and wheat flour was 500 g per Kg. Similar proportion of pasta was selected as the best extruded pasta in the study conducted by Alphia (2013) using finger millet incorporated pasta development. Hopper (2013) developed aloe vera gel incorporated pasta, were the quantity of aloe vera gel was 300 g/ Kg and of wheat 500 g/ Kg of pasta.

Hopper (2013) proposed that the quantity of other ingredients should not exceed 300 g per Kg while incorporating other ingredients instead of wheat flour in pasta processing. Fig 24 to Fig 28. represents the results of MFR study in the developed pastas.

5.2.5. Quality Evaluation of Pasta Product

Appealing qualities that pasta must have are a uniform, amber-yellow colour without shades of grey or red, a clean surface appearance without brown, black or white spots or other signs indicating faulty milling, when cooked, pasta

must not be glutinous on the surface i.e. stick together, but should have good ribbing and resistance to mastication; a pleasant aroma and taste typical to pasta, practically zero contamination from chemical pesticides and preservatives (Jeremy, 2009).

All these characteristics can be measured using instruments, standard procedures, organoleptic tests and constitute the basic requirements for a quality pasta. Pasta with ideal physical and sensory quality is characterized by cohesive and elastic dough, minimal cooking losses, no stickiness, and reasonable firmness after cooking (Howard *et al.,* 2011).

In order to assess the quality of developed pastas, functional characteristics, organoleptic characteristics, chemical and nutritional composition, shelf stability and consumer acceptance and preference studies were conducted.

5.2.5.1. Functional Characteristics of Pasta Product

In the study of functional characteristics, the developed pastas were compared with the control (commercially accepted pasta). Pasta with ideal physical and sensory quality is characterized by cohesive and elastic dough, minimal cooking losses, no stickiness, and reasonable firmness after cooking. On the basis of these pasta characteristics, to design new formulae it is necessary to assess the cooking properties of pasta.

Swelling Index (SI)

Swelling of pasta strands occurs during cooking due to water uptake by starch granules. As the quantity of wheat increases, the swelling index also increases (Manthey *et al.,* 2004).

In the current context, lower swelling index were observed for all the developed pastas compared with control. It is due to the less amount of wheat flour. The swelling index of control was 1.78., were as the range of swelling index of developed pastas were from 1.2-1.3.

The control sample was a wheat based product while partial substitution of wheat flour with fruit pulp and pulse flour was there in the developed pastas. According to Altan *et al*. (2008) wheat protein gluten has an excellent binding property which increases swelling power in pasta. As the wheat content decreases

the swelling strength also decreases. Thus it could be concluded that due to the presence of fruit pulps and gram flour the swelling power of the developed pasta decreased.

Swelling index of P2P was high compared to P1B, P3J and P4MF. P2P was the pasta made with papaya pulp. Papaya is an excellent fruit which can be processed in to various forms.

Abdoulaye *et al.* (2012) developed papaya and sapota incorporated extruded breakfast bar and opined that papaya was quiet suitable for making extruded products, therefore it can be utilized for value added pasta and noodles making. High fiber content in jackfruit and banana restricts the swelling or water uptake (Sudha and Vetrimani 2007), hence the developed P2P had high swelling index.

Cooking Loss per cent

Kein *et al.* (2009) proposed that cooking loss is the amount of dry matter lost into the cooking water of optimally cooked pasta. Lack of compact texture results in elevated cooking loss per cent.

In this study, cooking loss per cent of control pasta was less when compared to developed fruit incorporated pastas. Among the developed pastas P2P obtained with less cooking loss per cent. Hopper (2013) also observed high cooking loss per cent in aloe vera gel incorporated pasta than that of ordinary pastas. Consequently the study stress out that substitution of wheat flour with other ingredients can elevate cooking loss. Silvia *et al.* (2013) opined that enzymes in papaya help in maintaining the textural integrity, hence P2P observed with less cooking loss compared to other pastas.

According to Silvia (2012) presence of fiber also plays an important role in maintaining textural integrity. All the developed pastas had fiber (>1%) content while control sample (< 1%) had not. Thus it could be concluded that because of the fiber content present in fruit pulp incorporated pastas resulted in high cooking loss per cent.

Cooking time

According to international standards of pasta the average cooking time for ordinary wheat pasta is 11-15 minutes. Cooking time was observed high for P3J (12.5 minutes) followed by P1B (11.5 minutes), P2P (11 minutes) and P4 MF (10.75 minutes).

The cooking time observed for control was 11 minutes. Anyway all the developed pastas had the average range of cooking time as that of ordinary pasta made from durum wheat. Cooking experiment conducted by Pszczola (2000) indicated that time required for cooking jack fruit was high compared to banana, mango and papaya. Consequently the pasta made with jackfruit pulp also showed more cooking time in minutes compared to pastas made with banana and papaya.

Water absorption Index (WAI)

WAI, an indicator of the ability of flour to absorb water, depends on the availability of hydrophilic groups which bind water molecules and on the gel-forming capacity of macromolecules. Nevertheless highest WAI denotes the excellent binding capacity of ingredients.

The study showed high water absorption index in control than that of developed four pastas. Granito (2003) observed wheat semolina replacement by other flours or ingredients implies a decrease in the gluten content, leading to poorer water absorption index.

Among the developed pastas P2P had higher water absorption index where as P3J had lesser water absorption index. Accordingly study confirms that P2P had excellent binding property than other three developed pastas.

Colour analysis

Whiteness index ‘L’ was noticeably high for P4MF compared with other three developed pastas. Considerably high ‘L’ value was obtained for commercial pasta, indicating the degree of white colour. The study highlight that commercially available pastas have whiter colour than the developed fruit pulp incorporated pastas.

The degree of redness index ‘a’ was less for commercial pasta. Presence of red color was high in developed pastas due to the partial substitution of wheat

flour with fruit pulp. As fruit pulps are rich in pigments, the developed pastas with fruit pulp also showed red color than that of control pasta.

Among the developed pastas, ‘a’ value was high for P2P, the papaya pulp incorporated pasta. Yellowness index was almost similar for all the developed and commercial pastas. The ‘b’ value was ranging from 20.38 to 23.36. ‘b’ value was high for P2P, signifying more yellow colour for the pasta. The yellow index of commercially available pasta was 22.97. The universally recognized colour of pasta is yellow (Dexter, 2004). Hence the study point out that all the developed pastas had universally accepted yellow colour.

Texture analysis

Texture properties of pasta are generally recognized as the most important parameter in evaluating its overall quality. In the present study, firmness or hardness test was conducted for the developed pastas and compared with the commercially available pasta (control).

The comparative study revealed that the hardness of control pasta was higher than that of developed fruit incorporated pastas. Hardness of pasta was determined by force applying to it till it breaks.

According to Donald *et al.* (2001) pectin depolymerization during fruit ripening has been shown to be largely due to pectinolytic enzymes, including polygalacturonases and pectinmethylesterases. Studies have shown that these enzymes are the primary determinants of softening, participates in texture changes during the late stages of ripening seems evident.

In pasta processing fully ripened fruits were selected, hence due to the presence of depolymerized pectin which directly influences the texture that made the developed pastas with less hard texture compared to control.

On the whole the functional characteristics study accentuate that among all selected pastas, P2P had the best characteristics. Functional characteristics of P2P were shown similar to that of control. Fig 29. To Fig 32. explains the functional characteristics study.

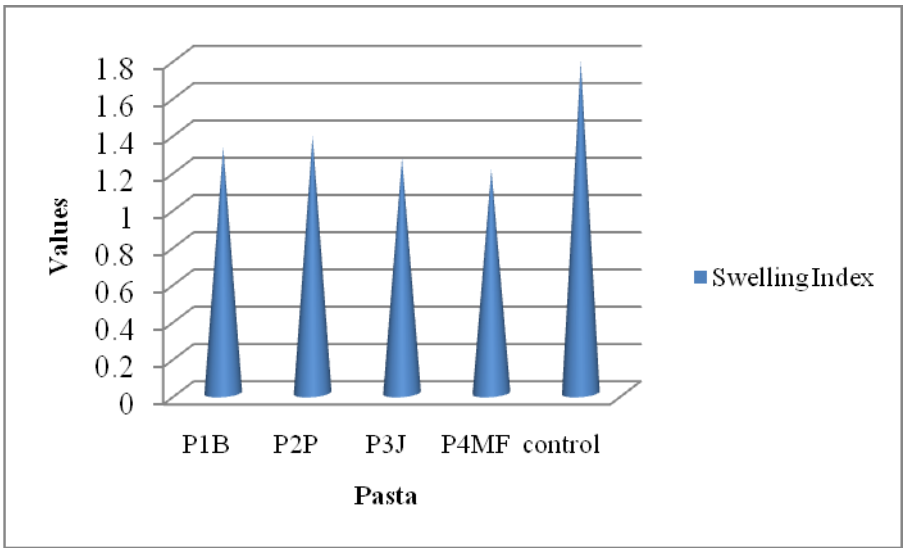


Fig. 29. Swelling Index of Pasta

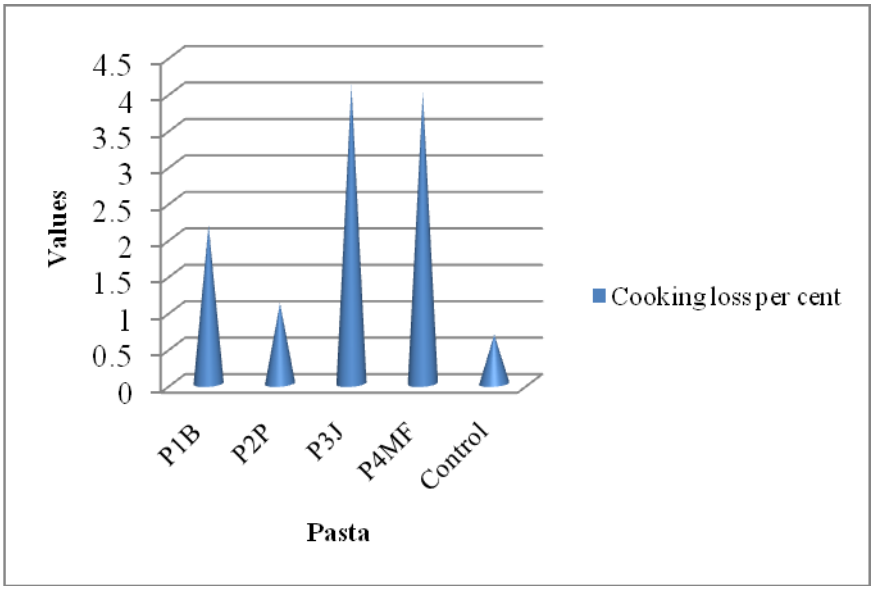


Fig. 30. Cooking loss per cent of Pasta

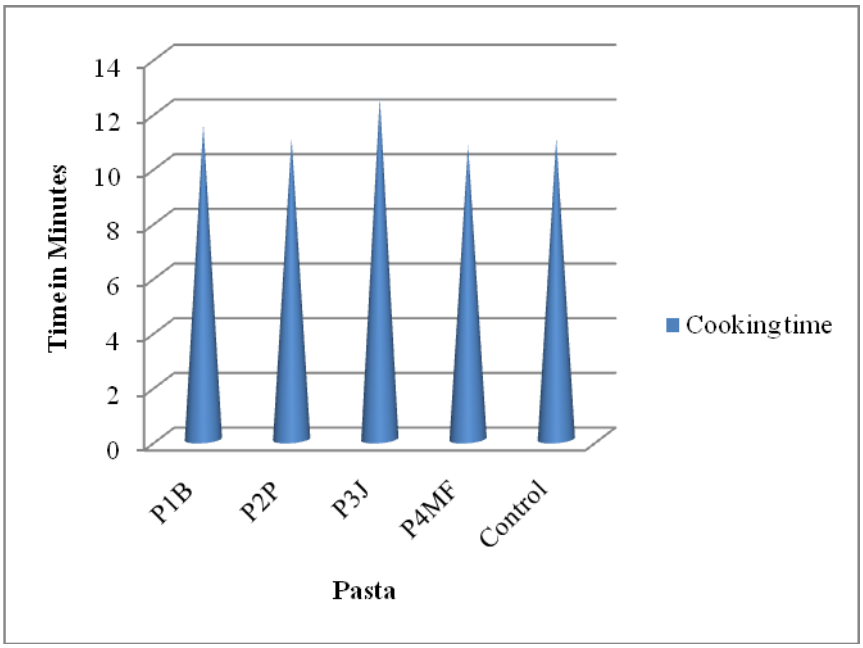


Fig. 31. Cooking time of Pasta

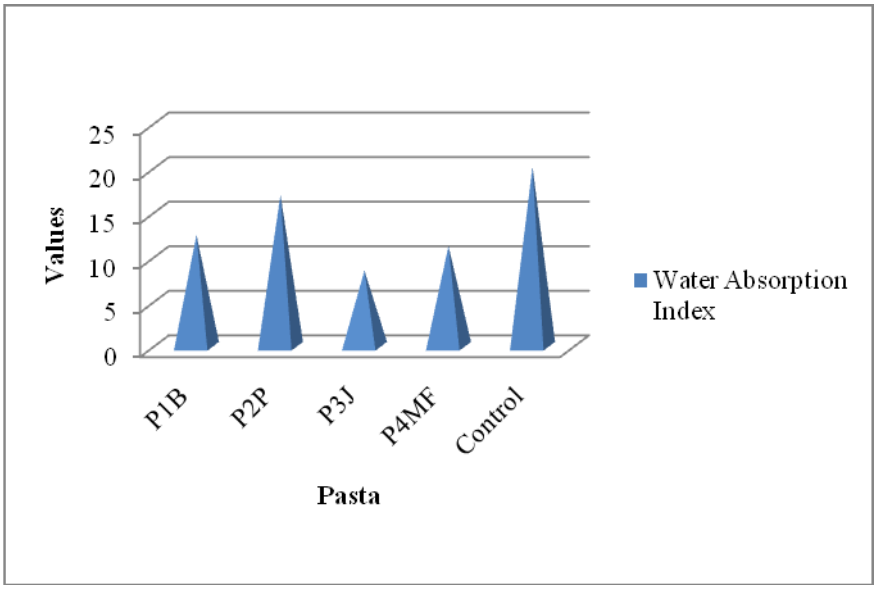


Fig. 32. Water Absorption Index of Pasta

5.2.5.2. Reconstitution and Sensory Evaluation of Pasta

Nowadays, scientists have developed sensory testing, as a formalized, structured and codified methodology, and they continue to develop new methods and refine existing ones. Sensory testing can establish the worth of a food or even its very acceptability. Cayot (2007) proposed main uses of sensory techniques are in quality control, product development, and research.

Angel (2007) opined that sensory evaluation of food is a growing science which is of particular interest in newly developed products.

In the current investigation selected proportions of pasta and control were reconstituted or cooked into recipes and conducted sensory evaluation by ten panel members using a score card. Spotless and pure appearance is preferred for cooked pasta.

Study came out with high scores for P1B pasta than control with respect to appearance. P1B, which was the pasta made using banana pulp. Similar result was reported by Helen *et al.* (2013). Substitution of banana flour significantly improved the appearance of complementary food prepared from maize. Zhang *et al.* (2005) reported that bananas maintain natural color and flavor with a firm texture even after processing. Addition of banana powder to toast bread formulation improved sensory properties (Sanaz *et al.,* 2012).

Consumers appreciate bright yellow color for pasta. A black spot or colour change in the pasta, make it an unacceptable product. In the present study the colour of developed pastas P1B and P2P were similar to that of control, the commercially accepted pasta. P3J was observed with low scores for colour parameter. Sambamurty and Ramalingam (2005) pointed out that due to the presence of high mineral content, dark colour in jackfruit products can be seen.

Texture is the primary attribute which comprises the sensory quality of pasta (Hashmi, 2009). Texture score of control pasta was high. Among the developed pastas high scores was shown by P2P, pasta made with papaya pulp. Thus the study indicates that P2P had high-quality texture as similar to that of commercially accepted pasta.

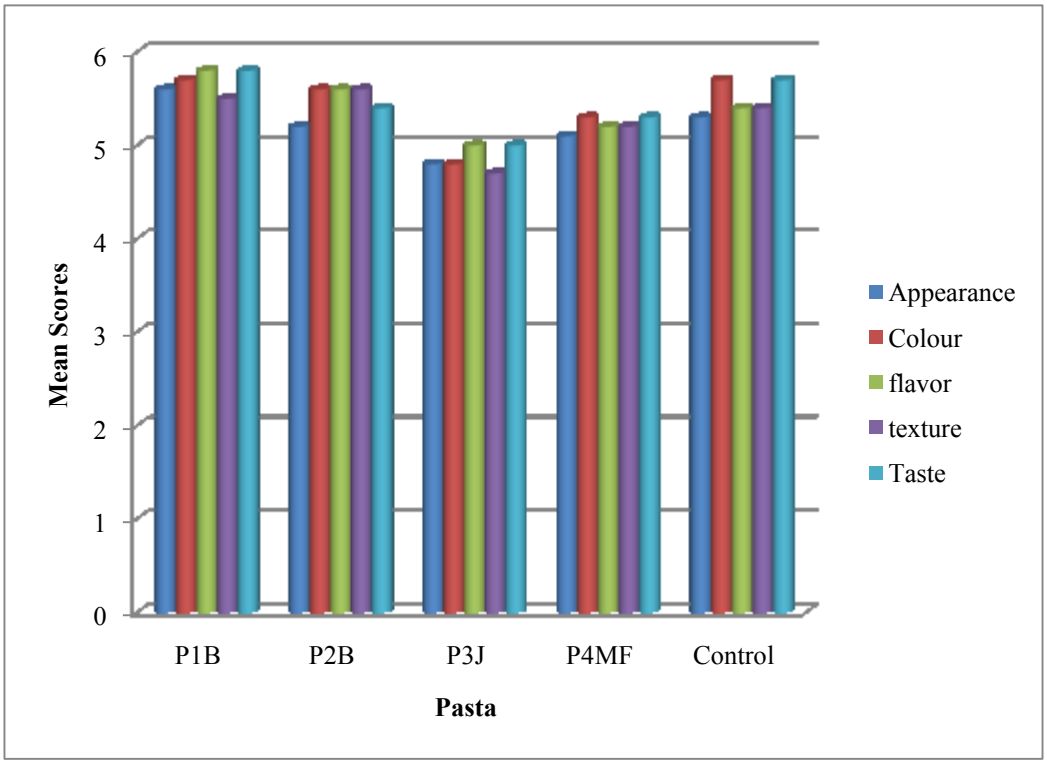


Fig. 33. Sensory scores of pasta

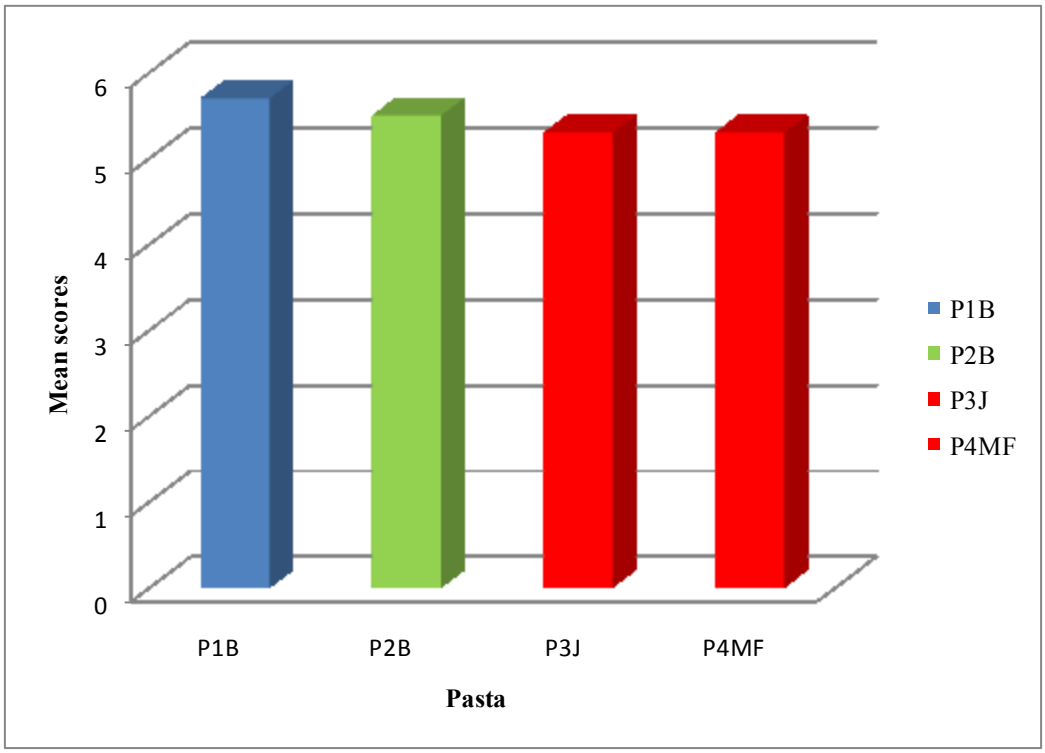


Fig. 34. Overall acceptability of developed pastas

Consumers are most influenced by flavor when it comes to liking a particular pasta or noodle. Among all the tested pastas, P1B was shown with highest score for flavor. Similar result was observed by Zainun (2008) in which flavor parameter of banana pulp incorporated bread was significantly high to that of ordinary commercial wheat bread. Taste is an important attribute. Taste studies indicated P1B as the finest pasta. Banana pulp will improve overall sensory quality of the product especially taste.

On the whole study indicated that, all the parameters were highly scored except for texture. P1B was the pasta that scored maximum than that of control (commercially accepted pasta). The study also expose that both P1B and P2P were equally good. Thus it could be concluded that all the developed four pastas were excellent with respect to sensory quality. Fig. 33. and Fig. 34. shows the sensory evaluation of pasta.

5.2.5.3. Nutritional Quality of Pasta Product

The processed and convenient foods, available today are more of transfat, salt, sugar and empty calories. Consumption of processed foods predisposes to various health problems. WHO and FAO strongly recommend food manufacturers to develop innovative nutrient rich convenient foods from natural resources (Astrup *et al.,* 2008).

Food manufacturers now recognize the importance of safe and healthy food (Rivera *et al.,* 2004). Hence nutritional and chemical assessment is an inevitable part of a new product development study. In the current investigation also nutritional and chemical compositions of the developed pastas were assessed using standard procedures.

Energy, carbohydrate, fat, calcium, iron sodium and potassium content of P1B pasta was notably high compared to other developed pastas. Protein content was high in P1B, approximately similar protein content was observed for all the other developed pastas hence no considerable difference was noticed. Beta carotene was found drastically high in P2P pasta.

The amount of calories in a food is a measure of how much potential energy that food possesses. Calories are the major as well as basic constituent in

food. Lowest energy value was observed for P2P, the pasta made from papaya pulp. Park *et al.* (2007) recommends banana as an instant energy supplier. Most of the power foods are developed by incorporating banana for improving energy content. Logan *et al.* (2005) stated that carbohydrates are all about energy and are mainly found in foods like fruits, breads, and pasta products. The carbohydrates and proteins are essential components of human food. Among fruits bananas are a good source of carbohydrates and proteins. Studies have suggested that consumption of bananas confer healthy fat (Rashmi and Jyothsna, 2011). The fat content of papaya and jackfruit is less. Therefore the pasta developed by incorporating papaya pulp and jackfruit pulp also showed less fat.

Nutritional and chemical composition studies stressed that banana is rich in minerals particularly potassium, iron, sodium and calcium. Daily intake of banana is recommended for adolescent girls in order to maintain optimum nutrition (Leterme *et al.,* 2006). Emaga *et al.* (2006) opined that intake of one banana per day will provide all vital nutrients. Banana is also enriched with minerals like potassium, phosphorus, magnesium and calcium. The study revealed that the nutritional quality of banana directly influenced the nutritional quality of banana pulp incorporated pasta (P1B). Beta carotene is an important nutrient which is abundant in papaya. Hence P2P and also P4MF, papaya pulp incorporated pastas had highest beta carotene content. Comparatively papaya contains less calorie, fat and carbohydrate content, as a result the study highlight that the people who going for low calorie diet P2P pasta is suitable where as in case of normal diet all the other developed pastas are appropriate.

5.2.5.4. Chemical Composition of Pasta Product

The quality of many foods depends on the concentration and type of chemicals they contain, including their taste, appearance, texture and stability. So evaluation of chemical composition is essential. Chemical components such as moisture, poly phenols, peroxide, fiber and total minerals were assessed for the developed pastas.

All the analyzed chemical constituents were found high in P3J pasta, the pasta made with jack fruit. The edible bulbs of ripe jackfruit are rich in minerals

and fiber. According to the study conducted by Sissons (2008) in pasta, stated that the chemical composition of pasta is directly influenced by the raw materials selected and quantity used for its preparation. Roy *et al.* (2012) opined that ripened jack fruit bulb is rich in moisture.

Since the moisture content of ripened jackfruit is high, the developed pasta also possessed high moisture content. High mineral contents are observed for jack fruit. It is often important to know the mineral content of foods during processing because this affects the physicochemical properties of foods. Sambamurthy and Ramalingam (2005) stated that jack fruit is rich in total minerals. Thus the developed pasta (P3J) also provided more total minerals than the other developed pastas.

Roy *et al.* (2012) opined that highest peroxide content was observed for value added papad produced from jack fruit. Similarly, the developed pasta (P3J) also showed high peroxide value compared to other pastas. Dainy *et al.* (2007) stated that polyphenols are widely distributed in plant foods, and have been linked to improved human health through reduced risk of chronic diseases. Thus estimation of polyphenols is indispensable in processed foods. Jack fruit is a rich source of polyphenols as a result the developed pasta (P3J) also showed high poly phenol content. A high fiber in the diet has many health benefits. The cookies developed by incorporating jackfruit had higher fiber content than the ordinary cookies (Roy *et al.,* 2012). In this study also similar result was obtained.

In general nutritional and chemical composition study confers that presence of analyzed chemical constituents were higher in P3J pasta but observed less in other pastas being P1B, P2P and P4MF. With respect to nutritional quality, P1B showed higher nutrients except for beta carotene. Even though all the fruit pulps were present in P4MF, the quantity of each fruit pulp was less. Hence P4MF showed less nutrient and chemical constituent contents in this study.

5.2.5.5. Comparitive Study of Nutrients with Control Pasta

A comparative study of developed pastas and the commercially available or accepted pasta (control) was conducted with respect to certain nutrients such as energy, protein, fat, carbohydrate and fiber.

Browni (2006) reported that a hundred gram of wheat based pasta delivers 360 K cal of energy on an average. In present investigation, developed pastas showed a higher energy content than that of control pasta except P2P (338 K cal), pasta made with papaya pulp. Significant difference was noticed with respect to protein examination. Wheat protein is an excellent protein. Presences of protein in fruits are very meager. Bothwell *et al.* (2002) stated that cookies developed by incorporating 30 per cent strawberry showed less protein content compared to ordinary wheat based cookies. Correspondingly, the developed pastas were obtained with lesser protein content than that of control (9. 90 g). However, pasta is not recognized as a balanced product due to its poor biological value of proteins and the low content of dietary fiber. (Dewettinck *et al.,* 2008). Despite the fact that the developed products had less protein compared to control, the biological value of protein was assumed to be of high due to the presence of cereal pulse combination (wheat and green gram).

Fat was observed high in control pasta (2.30 g). Frost *et al.* (2003) opined that ordinary pasta available in the market have high fat content, thus value added pasta with less fat content should be developed. The developed pastas in this study were less in fat content than the commercially available pasta. Integration of fruits and vegetables in pasta dough can reduce the fat content of ordinary pasta (Jones, 2006).

Mehta (2011) opined that ordinary wheat pasta is a rich source of carbohydrate, which may not suit for low GI diet consequently low carb pasta, may help in such situation. Partial substitution of cereal flour with fruit and vegetable pulps will lower the total carbohydrate content of pasta. Accordingly, in the present study the pastas developed by incorporating fruit pulps had less carbohydrate level than control.

According to BeMiller and Whistler (2009) high fiber content in pasta is inversely proportional to the pasta quality retention. Ordinary pasta made out of wheat alone had a fiber content of less than 1%. In the current investigation also fiber content was seen less in control, where as fiber content was high in all developed fruit incorporated pastas.

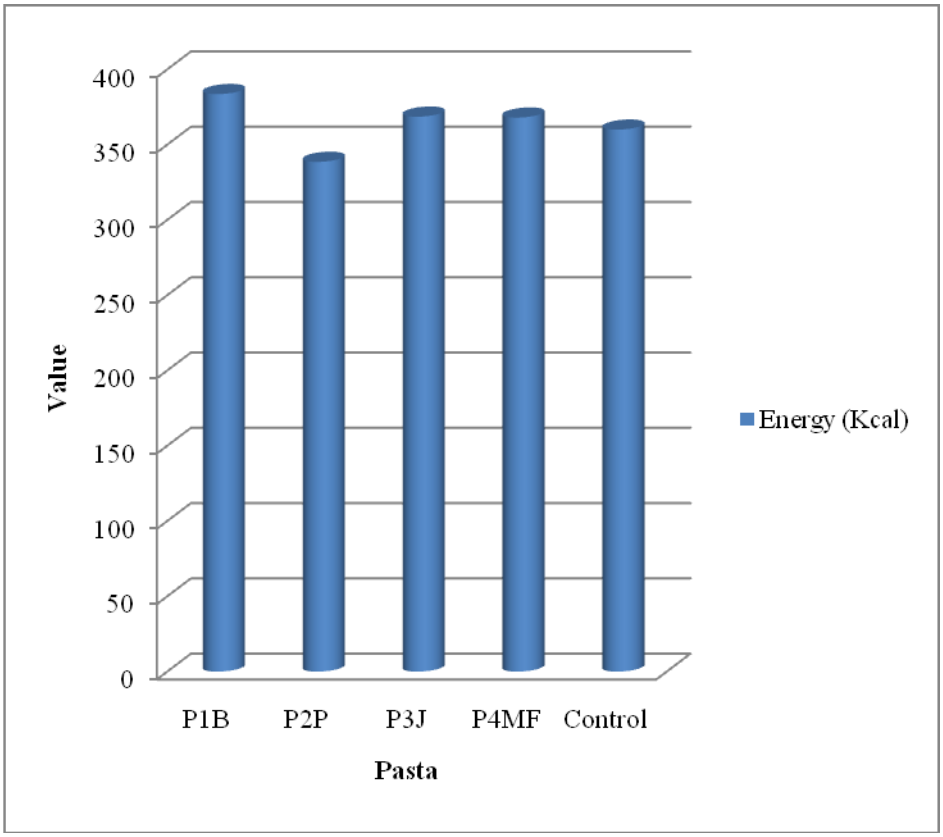


Fig. 35. Energy content of pasta

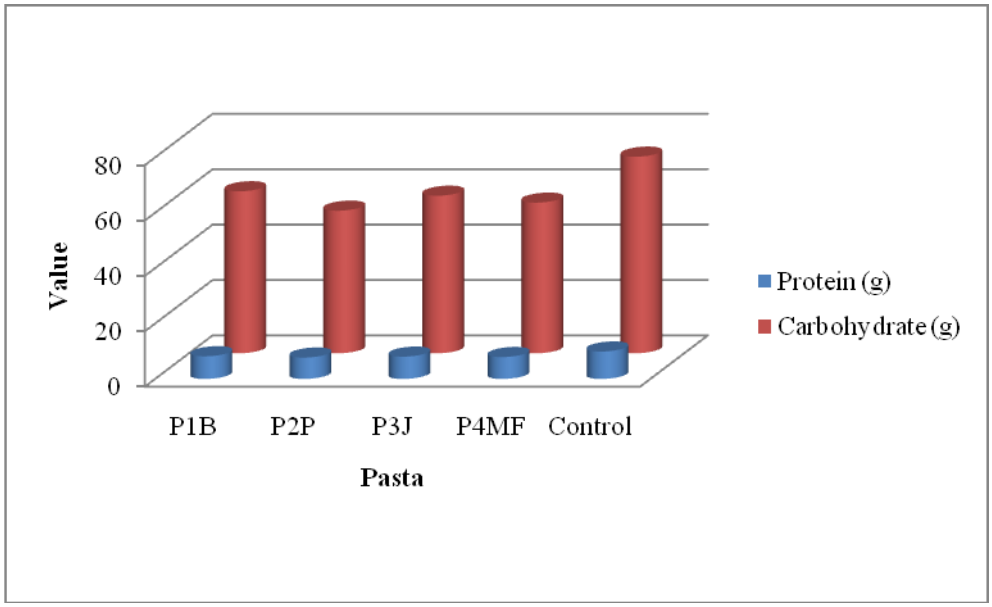


Fig. 36. Protein and carbohydrate content of pasta

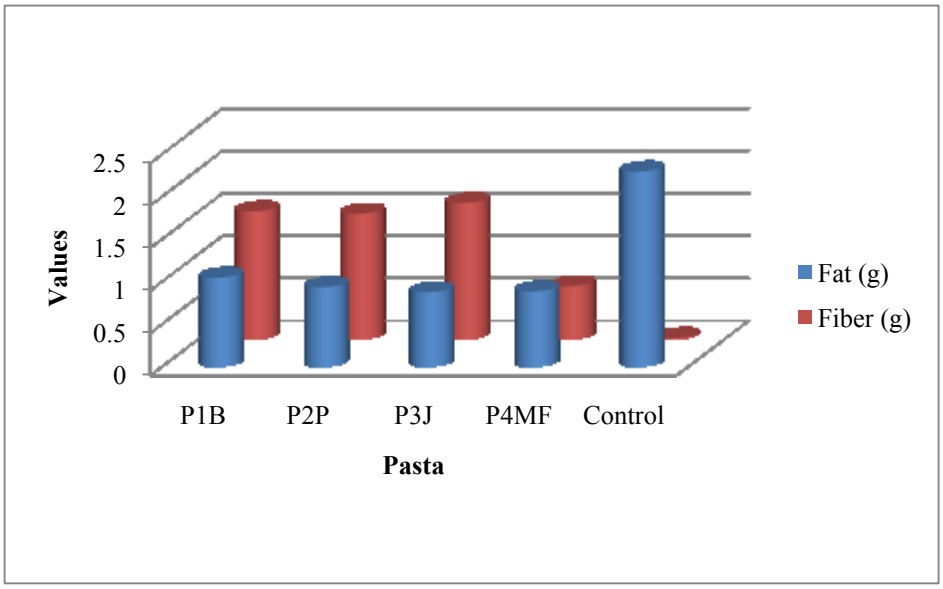


Fig. 37. Fat and Fiber content of pasta

On the whole, the study reveals that energy and fiber content were seen higher in developed pastas where as protein, fat, and carbohydrates were more in ordinary control pasta. Fig. 35. to Fig. 37. represents the nutritional comparison study of pasta.

5.2.6. Shelf Stability of Stored Pasta

Shelf life is the period between the manufacture and the retail purchase of a food product, during which time the product is of satisfactory quality in terms of nutritional value, flavor, texture, and appearance.

Shelf life must be determined for each product by the processor. Storage studies are an indispensable element of food product development, with the processor attempting to provide the longest shelf life practicable consistent with economics and distribution. Inadequate shelf life will lead to consumer dissatisfaction and complaints, and eventually adversely affect the acceptance and sales of branded products (Robertson, 2003). In this study also shelf stability of developed pastas stored in laminated pouches were assessed for successive three months. The product was analyzed for its sensory quality parameters, chemical composition changes and also microbial content at an interval of one month.

5.2.6.1. Organoleptic Quality of Stored Pasta

Martin, (2006) stated that sensory evaluation is a conscious effort to identify and judge different sensations and components in an object, be it a piece of food, a beverage, or a perfume. Sensory evaluation encompasses all of the senses and takes into account several different disciplines but emphasizes the individual's perception. Sensory study involves the measurement and evaluation of sensory properties of food and other materials (Lengard, 2006). Human judges are used to measure the flavor or sensory characteristics of food. In short, sensory evaluation is a very organized holistic approach to product assessment.

In the present study, organoleptic assessment was done for three consecutive months of stored pasta. Each month the product was reconstituted to recipes and presented uniformly to judges. Rive *et al.* (2000) stated organoleptic characters of ordinary pasta available in the market do not change during storage. The keeping quality of commercial pasta is about more than one year even

without any added preservatives or storage conditions. But organoleptic scores for all the developed pastas were diminishing at a less significant level during the period of storage.

The results revealed that sensory scores for colour for P1B and P2P pastas were similar, whereas similar diminishing scores were observed for P3J and P4MF. At the same time significant differences were noticed between P1B and P2P with P3J and P4MF. Khan *et al.* (2007) reported that pasta need to be plain yellow or cream colored. However the ingredients used in pasta production have a significant role in determining pasta colour. Anyway, the mean scores obtained for colour were of acceptable range from 5.3 to 5.7.

Studies reported that storing pasta for long period severely reduces the sensory qualities of the product, mainly because of starch retrogradation (Fardet *et al.,* 2008). Good appearance for the food product is preferred by the people. According to the survey conducted by Lione *et al.* (2007) the appearance of a food product is high; the choice for that food among the consumers is also high. George (2004) proposed that the appearance of stored food products can be altered and the alteration may occur due to the influence of various factors.

Anyway in the present study significant difference in appearance scores were noticed. The pasta P3J (5.5) showed minimum score for appearance. Even though there was a trend in reduction of appearance scores, all the developed pastas were acceptable. The texture of pasta must be strong and it should be slight rubbery in nature while chewing. Kein and Pagani (2009) reported that if texture of pasta is not maintained up to the standard, then the quality of pasta is plagued. During the shelf life study for three months, the texture scores of the developed pastas were decreasing at lower rate. High score for texture was obtained by P2P (5.7). Lowest score was for P4MF (5.1). Anyway the texture scores ranged from 5.1 to 5.7, thus emphasizing that scores for texture of developed pastas were acceptable. In a new product formulation research, determination of flavor and aroma of the food is quiet important especially during storage. According to the survey conducted by Stiles (2009) 76.45 per cent consumers decide on food based on its flavor. Hence assessment of flavor in the developed pasta products is

indispensable**.** Flavor and aroma changes may occur in stored processed foods that lead to poor consumer perception. Thus flavor assessment helps in adopting right prevention method to delay the changes.

In the present study scores for flavor was decreasing in each month at a less significant level. Considerable difference was observed between the flavor scores of pastas P1B (5.7) and P2P (5.6) with the pastas P3J (5.4) and P4MF (5.4). Lowest score was shown by P3J and P4MF. Change in taste was observed in processed foods when it was stored (Wein *et al.,* 2007). Girge *et al.* (2009) opined that as far as a food is concerned taste is an imperative parameter that consumers used to judge the quality of food.

As the quality of food changes the taste is also get changed. The scores for taste were reducing in each month of storage at a significant level. But P1B pasta had highest score for taste 5.9 out of 6, which was the maximum score. Although a decreasing trend in scores were noticed all the developed pastas in the study were acceptable. All the developed pastas obtained scores above 5 out of 6.

The storage study conducted by Wu *et al.* (2001) on fortified pasta with fish protein also showed diminishing sensory scores during the period of 6 months storage study. Wang *et al.* (2009) also showed reducing trend in overall scores for sensory parameters of pasta developed by incorporating 40 per cent buckwheat flour and legume flour during the shelf life period of 6 months. Similarly the study also put emphasis on substitution of wheat flour with other ingredient may reduce the sensory acceptance during storage. Such products can be catered as fresh pasta. Fig 38. to Fig 43. shows the sensory study of stored pasta products.

On the whole, the sensory study of developed pastas during the storage period showed that there were decreasing trend in scores for all the sensory parameters. But the scores obtained for pastas were in a range between 5-5.9 out of 6. The study also revealed that all the pastas, P1B, P2P, P3J and P4MF were equally good. On close observation, all the sensory scores were high for P1B. Fig. 39 to 43 describes the organoleptic study of stored pasta.

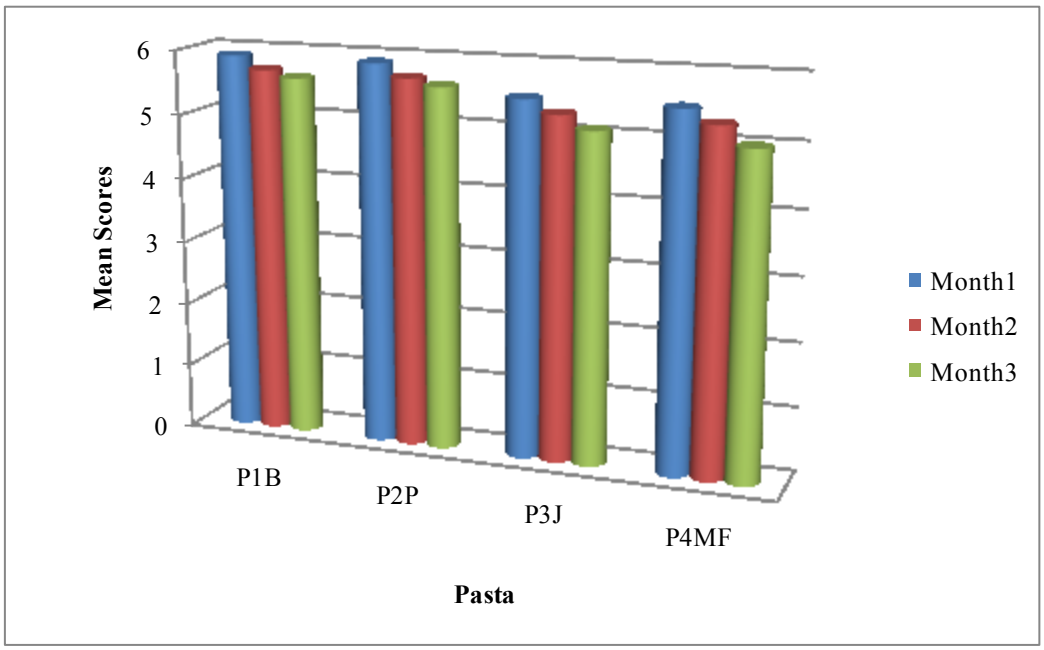


Fig. 38. Colour score of stored pasta

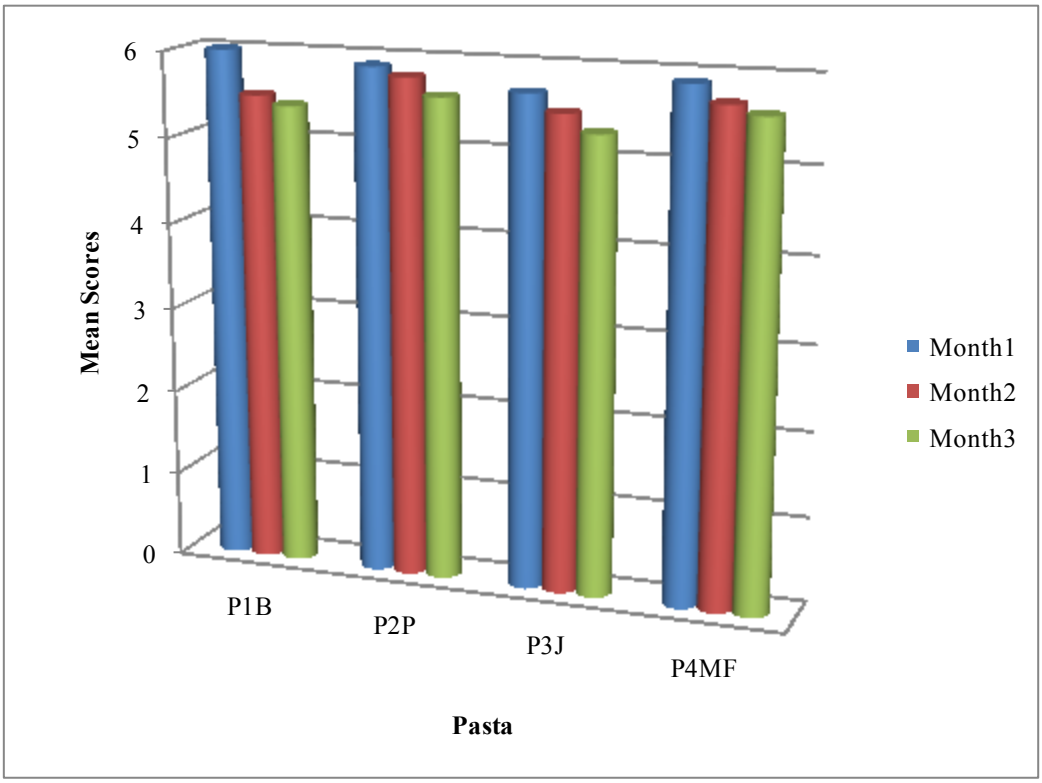


Fig. 39. Appearance score of stored pasta

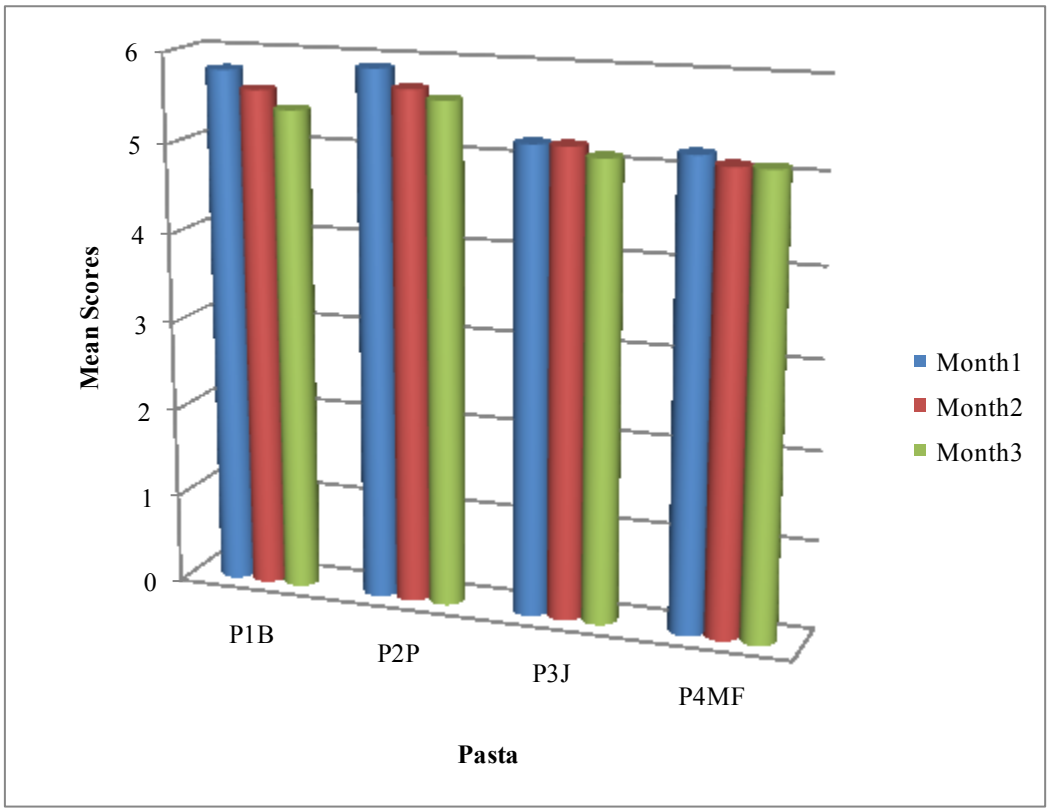


Fig. 40. Texture score of stored pasta

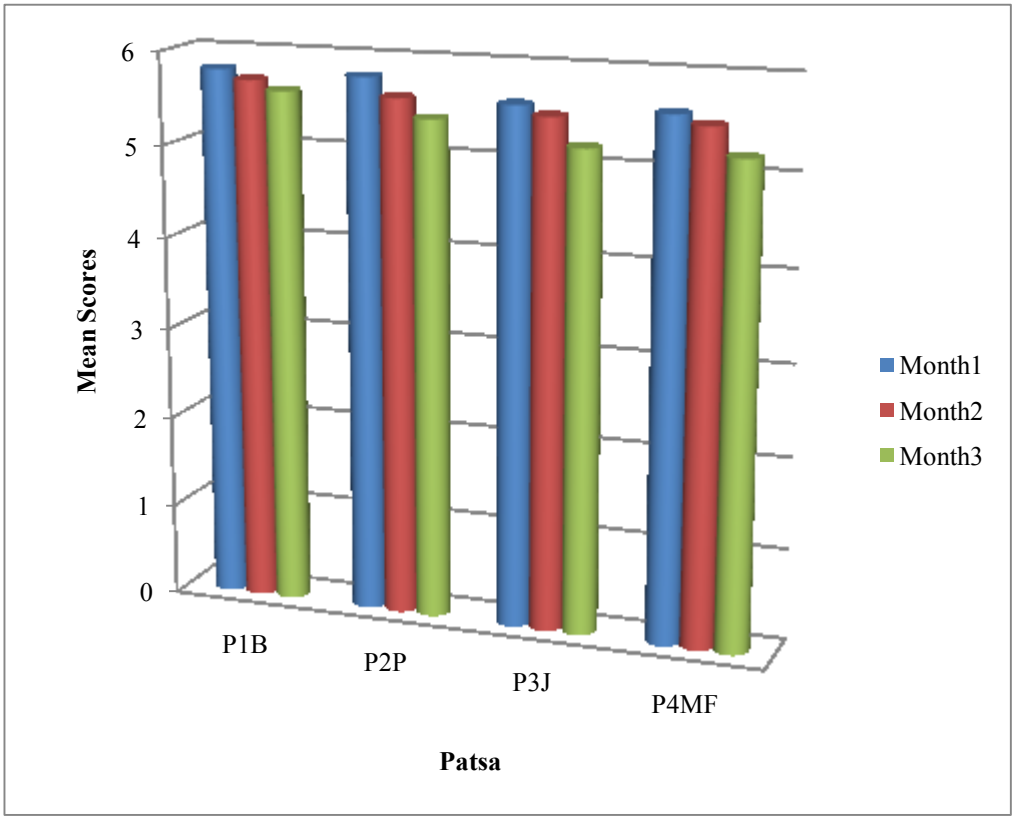


Fig. 41. Flavor score of stored pasta

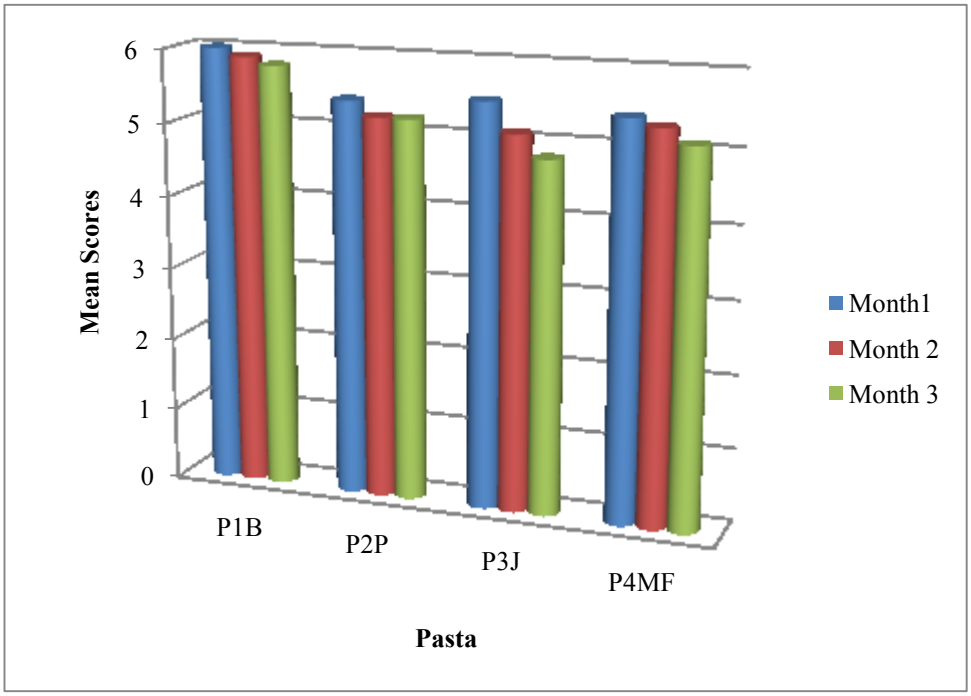


Fig. 42. Taste of stored pasta

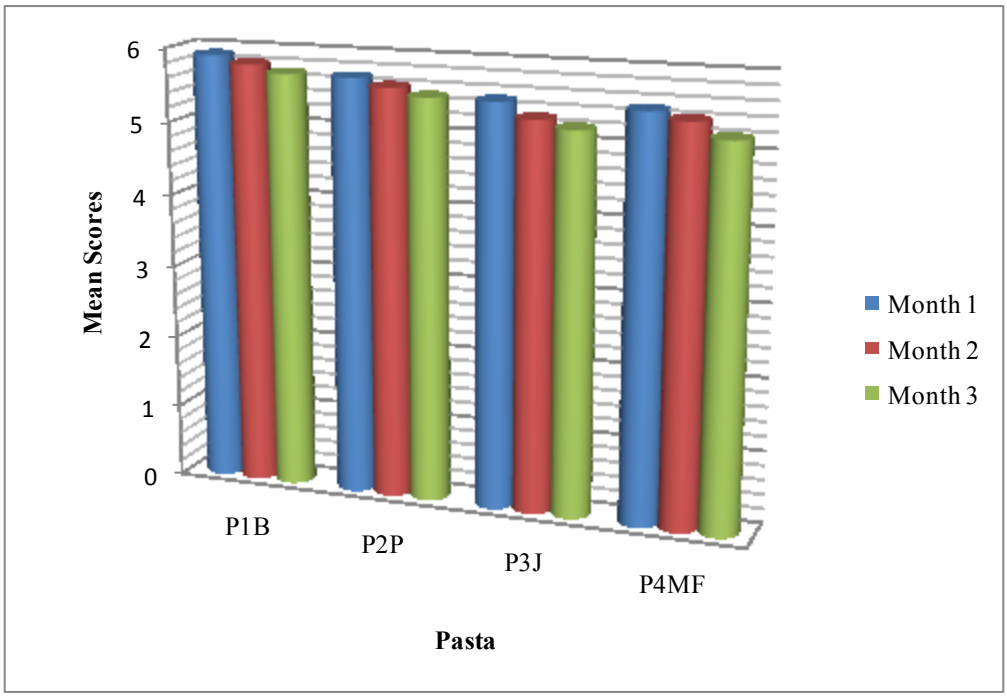


Fig. 43. Overall acceptability of stored pasta

5.2.6.1. Chemical Composition of Stored Pasta

Mike *et al.* (2009) proposed that change in chemical constitution may occur to food products during storage. Chemical composition of a food directly influences the quality judgments. For this reason assessment of chemical composition of stored food products is unavoidable from this study.

The chemical constituents being moisture, peroxide, polyphenols and total minerals were examined in stored pastas. The duration of the study was conducted for three consecutive months and each month sample was investigated.

Measurement of moisture content in food is very important with respect to shelf stability aspect. According to Derek (2009) as the moisture content in food increases there is more chance for spoilage by microorganisms. In the current investigation all the pastas P1B, P2P, P3J and P4MF showed no significant change with respect to moisture content.

Peroxidation of the lipids in fresh and processed foods is one of the main causes of food deterioration, reduced stability, and formation of off-flavors that negatively affect quality and storage life of food product and its consumer acceptance. Insignificant change was observed in peroxide analysis of pastas P1B, P2P, P3J and P4MF during the storage period.

Brutos *et al*. (2004) stated that phenolic compounds in processed foods can vary during storage period hence determination of total phenols of stored products is vital. Considerable difference in polyphenol content was not observed all for the developed pastas.

According to Vasudevan *et al.* (2007) total minerals content must be labeled in food package. In such situation, mineral estimation must be done for processed foods. Scott (2009) opined that there is chance for loss in minerals in packaged foods. Even though a decreasing trend in mineral content was observed there was no significant change in all the developed pastas, P1B, P2P, P3J and P4MF.

In general, the study pointed out that there was no significant change in any of the chemical constituent during the storage period of all pastas (P1B, P2P,

P3J and P4MF). Thus, it could be concluded that the developed pasta products were shelf stable up to three months.

5.2.6.3. Microbial Study of Stored Pasta Product

Simpson (2006) suggested processed foods and other food materials provide ample scope for contamination with spoilage organism, thus necessitating microbial quality assessment as an integral part of processing. According to Smith *et al.* (2005) several factors such as raw materials quality, storage temperature, storage containers, and process employed and the environment in which it is processed will have an effect on the microbial quality of the processed foods.

Serious health problems are arising all over the world due to the consumption of foods contaminated with pathogens or microbiologically spoilt foods (Reghuramaih, 2001). Spoilage causing micro organisms is responsible for the development of an off flavor and off taste that leads to economic loss (Rao, 1998).

Keeping quality of the product very much depends upon the microbial contamination. Initially, no microbial count was seenl in any of the developed pastas. However at the third month of storage study and fifth day of observation after plating, fungus and yeast growth were noticed in all the pastas.

In P3J and P4MF pastas, the growth of microflora was observed during the second month of storage analysis. The count was observed high in P4MF (3.96×10^{-3}cfu /g). Therefore study pointed out that pasta P3J and P4MF were more vulnerable for microbial growth and spoilage where as P1B and P3J were less at risk. During the course of study, no bacteria and actinomycetes growth were noticed in any of the developed pastas.

5.2.7. Consumer Acceptance of Pasta Product

The choice of foods depends on consumer's beliefs and attitudes. Consumers use numerous products criteria to evaluate whether a food product satisfies their expectations and requirements (Gellynck *et al.,* 2008). This study examines consumer's willingness to consume different types of nutritionally enhanced pasta product derived from fruit pulps.

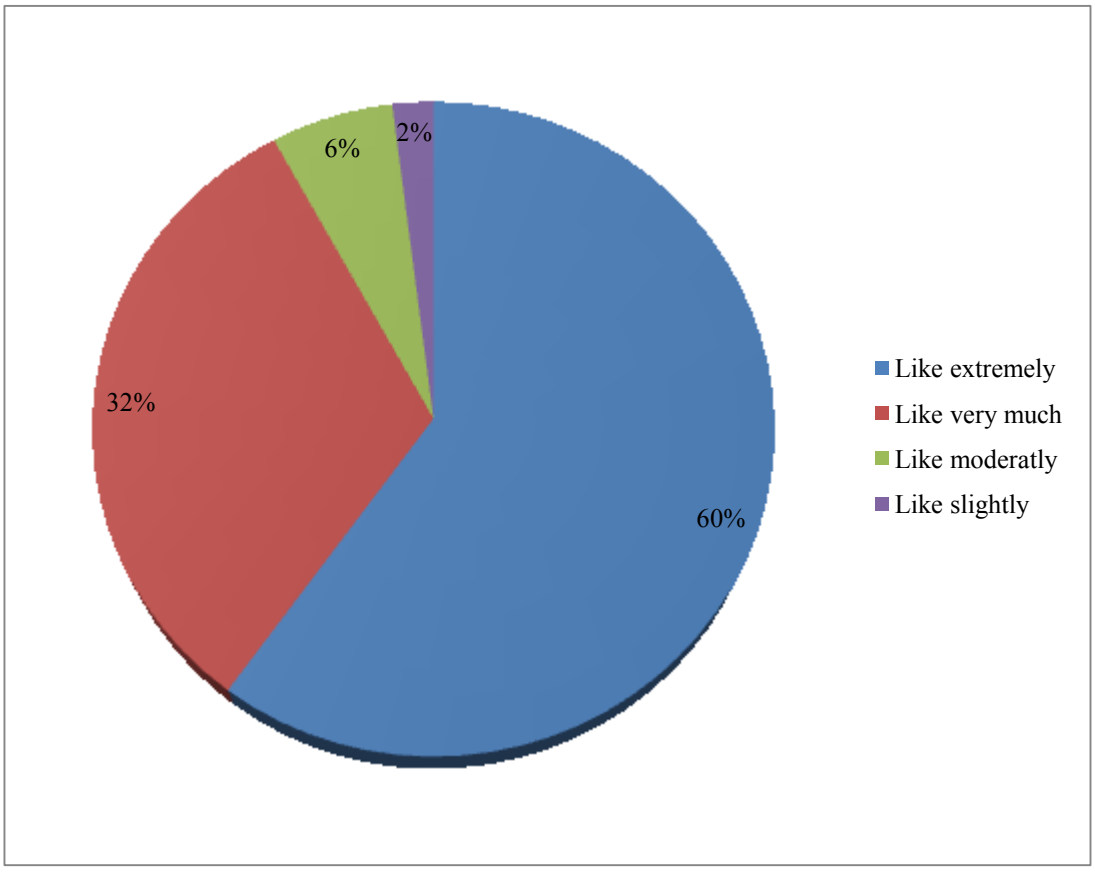


Fig. 44. Consumer acceptance for P1B pasta

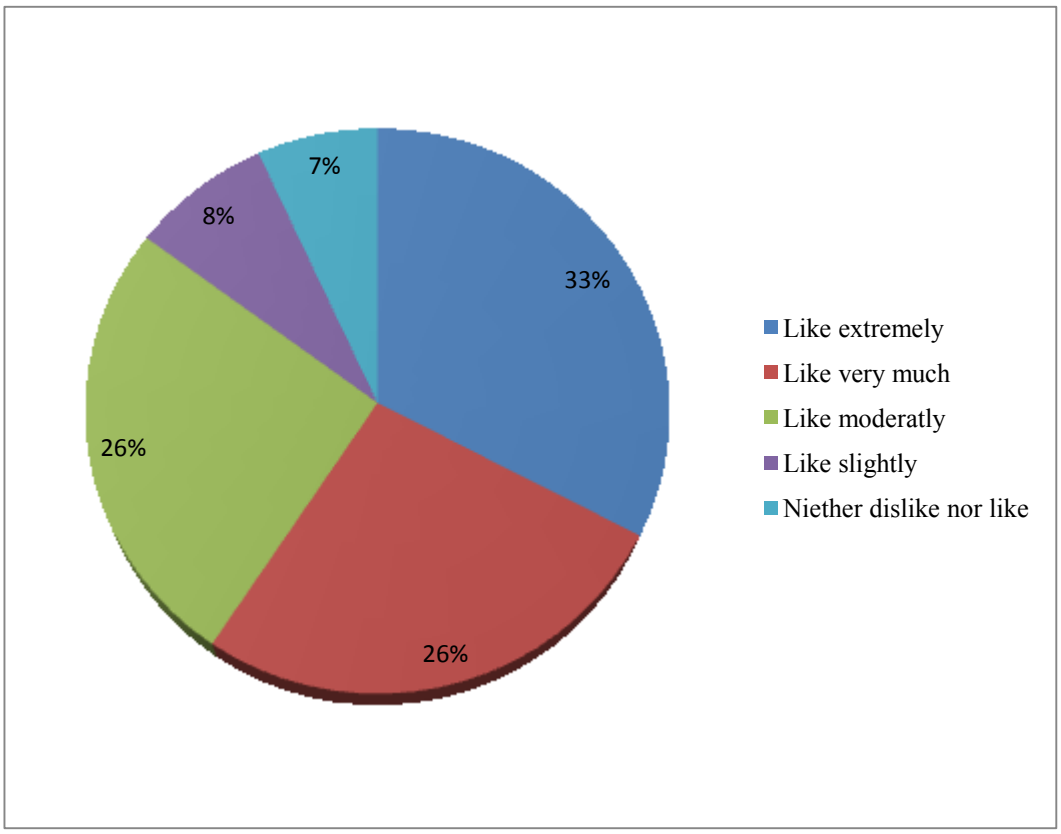


Fig. 45. Consumer acceptance for P2P pasta

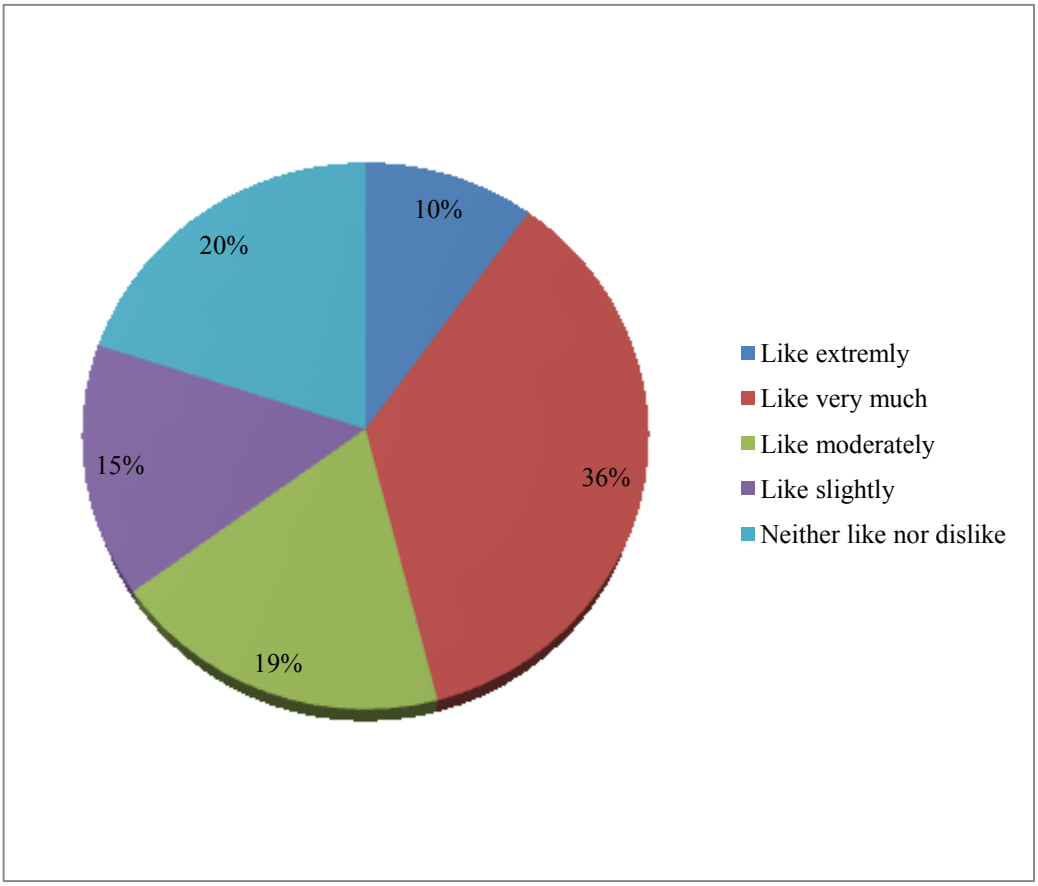


Fig. 46. Consumer acceptance for P3J pasta

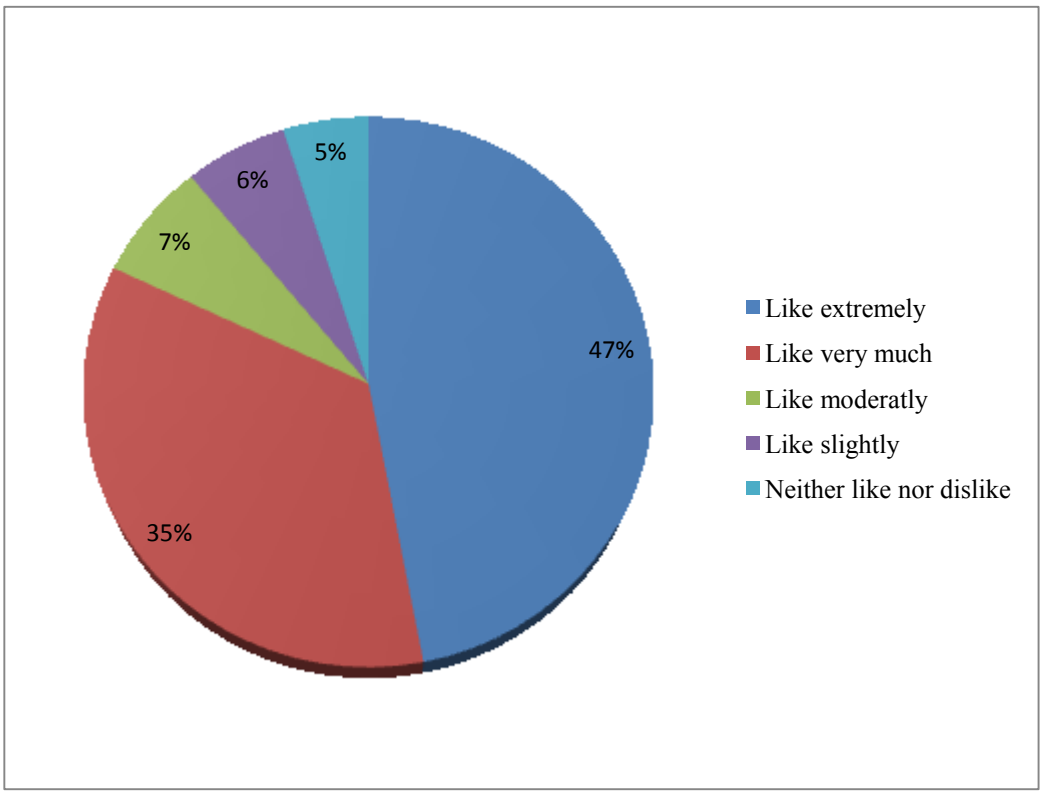


Fig. 47. Consumer acceptance for P4MF pasta

The results showed that the selected consumers rated all the developed pastas high on the nine point hedonic scale. The preferences rate was high among selected adolescent groups followed by adults and children which support the study conducted by Tomy and Marquis (2010), who stated that adolescents are the major consumers of convenient foods such as pasta and noodles.

The well accepted pasta by the selected subjects was P2P (8.7/ 9), the pasta prepared by incorporating papaya pulp. Consumer acceptance and preference study is given in Fig. 44. to Fig. 47.

5.2.8 Cost analysis of pasta product

Cost calculation is an accounting methodology that traces and accumulates direct costs, and allocates indirect costs in a food manufacturing process. In the present study the cost of four developed proportions of pastas was very low which is suitable for developing country. Cost calculation revealed that P3J had higher cost followed by P4MF. This is because yield from jackfruit was comparatively less.

The cost of P1B pasta was Rs 248/Kg and for P2P (Rs 240/ Kg). Lowest cost was observed for pasta P2P. Cost of commercially available pasta was Rs 75/ 250 g. When compared with commercial pasta; the developed pastas were of less cost.

SUMMARY

6. SUMMARY

The study entitiled “Development and quality evaluation of fruit based instant snack and pasta product” was conducted at College of Agriculture, Vellayani, Trivandrum. The objective of the study was to develop nutritious fruit based instant snack and pasta product and assessment of its quality in terms of sensory, chemical and nutritional composition and shelf stability. Consumer acceptance and preference of the developed products were also ascertained.

The present investigation was carried out in two parts.

Part I Development of instant snack

Part II Development of pasta product

PART I DEVELOPMENT OF INSTANT SNACK

Fruits (Jack fruit CV Koozha, Papaya Pusadwarf and Banana Nendran), cereals (Parboiled rice, Wheat), pulses (Horse gram, Green gram) and coconut were the eight ingredients selected for the study. Each ingredient was given various processing techniques.

The processed ingredients were blended together in various combinations. Eight different combinations (C1 – C8) of instant snack were formulated and proportion of each ingredient varied in each combination. In order to select the best combination, each combination was taken for sensory analysis (hedonic rating scale) and nutritional analysis (Energy and Protein).The combination with high organoleptic scores and nutritional (energy and protein) value was selected as the developed instant snack in this study.

The study revealed that formulated combination (C2) as the best combination of instant snack in which the proportion of ingredients was 1:1:1:1:2:1:2:1. Thus the instant snack (combination C2) was further produced in bulk amount, packed in laminated pouches and stored in room temperature.

The product was further taken for detailed investigation with respect to quality aspects (sensory, chemical and nutritional composition, shelf stability and consumer preference).

Colour, appearance, flavour, texture, taste of the instant snack was analyzed by the selected semi trained panel members using 6 point scale score card and found that all the parameters were highly scored well above 5 out of 6.

According to chemical and nutritional composition study developed instant snack provides energy (349.8 K cal/100 g), protein (10.83 g/ 100 g), fat (4.95 g/ 100 g), calcium (70. 18 mg/ 100 g), iron (3.96 mg/ 100 g) sodium (16. 46 mg/ 100 g), potassium (280.86 mg/ 100 g) and beta carotene (115.46 µg/ 100 g). Chemical analysis of hundred gram of developed instant snack endow with 13 g of moisture, 0.65 meq of peroxide, 1.27 mg of poly phenols, 2.9 g of fiber, 2.28 g of total minerals.

The shelf stability study was conducted for successive three months. At an interval of one month, organoleptic parameters, chemical components (peroxide, moisture, poly phenols and total minerals) and microbial growth were examined.

The study produced no significant difference with respect to organoleptic study conducted in three consecutive months. Monthly examination of moisture, total minerals, peroxide and polyphenols found no significant difference in their values. No microbes were also observed during the period of study, emphasizing that the developed snack was shelf stable for three months.

The consumer acceptance and preference study was carried out among 150 selected subjects (Children 50, Adolescents 50, and Adults 50) using hedonic rating scale. Results indicated that all the selected subjects equally preferred the developed instant snack.

PART II DEVELOPMENT OF PASTA PRODUCT

Pasta product was developed using fruits (Jack fruit CV Koozha, Papaya Pusadwarf and Banana Nendran), wheat, green gram and tapioca. Fruits were processed to pulps, wheat and green gram milled to flour and tapioca processed to tapioca starch. The extruding machine used was Dolly Mini. Using the above ingredients different proportions of pasta were formulated.

Total nineteen proportions of pastas developed in which 5 proportions of each jackfruit pulp, papaya pulp, banana pulp incorporated pasta and 4 proportions of mixed fruit pasta (Jackfruit pulp + Papaya pulp + Banana pulp). In

each proportion the quantity of fruit pulp and wheat flour varied from 200 g to 600 g while the quantity of green gram and tapioca were kept constant (100 g).

From the various proportions worked out the best extruded pastas were selected based on the high MFR (Mass Flow Rate) value and low blending time.

In the present study, proportion number 2 (P1B), proportion number 7 (P2P), proportion number 12 (P3J) and proportion number 17 (P4MF) banana pulp + papaya pulp + jack fruit pulp from mixed fruit pulps respectively were selected as the best proportions of pasta. In all the selected proportions of pasta, the quantity of fruit pulp was 300g and wheat flour was 500 g per Kg.

The developed pasta products were further taken for detailed investigation with respect to quality aspects (functional characteristics, sensory, chemical and nutritional composition, and shelf stability and consumer preference).

Functional characteristics such as swelling index, cooking loss per cent, cooking time in minutes, water absorption index, colour and texture were assessed. The developed pastas were compared with the commercial pasta which was taken as control.

In the present investigation, lower swelling index were observed for all the developed pastas compared with control. Cooking loss per cent of control was less when compared to developed fruit incorporated pasta. The cooking time observed for control was 11 minutes. All the developed pastas had the average range of cooking time as that of ordinary pasta made from durum wheat.

The water absorption index of control was high, where as developed pastas were less. Colour analysis highlighted that commercially available pasta has whiter colour than the developed fruit pulp incorporated pastas. The comparison study showed that the hardness of control pasta was high than that of developed fruit incorporated pastas.

On the whole the functional characteristics study accentuate that among all selected pastas, P2P had the best characteristics. Functional characteristics of P2P were shown similar to that of control.

For sensory investigation selected proportions of pasta and control were reconstituted or cooked into recipes and conducted sensory evaluation by selected

ten semi trained panel members using a 6 point score card. Study indicated that, all the parameters were highly scored except for texture. P1B was the pasta that scored maximum than that of control (commercially accepted pasta). Thus it could be concluded that all the developed four pastas were excellent with respect to sensory quality.

The nutritional study revealed that energy, carbohydrate, fat, calcium, iron sodium and potassium content of P1B pasta were notably high compared to other developed pastas. Protein content was approximately similar for all the developed pastas hence no considerable difference was noticed. Beta carotene was found drastically high in P2P pasta.

The analysis of chemical composition revealed that all the chemical constituents were found high in P3J pasta, the pasta made with jack fruit followed by P1B, P4MF and P2P.

Shelf life study of developed pastas up to three successive months was conducted. The pasta were packed in laminated pouches and stored in room temperature and each month the product was analyzed for its sensory quality parameters, chemical composition changes and also microbial content.

The sensory study of developed pastas during the storage period showed that there were decreasing trend in scores for all the sensory parameters across the months. But the scores obtained for pastas were in a range between 5-5.9 out of 6. The study also revealed that all the pastas, P1B, P2P, P3J and P4MF were equally good. In close observation, all the sensory scores were high for P1B.

With respected to chemical component analysis in stored pasta products, no significant change in any of the chemical constituent of all pastas (P1B, P2P, P3J and P4MF) was observed. Thus, it could be concluded that the developed pasta products were shelf stable up to three months.

Microbial study pointed out that in P3J and P4MF pastas, the growth of microflora was observed during the second month of storage analysis. The count was observed high in P4MF (3.96×10^{-3}cfu /g). Therefore study point out that pasta P3J and P4MF were more vulnerable for microbial growth and spoilage

where as P1B and P3J were less at risk. During the course of study, no bacteria and actinomycetes growth were noticed in any of the developed pastas.

The results of consumer acceptance and preference study showed that the selected consumers (50 children, 50 adolescents and 50 adults) rated all the developed pastas high on the nine point Hedonic scale. The preferences rate was high among selected adolescent groups followed by adults and children.

On the whole, the study concluded that the developed products both instant snack and pasta products were high-quality with respect to nutritional and chemical composition, organoleptic quality and shelf stability. These types of developed products add diversity to the diet. Consequently these products can be scaled up for marketing and commercialization.

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Appendices

APPENDIX - I

SCORE CARD FOR SELECTION OF PRETREATMENT

Criteria	Score	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8
Colour & Appearance									
Excellent	6								
Very good	5								
Good	4								
Fair	3								
Poor	2								
Very poor	1								
Texture									
Excellent	6								
Very good	5								
Good	4								
Fair	3								
Poor	2								
Very poor	1								
Flavor									
Excellent	6								
Very good	5								
Good	4								
Fair	3								
Poor	2								
Very poor	1								
Taste									
Excellent	6								
Very good	5								
Good	4								
Fair	3								
Poor	2								
Very poor	1								

APPENDIX - II

SCORE CARD FOR SELECTION OF OSMOTIC TREATMENT

Criteria	Score	OT1	OT2	OT3	OT4
Colour & Appearance					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Texture					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Flavor					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Taste					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				

APPENDIX - III

SCORE CARD FOR SENSORY ANALYSIS OF INSTANT SNACK

Criteria	Score	Instant snack
Colour & Appearance		
Excellent	6	
Very good	5	
Good	4	
Fair	3	
Poor	2	
Very poor	1	
Texture		
Excellent	6	
Very good	5	
Good	4	
Fair	3	
Poor	2	
Very poor	1	
Flavor		
Excellent	6	
Very good	5	
Good	4	
Fair	3	
Poor	2	
Very poor	1	
Taste		
Excellent	6	
Very good	5	
Good	4	
Fair	3	
Poor	2	
Very poor	1	

APPENDIX - IV

SCORE CARD FOR SENSORY ANALYSIS OF PASTA

Criteria	Score	P1B	P2B	P3J	P4MF
Colour & Appearance					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Texture					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Flavor					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Taste					
Excellent	6				
Very good	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				

APPENDIX – V

HEDONIC RATING SCALE FOR TESTING INSTANT SNACK

Tested by:

Age:

Date:

Rating	Score	Instant snack
Like extremely	9	
Like very much	8	
Like moderately	7	
Like slightly	6	
Neither like nor dislike	5	
Dislike slightly	4	
Dislike moderately	3	
Dislike very much	2	
Dislike extremely	1	

APPENDIX – VI

HEDONIC RATING SCALE FOR TESTING PASTA

Tested by:

Age:

Date:

Rating	Score	P1B	P2P	P3J	P4MF
Like extremely	9				
Like very much	8				
Like moderately	7				
Like slightly	6				
Neither like nor dislike	5				
Dislike slightly	4				
Dislike moderately	3				
Dislike very much	2				
Dislike extremely	1				

APPENDIX - VII

COMPOSITION OF MEDIA USED

1.Potato Dextrose Agar

Peeled and sliced potatoes -200 g

Dextrose – 20 g

Agar-agar -20 g

Distilled water -1000 ml

Potatoes were boiled in 500 ml of distilled water and the extract was collected by filtering through a muslin cloth. Agar –agar was dissolved separately in 500 ml of distilled water. Potato extract was mixed in the molten agar and 20 g of dextrose was dissolved in to the mixture. Volume was made up to 1000 ml with distilled water and medium was sterilized at 15 psi and 121 ^{o}C for 15 min.

2. Nutrient Agar

Beef extract – 3.00 g

Peptone – 5.00 g

Sodium chloride – 1.00 g

Agar – agar – 20.00 g

Water – 1000 ml (to be make up)

pH – 7 (to be adjusted)

3.Yeast Peptone Potato Dextrose Agar

Yeast – 100 mg

Peptone – 100 mg

Peeled and sliced potatoes – 200 g

Dextrose – 20 g

Agar – agar -20 g

Distilled water – 1000 ml

4.Kennights

Glucose	– 1.0 g
Dipotassium hydrogen phosphate	– 0.1 g
Sodium nitrate	– 0.1 g
Potassium chloride	– 0.1 g
Magnesium sulphate	– 0.1 g
Starch	– 10.0 g
Agar – agar	– 15 g
Distilled water	– 1000 ml (to make up)
pH	– 7 (to be adjusted)

APPENDIX- VIII

RECIPE OF PASTA

INGREDIENTS :

Pasta – 50 g

Butter – 1 table spoon

Chopped onion – 10 g

Chopped capsicum – 20 g

Tomato sauce – 10 g

Chilli sauce – 10 g

Step 1: Cook 50 g pasta in 100 ml hot water for 11 minutes

Step 2: Strain water and keep for cooling

Step 3: Heat butter in a frying pan

Step 4: Add chopped onion and capsicum and saute it for 3 minutes

Step 5: Add tomato sauce and chilli sauce and sauté for 2 minutes

Step 6: Add cooked pasta and mix well for 1 minute

Step 7: Garnish with chopped coriander leaves and serve hot

Cooking time : 18 minutes

Serving size : 120 g

ABSTRACT

DEVELOPMENT AND QUALITY EVALUATION OF FRUIT BASED INSTANT SNACK AND PASTA PRODUCT

POORNIMA K. DAS
(2011-24-102)

Abstract of the
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for the degree of

DOCTOR OF PHILOSOPHY IN HOMESCIENCE
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ABSTRACT

The present study entitled "Development and quality evaluation of fruit based instant snack and pasta product" was carried out at Dept of Home Science, College of Agriculture, Vellayani, Trivandrum during the period 2011 to 2014. The objective of the study was to develop fruit based ready to eat instant snack and ready to cook pasta product by incorporating locally available fruits and also to assess the quality aspects such as nutritional, chemical, shelf stability and consumer acceptance and preference.

Part .I. Development of instant snack

The ingredients in instant snack product were jackfruit, papaya, banana, parboiled rice, wheat, horse gram, green gram and coconut. Each component had undergone various degrees of processing and optimization. Eight different combinations (C1, C2, C3, C4, C5, C6, C7 and C8) of the instant snack were worked out, from which the best combination C2 was selected based on the nutrient content and sensory evaluation by selected trained panel members. The ratio of the selected combination was 1: 1: 1: 2: 1: 2: 1: 1. The nutritional analysis revealed that instant snack had 349. 8 K Cal, 10.83 g protein, 66.96 g carbohydrates and 4.9 g fat per 100 g of the product. Organoleptic evaluation of the product emphasized that the flavor parameter was highly scored (5.8/6) and all the other parameters were also equally scored well above 5 out of 6. The highlight of the storage study conducted for 3 months showed that there was no significant difference in sensory parameters and chemical constituents and no microbial growth was observed. Consumer acceptance and preference study conducted among three different groups (children, adolescents and adults) showed that all the participants equally preferred the developed instant snack with mean scores ranging from 7.78 to 7.84 out of 9. The cost of the developed instant snack was Rs-170/- per Kg.

Part .II. Development of pasta

The second part of study, focused on the incorporation of fruits, jack fruit (Koozha) papaya (Pusa Dwarf), banana (Nendran) along with other ingredients ie green gram flour, wheat flour, and tapioca starch for the production of pasta.

Different proportions of various ingredients such as wheat flour, green gram flour, tapioca starch, and fruit pulps were tried out for the pasta production. A total number of 19 proportions of pasta were tried out using banana pulp, papaya pulp, jack fruit pulp and mixed fruit pulp.Based on the Mass Flow Rate (MFR) best four proportions were selected from each fruit being banana pasta (P1B), papaya pasta (P2P), jackfruit pasta (P3J) and mixed fruit pasta (P4MF). The MFR values ranged from 0.52 to 2.72. The least MFR value was shown by P3J (0.52). P2P shown greater MFR value (2.72), followed by P4MF (2.11), and P1B (1.79). The ratios of selected proportions of pasta were 3: 5: 1: 1.

Physical characteristics such as swelling index, water absorption index, cooking time, cooking loss, colour, and texture were analyzed and found significant difference in certain characters amongst the selected proportions of pasta. The sensory study indicated that the overall score was high for the P1B. The calorie content for P2P, P3J and P4MF pastas were 338.68, 368.65 and 368.65 respectively. Carbohydrates were found to be high in P1B (58.56) followed by P3J (56.91), P4MF (54.46). P2P (51.56) had the lowest carbohydrate content. In general, the nutrient content of P1B was relatively high. Even though a decreasing trend was observed for sensory scores of stored pasta, no significant difference was noticed. Analysis of chemical constituents of developed stored pasta also had no significant change. Fungal and yeast growth was observed only in the third month of storage for all the stored pasta samples. The consumer acceptance and preference study among children, adolescents and adults showed that the product pasta was highly preferred by adolescents followed by adults and children. The costs of the developed products ranged from Rs. 240/- per Kg to 265/- per Kg.

Nevertheless, the well accepted ready to eat snacks and pasta products that were developed in the study can be scaled up for potential commercialization and marketing. Other underutilized fruits also can be similarly utilized for development of such products which will have high nutritional value and low cost.