`DEVELOPMENT AND QUALITY EVALUATION OF GRANULAR FRUIT BARS

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled "Development and quality evaluation of granular fruit bars" 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, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **"Development and quality evaluation of granular fruit bars"** is a record of research work done independently by Ms. Meghna. K under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

%	Per cent
CD	Critical Difference
°C	Degree Celsius
Cfu/ml	Colony forming units per milliliter
et al	And other co workers
Fig.	Figure
G	Gram
µg	Micro Gram
g/ 100g	Gram per 100 gram
NDP Cal %	Net dietary protein calories per cent
°Brix or °B	Degree brix
ml	Milli litre
mg	Milli gram
viz.	Namely
TSS	Total Soluble Solids
ND	Not detected
i.e	That is
Rs.	Rupees
GFB	Granular fruit bars
A_1	Pineapple bar coated granular bar
A_2	Papaya bar coated granular fruit bar
A_3	Blended bar coated granular fruit bar
RTE	Ready to eat

DEDICATED TO MY FAMILY

Introduction

1. INTRODUCTION

Nature provides enough food, nutrition and environmental security for every living being. The changing socio- economic scenerio in the country with hectic life styles and rise in disposable incomes, the Ready To Eat (RTE) food market is growing at fast rate of 35% every year. Several varieties of ready to eat foods are being produced and marketed which fall into two main categories, *viz,* pre-prepared and packed foods which only need reheating before consumption and snack foods that can be eaten straight from the pack (AIFPA, 2004). In India, different kinds of traditional snack foods made from cereals, millets, pulses, legumes, nuts and oil seeds, vegetables and fruits. Number of technologies has been developed to enhance utility and commercial value of these products (Devi *et al.*, 2014).

Nutrition and nutritional factors are widely considered to be crucial for health and well-being of the humans. The main cause of malnutrition is the lack of affordable and adequate food at the household level. The wide availability, appearance, convenience, taste and texture has created an increasing consumer demand for ready- to- eat snack foods (Nicklas *et al.*, 2003).

Food processing is the modification of foods from the state in which they are harvested or grown to better preserve them and feed consumers. Food has been processed since prehistoric times. As agriculture and animal husbandry spread, it was important to preserve foods to prevent losses due to spoilage and to survive at the time of scarcity. Food processing was apparently the foremost "technology" that was successful enough to led a separation of societies into distinct artisan industries. As such, food processing as an industry was probably the stepping stone to urbanization. Both fresh and processed foods consist of the major parts of the food supply. Processed food provide both food security (establish that sufficient food is available) and nutrition security (establish that food quality meets human nutrient needs) (Weaver *et* al., 2014).

Food processing enhances the quality of food because in the process, foodstuffs are converted into forms which may be more acceptable and completely different from the original material in terms of odour, taste, flavour, appearance and texture. Food processing involves a combination of procedures to achieve the intended changes in the raw materials. The aim of food processing include to extend shelf-life by preservation techniques which inhibit microbiological or biochemical changes; to increase variety in the diet by providing a range of attractive flavours, colours, aroma and texture in food; to provide the nutrients required for health; to reduce or eliminate anti-nutritional factors; and to remove contaminant from food (Fellows, 1990; Enwere,1998).

Snack bar is a convenient and healthy ready-to-eat food which provide balance nutrients (protein, fat, minerals, vitamins, calories, and carbohydrate) and it also relieve hunger (King, 2006; Ryland *et al.*, 2010; Wyatt, 2011). Due to these reasons snack bars continue to increase sales in market. Snack bars considered as a source of energy and is primarily marketed to athletes. Although, the developing luxury groups and health-conscious consumers had rose the sales performance of snack bars (Wyatt, 2011).

The varying socio-economic pattern of life and the rising number of working couples, the idea of fast food consumption becoming prominent in Indian market, because it conserves time and labour. As a result of developing urbanisation and varying food habits, the need for ready to eat foods has been increasing at a good rate and there is adequate latent market potential waiting to be utilized through developmental achievements. The current trend for consumption of convenience, healthy and innovative food is steered the market of cereal-bars to a progressive growth (Kowsalya and Sathyapriya, 2016).

The scientists and food industries have made changes in formulations and ingredients due to altering lifestyle of consumers and their health awareness. These innovations help to increasing nutritional value and safety of food. To satisfy consumers' needs "new" food products should contain nutritional benefits, be convenient, taste good and provide some element of fun (Sloan, 2003).

Developing a product that includes these attributes should enhance the opportunity of success in the market place. A snack bar formulation can be easily adapted (Estevez *et al.*, 1995) and consumed because of their nutritional benefit (Boustani and Mitchell, 1990); their suitability for travel, ease of eating due to cleanliness, consumability at work or in public, inexpensive price and convenience (Jack *et al.*, 1997). They are shelf-stable at room temperature, individually wrapped and small enough to carry in a pocket or purse.

Fruit leathers or bars can be simply defined as dried sheets of fruit pulp that have a soft, rubbery texture and a sweet taste. The edible portion of fruit is pulped, pureed, mixed with different ingredients to improve its physicochemical and sensory characteristics. These are then heated, formed and dried on flat trays until cohesive fruit leather is obtained. Fruit leathers can be eaten as snack foods or added to a variety of food preparations (Raab and Oehler, 1999). Fruits are nature's wonderful medicines which consists of vitamins, minerals, antioxidants and phyto-nutrients without which human body can not retain good health and establish resistance to diseases. The papaya fruit has abundant vitamins and mineral content. Papaya accounts the highest among fruits for β- Carotene precursor of vitamin A, vitamin C, riboflavin, thiamine, folate, iron, calcium, potassium, niacin and fiber (Gomez *et al.*, 2002). Pineapple is a major fruit of bromeliad family and can be eaten as fresh or processed form. This marvelous tropical fruit is rich in enzyme bromelain and antioxidant vitamin C, both of them play a important role in the body's curing process. It is a good source of dietary fiber.

Food processing industry helps to avoid post harvest loss of agricultural produce, adds value, enhances shelf life of the perishable agro food products and encourages diversification (Anand, 2000). Consumers are increasingly demanding convenient, ready to use and ready to eat foods, containing only natural ingredients. Therefore development of innovative nutritious convenient food is the need of the hour (Kumar *et al.*, 2008). Many of the processed foods in the market are high in calories and fat and less in micronutrients and fiber, consumption of which leads to obesity. As consumers are more aware of what they eat, improving

the nutritive quality of the final food product through the addition of natural resources is the goal of research in recent years (Jabs and Devine, 2006). Consequently innovative nutritious convenient food products are necessary to replace salt and fat enriched fast foods/ snacks.

Based on the concept of developing health promoting convenient foods from our local food resources, the present study is proposed with the objectives to develop granular fruit bars using fruit pulp, grains, nuts and pulses and to ascertain sensorial quality, chemical and nutritional composition, shelf stability and consumer acceptability of the products.

Review of Literature

2. REVIEW OF LITERATURE

The related literature of present study entitled "Development and quality evaluation of granular fruit bars" is reviewed under the following headings.

2.1 Importance of processed RTE product

2.2 Snack bars and fruit bars

2.3 Health benefits of snack bars and fruit bars

2.1 IMPORTANCE OF PROCESSED RTE PRODUCTS

Food processing sector vital for the complete development of economy as it supplies a major linkage and synergy between the Agriculture and Industry. It assists to diversify and commercialize farming; improve income of farmers; generate markets for export of agro foods as well as create greater employment opportunities. Through the presence of such industries, a wider range of food products could be sold and distributed to the distant locations (Adukia, 2007).

In the past, processed foods were refined and pure. Now there is a fluctuation in consumer demand to 'natural foods' which consist of appropriate quantity of dietary fibre. Most research observes that the processing of whole grains does not discard biologically essential compounds (Flucher and Rooney, 2002). Processing may prepare the food matrix, consequently permitting the liberation of highly bound phytochemicals from the grain gliadin (Slavin, 2003). New demands include less energy, less fats, less salts having more dietary fibres and nutrient components (Sabapathy and Bawa, 2003).

India obtained second position in the production of fruits and vegetables in world, but hardly 2 per cent of the produce is processed. In order to encourage the food and allied industries, the Government of India has created, a few national level organisations, which in one way or the other support the industry. These institutions either undertake fundamental and or applied research or do some developmental activity such as increasing production of raw material needed for the industry, developing physical infrastructure, developing new varieties to

decrease post-harvest losses and assesses to promote exports. India's food processing sector initially involves meat and poultry, fruit and vegetables, dairy products, fisheries, grain processing, plantation, alcoholic beverages and other consumer product groups like, chocolates, cocoa products and confectionery, soya-based products, mineral water and protein rich foods (Parthasarathy, 2008).

Technological developments in the field of food processing equipment and packaging materials have brought about revolution in the development of convenience foods. Convenience foods can be designed to suit all segments of the population including armies, airways, railways and even patients with suitable supplements. The retort processed foods do not need rehydration or cooking and can be take straight from the pouch with or without pre-warming, based on the demand of the users and the weather conditions. Today, most of the companies in food processing sector utilizing "Retort Technology" developed by Defence Food Research Laboratory (DRFL) (Rahman, 2013).

"Ready-to-eat" is defined as the status of the food being ready for immediate consumption at the point of sale. It could be raw or cooked, hot or chilled, and can be consumed without further heat-treatment including re-heating. The Indian Ready to Eat (RTE) and Ready to Cook (RTC) food section has appeared from its initial days of being a extreme alternative to home cooked meal or to eating out. A fast-rated urban lifestyle, rising popularity of nuclear family structure, increasing disposable income, larger number of globe-trotting Indians with an experimentative palate are all suitable demographic factors stimulating the selection of RTE and RTC foods in India. Further, the development of modern retail has supplied unprecedented brand and category visibility to convenience foods. Also, technological advancements in packaging and flavor science have brought RTE and RTC foods centre-stage among urban Indians. A greater portion of urban consumers are testing with RTE/RTC foods on a more periodic basis with the top two value propositions being 'saves time' and 'tastes good' (Rahman, 2013) .

Bower and Whitten, (2000) expressed that consumers are searching for easy and fast prepared foods, and facilitate the procurement of pre-prepared,

frozen, and ready-to-use products in the market". Consumers select minimally processed and nutritionally high convenience foods with extended shelf life. The necessity of people to consume highly nutritious foods in place of sweets and candies has drives to the emergence of various bar types, which includes variations such as chocolate coating or incorporation of different types of fruits and nuts. The cereals have a major role in the modern lifestyle due to the convenient forms they can be used viz. ready-to-consume instants, cereal bars and energy bars (Silva *et al.,* 2014).

2.2 SNACK BARS

Energy bars are considered as a dietary supplement frequently consumed by athletes and other physically active people to retain their calorific needs (Norajit *et al.,* 2011). People concerned in getting healthier foods and keeping the good body fitness have changed their eating habit which has promoted a growth in the cereal bars market of 20% per year (Lin *et al.,* 2010).

Cereal bar is a product produced from the mixture or combination of three or more foods which is hygienically developed with certain nutritional values and flavors, attached with a bonding ingredient that provides proper texture. Cereal bars were established in the last decade as a wholesome substitute of comfit when consumers exhibits more interest in health and diets. The relation between cereal bars and wholesomeness food stuffs is a well-established likelihood in industrial food. The cereal bar has been produced out of the demand to have a product that could bring together practicality and nutritional quality to boost or replace the morning and afternoon snacks as a complement to main meals. The main constituents of the cereal bar are fibers and fast absorbing carbohydrates. There is an effort to increasingly add functional products and cereals to the diet through various products. Therefore, food products, which are high in proteins, vitamins, minerals and fibers have been produced worldwide (Tettweiller, 1991). These bars are packaged and sold in individual portions of 25 to 30 grams (Izzo and Niness, 2001) and it consists of multiple ingredients, including cereal, fruit, nuts and

sugar. Different types of cereal bars are available in the market including high protein, high-fibre and high-calorie bars. Furthermore, other snack bars are exits including fruit bars, crunchy bars, salty bars, low-calorie bars and diet bars. Moreover, bars with filling, bars with chocolate, bars without chocolate and bars with potentially functional additives such as prebiotics are also available (Lobato *et al.,* 2011).

Snack bars are practical, easy to manufacture and depending on the ingredients used can be sold at a low price. These products can be efficiently added to a packed lunch or eaten as a snack. Although the method of formulating cereal bars is comparatively easy, incorporating increased amounts of functional components can be difficult because of the individual characteristics of the components and their interactions with corn syrup or other ingredients. In addition, these functional components can be detrimental to sensory parameters, such as texture and taste, and physical properties, such as water activity. Because of the developing consumer need for healthy, natural and convenient foods, efforts are being made to enhance snack foods nutritional values via altering their nutritive composition. Cereal bars are a popular and convenient food and, therefore, would be an ideal food format to deliver fruit-derived phenolic antioxidants and fibre (Sun -Waterhouse, 2010)

Generally, fruit leather is prepared by the dehydration of fruit puree or mixture of fruit concentrate into a thin, soft and flat layer. It can be dried in an oven or in direct sunlight. Usually, the ingredients incorporated are fruit juice or concentrate, pectin and glucose syrup or sugar. Many types of fruits can be used for making fruit leather such as guava, mango, pear, strawberry, kiwifruit, pineapple. (Phimpharian *et al.*, 2011; Vijayanand *et al*, 2000).

Fruit leathers or bars are eaten as candy or snacks, and presented as flexible stripes or sheets. The origin of fruit leathers may go back to the Persian Empire. They are known as Pestil in Turkey, Bastegh or Pastegh in Armenia, Qamar al deenǁ in Lebanon, Syria and other arab countries and fruit roll or fruit leather in the United States (Muskan *et al,*. 2010 ; Chan and Cavaletto, 1978). According to Natalia *et al.* (2011) the other ingredients like sucrose or glucose

syrup are added to increase sweetness and solids content. Work carried out by experts in this field has revealed that almost any type of fruit is acceptable for making fruit leathers, including apples, apricots, berries, grapes, jackfruits, kiwifruits, oranges, papayas, peaches, pears, tomato, and various other fruits (Irwandi and Che Man, 1996; Chen *et al.*,2002; Maskan *et al.*, 2002).

Manufacturing of fruit bars exists in food industries from many years. This is considered as one of the preservation technologies to preserve the fruits. The major part of fruit bar is fruit pulp retain most of the nutrients, minerals and flavor constituents which forming an excelllent nutritional supplement besides being a confectionery product. The advantage of this product is its simplicity and lower inherent cost in production with better consumer appeal (Ukkuru and Pandey, 2007).

Fruits are generally liked by most of the people from all age groups. But fruits are available only during particular season. There are many methods for preserving fruits and making fruit bars is one such method. Consumption of fruits is essential as they are nutritious and provide vitamins and minerals. Pulpy fruits like banana, mango, guava, papaya, apple etc. are best acceptable for making fruit bars (Chan, 1978). Papaya or paw-paw is a popular tropical fruit. It was originated in America but is now common world wide in tropical region. Papaya is cultivated as nutritious fruits which are consumed as table fruits as well as in processed forms. Papaya fruit is an important and economical source of certain vitamins and minerals and it has therapeutic values. It is utilized for the treatment of piles, dyspepsia of spleen and liver, digestive disorders, diphtheria and skin blemishes (Singh,1990). Fruit leather is a dried-fruit treat, chewy and flavorful. Rich in fiber and carbohydrates, fruit leather is naturally low in fat. When the water is excluded from fruit during the drying process, the remaining sugars, acids, vitamins and minerals become concentrated in the remaining solid part of the fruit, making fruit leather a nutritious snack. Due to fruit leathers are light weight, they store and pack easily (Jaswir *et al.,* 1998).

The leathery sheets of dried fruit purée are easy to make at home using either fresh or canned fruits. Many fruits are suitable for fruit leather, including

apples, apricots, bananas, berries, cherries, grapes, oranges, pears, pineapples, plums strawberries, tangerines, and tomatoes. Pineapples have many nutritional benefits providing several essential mineral, vitamins (B1,B2, C) and fibre. They are also low in calories, rich in carbohydrates, fat free and versatile. Raw, juiced, cooked dried or canned pineapples offer tremendous nutritional value (U. S. department of health and human services, 2005). Fruit combinations make a variety of flavors possible (Raab and Oehler, 2000). In India where fruit leathers are most 25 commercially successful traditional product, traditional method of preparation involves extraction of pulp, mixing with sugar and sun drying on bamboo mats adding layer by layer after the previous one is dried. These slabs are cut into slices of uniform sizes, wrapped in cellophane paper and marketed (Rameswar, 1979). The benefits of preparing our own fruit leathers are to use less sugar and to combine fruit flavors. For the diabetic adult or child, fruit leathers made without sugar are a healthy choice for snacks or desserts. Fresh, frozen or drained canned fruit can be utilized for making fruit leathers. Drying eliminates the moisture so that bacteria, yeasts and molds cannot survive and slows down the action of enzymes. The product becomes smaller and lighter in weight. Papaya, pineapple and apple are important fruits and when ripe, are highly digestible, and a good sources of vitamins and minerals (Huang and Hsieh, 2005).

The fruit bars or fruit-slabs or fruit-leathers are the terms used for the products prepared by dehydration of fruit pulps. Mango, banana, citrus, guava, grape, pineapple, and apple are the important fruits out of which a good quality fruit bar/candy can be prepared. The fruit pulp has been dehydrated to form fruit leathers/bar or candy with addition of sugar, acid and other ingredients (Parimita and Arora, 2015).

Fruit bar is a concentrated fruit product and prepared by blending pulp/puree from sound ripe fruit, fresh or previously preserved nutritive sweeteners, butter or other vegetable fat or milk solids and other ingredients appropriate to the product and dehydrated to form sheet which can be desired shape. Fruit leathers are also used as ingredients in the manufacture of cookies, cakes and ice cream. The preservation of fruit leathers depends on their low

moisture content (15-25%), the natural acidity of the fruit and the high sugar content. Dehydration allows for long-term storage of fruits thus allowing preservation of vitamins and other nutrients in fresh fruits and vegetables that are critical for human health. Fruit leathers are confectionery products prepared from fruit pulp like mango, guava, banana and papaya (Cadenas, 2002).

Phimpharian *et al.* (2011) reported that changes in glucose syrup and pectin concentrations significantly affected velocity of forming and total soluble solids content of pineapple paste, but did not affect thickness of pineapple leathers. Increasing pectin concentration generally increased redness and yellowness, and hardness (tensile force and work) while decreased moisture content and a_w of pineapple leathers. Two most acceptable pineapple leathers were prepared with 6% glucose syrup and 0.5-1.0% pectin. Increasing pectin concentration from 1.0% to 1.5% negatively affected toughness acceptability, which was attributed to reduced moisture and a_w, and increased tensile force and work. The optimum formulation range consisted of 3.5-6.0% glucose syrup and 0.5-1.0% pectin, yielding products with acceptability scores of 6.7-7.3 (on a 9-point hedonic scale) for appearance, sourness, sweetness, overall-taste, toughness and overall-liking.

2.3 HEALTH BENEFITS OF SNACK BARS AND FRUIT BARS

Today, nutritious, convenient and natural food products are the need of the hour. Hence, food industries should be more careful in the production of new food products or alteration of composition of nutrients in snacks such as snack bars for better health benefits. A multigrain bar developed from ingredients such as amaranth seeds, sesame, pumpkin seeds, groundnuts, tofu and jaggery was found to be high in protein, iron, calcium and calories (Rani, 2011).

Consuming a balanced diet helps to correct or prevent ailments such as heart disease, obesity, malnutrition, diabetes, among other health problems that mostly have their emergence due to dietary errors. In this context, the need for safe and nutritious food is increasing worldwide and which leads to the food

industries to develop new cereal bar formulations and ingredients. Bean-based snack bar is considered as a good source of protein, fiber and low fat content. Fiber and protein rich convenient foods are highly needed in today's health conscious market (Silva *et al.*, 2014).

From a nutritional point of view, fruit bars were considered as a high calorie food which maintains most of the natural minerals and vitamins. Papaya fruit bar enriched with phytosterols was found to be effective in reducing plasma cholesterols in hypercholesteromic individuals (Sailaja *et al.,* 2014).
Marolo (*Annona crassiflora Mart*) is a typical Savannah fruit which is a major part of Brazilian eco-system and is rich in nutrients. Snack bar contains up to 20 per cent of marolo flour provides a snack food which is rich in vitamin C, minerals, fiber content and antioxidant activity (Silva *et al.*, 2014).

Snack bars considered as an ideal snack to provide both electrolytes and energy for the consumers. Snackbars which made with incorporating ingredients such as banana, coconut milk and glutinous rice flour was apt for different age group which constitutes 454.51 kcal of energy, 22.39% of crude fat, 56.89% of total carbohydrate, 6.36% of crude protein, 1.16% of crude fiber, 1.13% of ash and 13.23% of moisture (Tang *et al.*, 2015). The cereal bars incorporated with the pineapple peel flour possess characteristics such as lower pH and higher acidity which adds to the microbiological quality of the bars (Damasceno *et al.*, 2016).

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Development and quality evaluation of granular fruit bars" was aimed to standardize granular fruit bars and evaluate the chemical and nutritional composition, along with organoleptic qualities, shelf life and consumer acceptability. The materials and methods of the study are given under the following headings:

3.1. Selection and processing of ingredients

3.2. Step I. Development of outer coat of the granular fruit bar

3.3. Step II. Standardisation of filling for granular fruit bar

3.4. Step III. Development of final RTE product

3.5. Quality evaluation of the developed RTE product

3.5.1 Sensory evaluation

3.5.2 Chemical and nutritional composition

3.5.3 Shelf life

3.6. Consumer acceptance

3.7. Cost analysis

3.8. Statistical analysis

3.1. SELECTION OF INGREDIENTS

Pineapple and papaya fruits were selected for processing of fruit bar. Mature ripe fruits were purchased from the market. Fruit pulp was extracted from selected ripe fruit (pineapple and papaya) using a fruit pulper. The extracted pulp was used for the preparation of fruit bar mixing with sugar and pectin, which was finally used as the outer coat of fruit bar.

Puffed rice, oats, bengal gram dhal, groundnuts, flaked rice and osmotically dehydrated jackfruit were incorporated in the granular bar.
This experiment was planned in three steps.

3.2. STEP I. DEVELOPMENT OF OUTER COAT OF THE GRANULAR FRUIT BAR

Extracted fruit pulp was used individually and in combinations in order to standardize the outer coat of the granular bar, adding food adjuncts to obtain fruit bar of good consistency / texture.

3.2.1. Development of pineapple bar

Fully ripened pineapple was used for making pineapple bar. Pineapple was washed in tap water, non- edible portions were removed and cut into pieces. The pineapple pulp was extracted using a fruit pulper. The fruit pulp was dried in a tray drier and bar was prepared.

3.2.2Development of papaya bar

Fully ripened papaya was used for making bar. Papaya was washed in tap water, peeled, non- edible portions were removed and cut into pieces. The papaya pulp was extracted using a fruit pulper. The fruit pulp was dried in a tray drier at and papaya bar was prepared.

3.2.3Development of blended fruit bar

Pineapple and papaya pulp was blended in a 1:3 proportion to obtain blended fruit bar. The developed fruit bars were dried in a tray drier at 55-60°C.

Total Soluble Solids (TSS) in fruit pulp and fruit bar was noted. Drying characteristics such as moisture loss, drying time, yield ratio and TSS were also recorded.

Flow chart for development of the three fruit bars viz. pineapple bar, papaya bar and blended fruit bar are given in fig.1.

Figure 1. Flow diagram for development of fruit bars

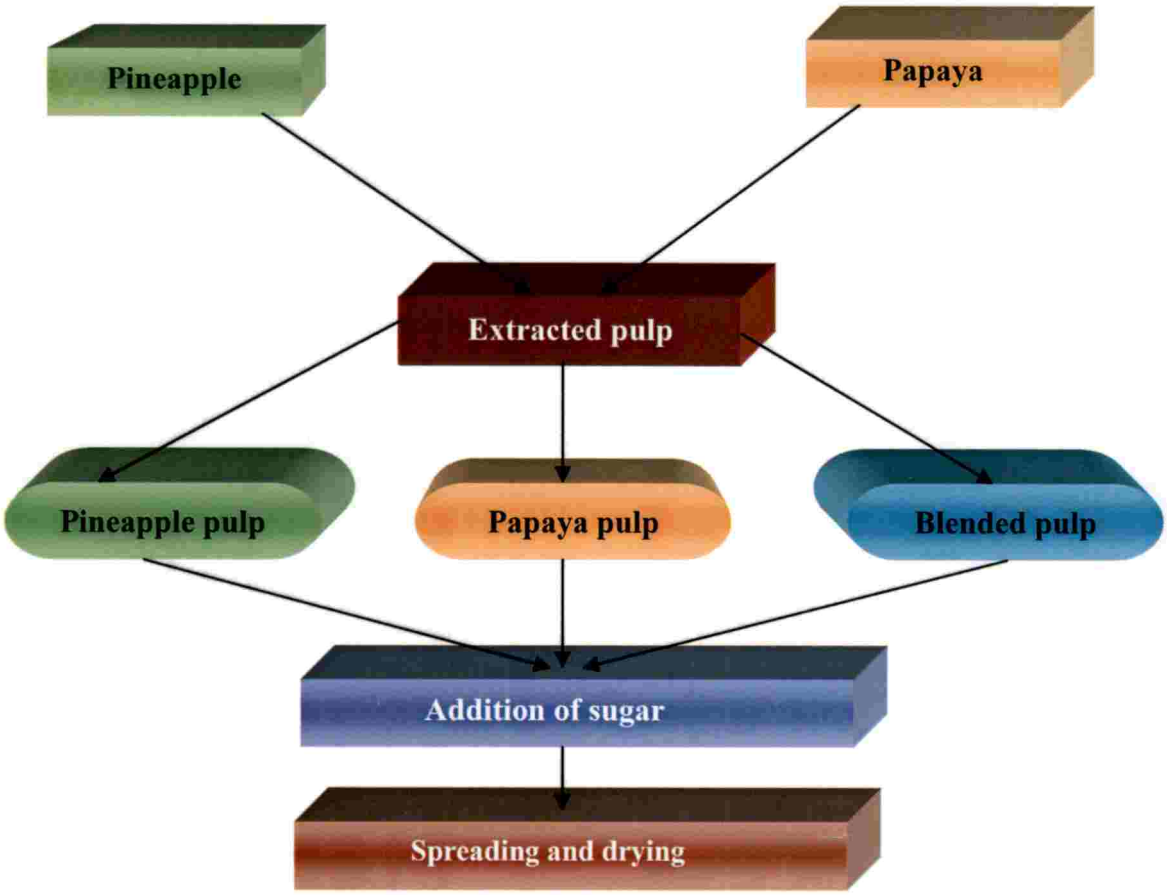
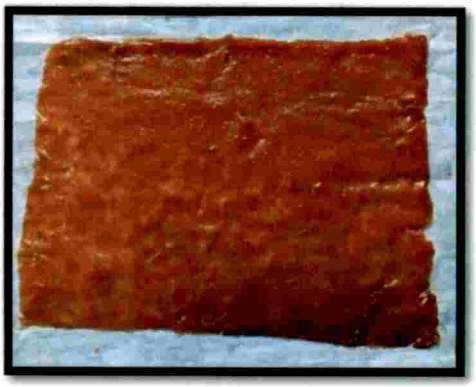


Plate No: 1. Developed pineapple, papaya and blended fruit bars

Pineapple bar

Papaya bar



Blended fruit bar

3.3. STEP II. STANDARDISATION OF FILLING FOR GRANULAR FRUIT BARS

Selected cereals, pulses and nuts except osmotically dehydrated jackfruit were purchased from the market as such. Puffed rice, flaked rice and roasted oats were the cereal source in the granular bar. Puffed Bengal gram dhal and roasted groundnuts were used as a source of protein for granular fruit bars. Osmotically dehydrated jackfruit was used in the granular fruit bar as dried fruit. Jaggery was used as a sweetening agent for the product.

3.3.1. Development of osmotically dehydrated jackfruit

Selection and preliminary processing of jackfruit

Good quality uniformly matured jackfruit were purchased from the market as such.

Preparation of jackfruit cubes

Semi ripened jackfruit was washed under tap water to remove dust and dirt, cut into pieces, bulbs were removed manually.

Pretreatments of jackfruit

Pretreatments of fruits were done to improve texture, firmness and keeping quality of fruits. The jackfruit cubes were directly soaked in pretreatment solution (lime water at 15% concentration) for 6 hours and removed. All these process were done manually.

Osmotic dehydration of pretreated jackfruit

Osmotic dehydration is less energy intensive than air or vaccum drying process because it can be conducted at low or ambient temperature. It has the potential advantages for the processing industry to maintain the food quality and to preserve wholesomeness of the food. It involves dehydration of fruit slices in 2 stages, removal of water using osmotic agent (osmotic concentration) and

Plate No: 2 Developed fillings for granular fruit bars

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. Fruit cubes were washed thoroughly before osmotic dehydration. Sugar solution of was used for the osmotic treatment solution with treated cubes was maintained at 70° B for 12 hours, drained and packed. Fig.2 represents flow chart for development of osmotically dehydrated jackfruit.

3.3.2Development of granular bar

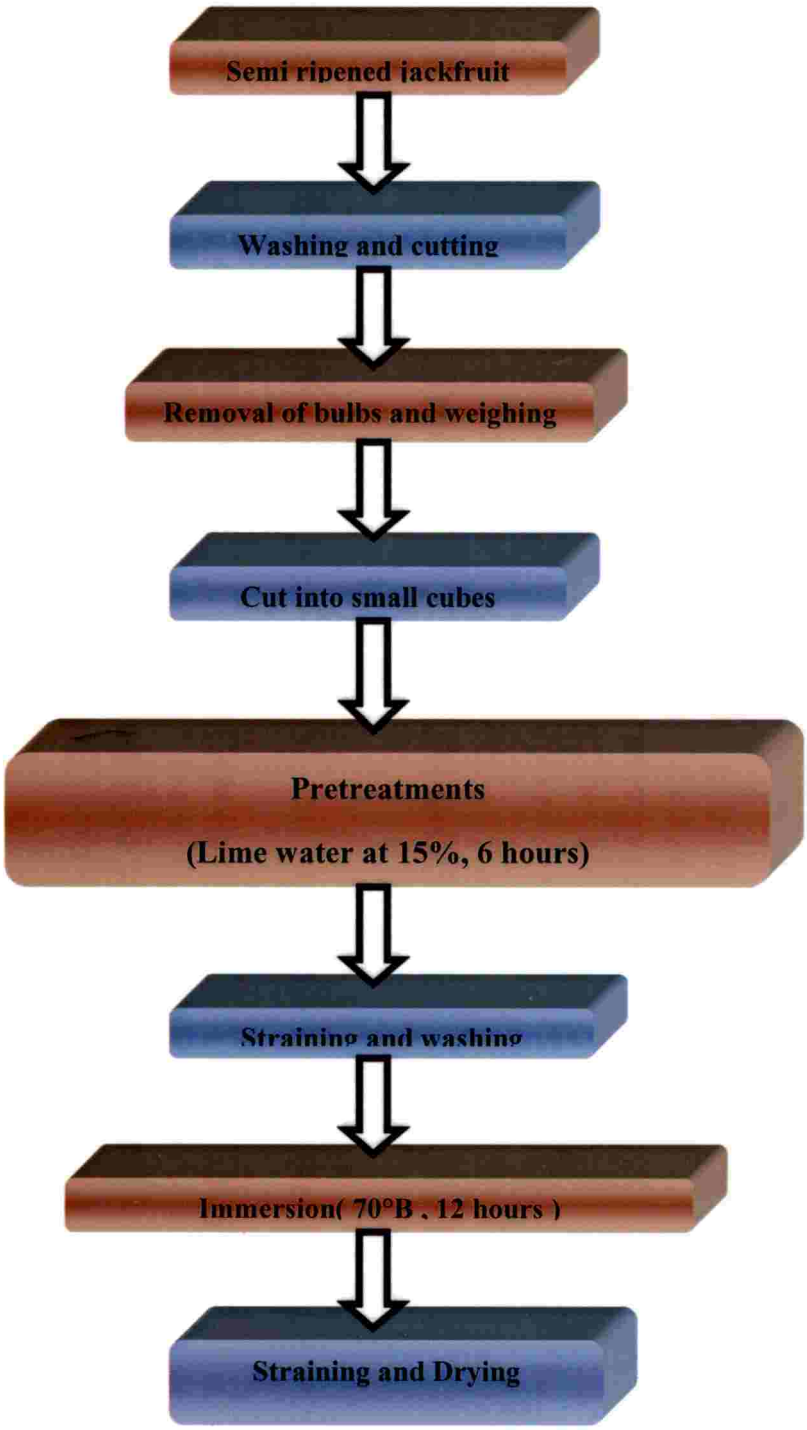
Different proportions of ingredients were formulated to obtain suitable combination for making granular fruit bar. Nutrient composition, chemical score and NDP Cal% and of different proportions were computed. Nutrient density of the proposed treatments were computed using the food composition table (Sesikeran, 2010). Chemical score is the ratio between the content of the most limiting amino acid in the test protein to the content of the same amino acid in egg protein expressed as a percentage (Srilakshmi, 2012). Platt *et al* (1961) reported that the protein requirements are best expressed in terms of net dietary protein calories per cent (NDP Cal%). Based on the nutrient density, chemical score and NDP Cal% best treatments were selected and developed into granular fruit bars. The chemical score was found out using the formula

$$\text{Chemical score (CS)} = \frac{\text{mg of amino acid in 1g of test protein}}{\text{mg of amino acid in 1 g of reference protein}}$$

The formula to calculate NDP cal% is given below

$$\text{NDP cal\%} = \frac{\text{Protein calories}}{\text{Total calories}} \times \text{chemical Score} \times 100$$

Figure 2. Flow diagram for development of osmotically dehydrated jackfruit



Sensory evaluation of the granular bars was carried out and best formulations were identified. The major quality attributes included for scoring was appearance, colour, taste, flavor and texture. The score card on these lines were prepared and distributed among the panel members to express their scores for organoleptic quality of the samples. Details of the score card is presented in Appendix I.

3.4.STEP III. DEVELOPMENT OF FINAL RTE PRODUCT

The formulated outer fruit bar coat was cut into desired shapes and best filling identified was pressed in layers. The product was packed in laminated covers.

3.5. QUALITATY EVALUATION OF THE FINAL RTE PRODUCT

3.5.1Sensory evaluation

Organoleptic evaluation of three treatments of granular fruit bar products immediately after the preparation was carried out by a panel of 10 judges selected by triangle test using hedonic rating scale (Srilakshmi, 2010).

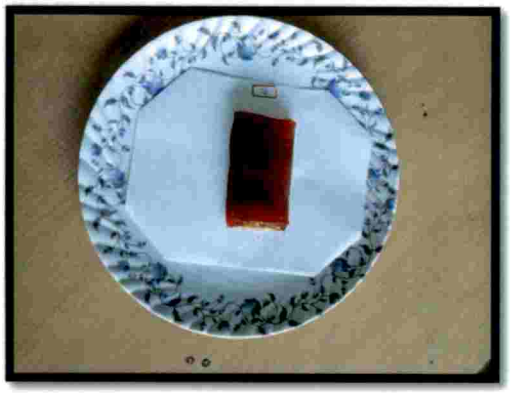
The granular fruit bars were processed and given to semi trained panel of judges for evaluate. A nine point hedonic rating scale was applied for evaluating the quality of developed product. The major quality attributes included for scoring was appearance, colour, taste, flavor and texture. The score card on these lines were prepared and distributed among the panel members to express their view and scores for organoleptic quality of the samples. Details of the score card is presented in Appendix I.

Judges were also permitted to take enough time to score the samples leisurely. The testing was conducted in the mid morning between 10am and 11am, since this time is considered as the ideal time for conducting the quality evaluation studies (Swaminathan, 1974).

Plate No: 3. Selected filling for development of GFB

Plate No: 4. Developed granular fruit bars

Pineapple bar coated GFB



Papaya bar coated GFB

Blended fruit bar coated GFB

3.5.2Chemical and nutritional composition of the granular fruit bar

The major nutrients analyased for the selected products were protein, carbohydrate, fat, fiber, polyphenols, calcium, energy, iron, sodium, potassium, vitamin c, acidity, TSS, β-Carotene, moisture, reducing sugar, total minerals using standard procedure as described in Table1.

Table 1. Methods adopted for chemical and nutrient analysis

Constituents	Methods
Protein(g)	Sadasivam and Manikam (1992)
Carbohydrate (g)	
Fat (g)	
Fiber (g)	
Polyphenols (mg)	AOAC (2005)
Calcium (mg)	
Energy (Kcal)	
Iron (mg)	
Sodium (mg)	
Potassium (mg)	Ranganna (2001)
Vitamin C (µg)	
Acidity (%)	
Total Soluble Solids (°Brix)	
β-Carotene (µg)	Srivastava and Kumar(1994)
Moisture (%)	
Reducing sugar (%)	AOAC (1990)
Total minerals (g)	

3.5.3 Shelf life of granular final RTE fruit bar

Microbial population in food products determines the quality and safety of food products. A food can be considered as safe by ensuring the absence of

pathogenic microorganisms and by all means preventing their multiplication (Beckers, 1988). Food products will be free of vegetative pathogens after adequate treatment during processing. So it can be regarded as safe for consumption. Microbial analysis of stored food products were done to determine the shelf life of the product. The growth of bacteria, actinomycets, E-coli and fungi were assessed by using Nutrient Agar (NA), Ken Knight's Agar (KEN), Eosin Methylene Blue (EMB) and Rose Bengal. This was done by serial dilution of samples followed by pour plating techniques suggested by Johnson and Curl (1972).

The developed granular fruit bars packed in laminated pouches were stored at ambient temperature for 3 months. Changes in moisture, acidity, sensory appeal, microbial growth if any was recorded in monthly intervals.

3.6. Consumer acceptance of the product

Consumer acceptance study was conducted among fifty members in order to assess the stability of these products from the consumer point of view. Preference test allows consumers to express a choice between samples, one sample is preferred and chosen over another or there is no preference (Watts *et al.*, 1989). A preference test was conducted by asking the consumers to rank or score the product served in the sequence of their liking. The preference evaluation was made in order o select the most promising product for large scale production.

3.7. Cost analysis of the granular fruit bar

Cost of the product was computed from input and output cost.

3.8. Statistical analysis

In order to obtain meaningful interpretation, the generated data was subjected to suitable statistical analysis. One way analysis of variance (ANOVA) at the 0.5 per cent level and kruskal wallis test were used to analyse the data and graphical interpretation of the data were also adopted.

Results

4. RESULTS

The results of present investigation entitled "Development and quality evaluation of granular fruit bars" are detailed in this chapter under following headings

4.1. Step I. Development of outer coat of the granular fruit bar

4.2. Step II. Standardisation of filling for granular fruit bar

4.3. Step III. Development of final RTE product

4.4. Quality evaluation of the developed RTE product

4.4.1. Sensory evaluation of granular fruit bar

4. 4.2. Chemical and nutritional composition of the granular fruit bar

4.4.3. Shelf life of granular fruit bars

4.5. Consumer acceptance of the granular fruit bars

4.6. Cost analysis of the granular fruit bar

4. 1STEP I. DEVELOPMENT OF OUTER COAT OF THE GRANULAR FRUIT BAR

The objective of the study was to develop a ready to eat (RTE) granular fruit bars from fruit pulp of papaya, pineapple and blended fruit pulp incorporating ingredients such as fruit pulp, grains, nuts and pulses. The experiment was planned in three steps. The freshly purchased fruits, papaya and pineapple were washed under running water and the initial weight was recorded. Non-edible portions of the fruits were removed and fruit pulp was extracted using a fruit pulper. The extracted fruit pulp was used individually and in combination in order to standardize outer coat of granular fruit bars adding food adjuncts to obtain fruit bar of good texture and taste. Three types of fruit bars were standardised following trial and error method. T_1 pineapple fruit bar, T_2 papaya fruit bar T_3 blended fruit bar. Pectin was mixed with fruit pulp at varying levels (1

to 2 per cent).Pineapple bar, papaya bar and blended bar were developed following the methods explained in materials and methods.

4. 1. 1 Development of pineapple bar (T_1)

Pineapple bar was standardised using pineapple pulp, sugar and pectin. One kilogram of pineapple pulp was mixed with 400g of sugar and 2 per cent pectin. The whole mixture was heated for 2 minutes to dissolve sugar and pectin to get uniform consistency. The pulp mix was spread uniformly in a tray and dried at 60°C for 20 hours. The dried pineapple bar was packed in laminated foils, sealed and kept at room temperature till use.

4. 1. 2 Development of papaya bar (T_2)

Papaya pulp, sugar and pectin were mixed in the ratio 1: 0.4: 0.01 and heated to dissolve the sugar and spread in trays uniformly and dried in tray drier at 60°C for 12 hours. The dried bars packed in laminated foils, sealed and kept for further use.

4. 1. 3 Development of blended fruit bar of pineapple and papaya (T_3)

Pineapple pulp and papaya pulp were blended in 1:3 ratio to obtain blended fruit bar. Sugar and pectin were added to it. The pulp was spread in a tray uniformly and dried in a tray drier at 60°C for 20 hours. Dried fruit bar was sealed in laminated covers and kept at room temperature.

Drying characteristics such as moisture loss, drying time, yield ratio and TSS of fruit pulp and fruit bars were recorded and are presented in Table 2.

Table 2. Drying characteristics of fruit bars

Treatments	Moisture loss (%)	Drying time (hrs)	Yield ratio	TSS (°B)	
				Fruit pulp	Fruit bars
T_1	39.50	19.59	0.61	14.00	76.00
T_2	19.42	10.84	0.81	13.00	74.80
T_3	33.71	19.59	0.66	14.00	75.40
CD(0.05)	0.017	3.059	0.125	NS	0.075

From the table 2, a significant difference was noticed in all the values of drying characteristics except TSS of fruit pulp. Moisture loss was ranged from 19.42% to 39.50%. Moisture loss was higher in T_1 (39.50%) and lower in T_2 (19.42%).

Drying time of T_1 was on par with T_3 (19.59 hrs). Drying time required for T_2 was 10.84hrs.

Yield ratio ranged between0.66 to 0.81. High yield ratio was observed for T_2 (0.81).

TSS content of papaya pulp (T_2) was 13°B. Fruit pulp of pineapple pulp(T_1) and blended fruit pulp (T_3) had same TSS content (14°B). TSS content of fruit bars ranged between 74.80 – 76 °B. High TSS content noted for T_1 (76 °B). There was significant difference in TSS between the three treatments. Finally pineapple, papaya and blended fruit bars were used as the outer coat of granular fruit bars.

4.2. STEP II. STANDARDISATION OF FILLING FOR GRANULAR FRUIT BARS

NIIR (2000) opined that wheat, rice, maize and barley are the cereals ideal for making shredded, granular, puffed and flaked products. To standardise granular bar, different combinations of different ingredients were formulated.

Table 3. Comparison of different formulations

Ingredients	Formulations with quantity (g)					
	T1	T2	T3	T4	T5	T6
Rice flakes	25	20	25	20	15	20
Puffed rice	30	20	25	20	15	15
Oats	10	20	15	15	15	25
Puffed bengal gram dhal	5	5	5	5	5	5
Ground nuts	5	5	5	5	15	5
Jaggery	20	25	20	30	30	25
Osmotically dehydrated Jackfruits	5	5	5	5	5	5

Puffed rice, flaked rice, oats, bengal gram dal, groundnuts, osmotically dehydrated jackfruit and jaggery were the ingredients used. Nutritive value, chemical score and NDP Cal% of each proportion was computed to identify the best combination. The best combination was selected mainly based on nutritional and sensorial quality.

The above ingredients except osmotically dehydrated jackfruit were purchased from the market as such. Jaggery was used as a sweetening agent for the product. Puffed rice or 'pori' was purchased from super market, cleaned and kept in air tight containers for further use. Purchased oats and groundnuts were roasted till the ingredients acquired crisp texture and roasted flavor. Random checking was done to find out the complete roasting procedure. The roasted ingredients stored in air tight containers after cooling. Puffed bengal gram dal and flaked rice were purchased and used. Osmotically dehydrated jackfruit was processed (Poornima, 2014) and used in the product. Jaggery was purchased and melted, filtered to remove impurities and stored in glass containers till use. Table .3depicts six formulations with varying proportions of ingredients. The cereal component in each combination varies from 10 to 30g. Puffed Bengal gram dal 5g was used. Roasted ground nuts quality ranged from 5 to 15g. Twenty to thirty gram jaggery was incorporated. Quantity of osmotically dehydrated jackfruit cubes was 5g each in all six combinations.

Nutrient content, chemical score and NDP Calorie per cent of these six treatments were computed and presented in Table 4. Chemical score is expressed as the ratio of each essential amino acid in test protein to the respective amino acid in the reference protein. NDP Calorie percent relates protein quality to the energy intake. It is useful in evaluation of human diet to examine or predict if protein need of an individual would be adequately met based on energy consumed. Dietary protein is expressed as percent of total calories rather than weight. NDP Cal per cent is the net dietary protein value expressed as per cent of total calories. The net dietary protein value is the utililizable protein content of diet.

For adult an NDP Cal per cent of 5 per cent would be adequate to maintain the health. Growth is supported only by diet providing an NDP Cal per cent of 8 per cent or above. Hence infants, children, adolescents and pregnant women would need to consume diets with over 8 per cent NDP Cal per cent to promote growth.

Table 4. Nutritional profile of the formulations

Treatments	Nutrient contents		Chemical score	NDP Cal%
	Protein (g)	Energy (Kcal)		
T_1	7.97	350.55	109.97	12.32
T_2	9.47	356.25	93.72	9.96
T_3	9.85	351.95	98.65	11.03
T_4	7.91	356.71	68.98	6.11
T_5	11.75	380.15	75.74	9.36
T_6	9.68	358.73	89.94	9.71

The protein content varied from 7.91 to 11.75g. Energy content ranged from 350.55 KCals to 380.15 KCals. It is clear from the table that the chemical score and NDP Cal% of T_1, T_2 and $T_3$was higher than other treatments while the protein and energy value were comparatively low. From this it is understood that T_1,$T_2$and T_3 contains optimum proportions of ingredients considering the higher values obtained for chemical score and NDP Cal%. Based on the above parameters T_1, T_2 and T_3 were selected for further studies. The selected T_1, T_2 and T_3 were standardised with roasted cereals, pulses and grains. Osmotically dehydrated jackfruits were added to it. Filtered jaggery solution was mixed with these ingredients and processed till it reached the two thread stage. The mixture was uniformly spread in trays and shaped in rectangular pieces. This served as the filling for the final product. Sensory evaluation was conducted on these three treatments to identify the best combination.

4.2.1 Sensory evaluation of granular fruit bar

When the quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or subjective or organoleptic. Sensory quality is a combination of different senses of perception coming into play in choosing and eating a food. Sensory evaluation of granular fruit bars was conducted using hedonic rating. The organoleptic evaluation of granular bar is presented in the Table 5.

Appearance

Sight has a major role in the assessment of the appearance and this character indicates the first impression of food. Three treatments of granular bars were scored for selecting best filling for granular fruit bar. The highest score was obtained for T_1. Appearance of the three treatments showed significant difference in their values. The highest mean score of 8.07 was obtained for T_1. The lowest mean score was obtained for T_3 (6.27). Mean score of T_2 was 6.6.

Colour

Colour is used as an index to the quality of a number of foods. The product developed from the three treatment showed difference in their colour. Treatment 1 obtained highest mean score (7.93). T_2acquired 6.47 and T_3 noticed with lowest mean score of 6.13.

Flavour

The flavor of food has three components- odour, taste and a composite of sensation known as mouth feel. A substance which produces odour must be volatile and the molecules of the substance must come in contact with receptors in the epithelium of the olfactory organ. Aroma is able to penetrate even beyond the visual range when comparatively volatile compounds are abundant.

Flavour of the three treatments showed difference in their values. From this table, it is evident that T_1 scored highest mean score of 8.07, followed byT_2 (6.73) and T_3 (6.26).

Texture

Texture refers to those qualities of a food that can be felt with the fingers, tongue, palate, or teeth. Foods have different textures, such as soft or hard, mushy or crunchy, or smooth or lumpy. The granular fruit bars developed as three treatments varied in their scores and T_1 showed maximum score of 7.87 and lowest score was secured by T_3 (5.8). Mean sore attained for T_2 was 6.13.

Taste

Taste in the sensation which the taste buds and register are recognized as sweet, salt, sour or bitter. The concentration required for identification is known as "threshold" for that particular substance. Individual differences occur in sensitivity to the four taste sensations and the threshold for each of the primary taste is usually not at the same level in any one individual. Maximum taste was recognized in T_1 (8.47). The three treatments shows significant difference in their values.

Overall acceptability

Overall acceptability was computed based on sensorial qualities. Granular bar developed from T_1had the highest acceptability scored 8.2 and the three treatments differ in their scores.

Sensorial evaluation of the selected three treatments showed that there was significant difference between the sensorial characteristics like appearance, colour, flavor, texture, taste and overall acceptability. From the sensory evaluation, it is observed that T_1 obtained highest rank in all sensory parameters when compared to T_2 and T_3. T_1 also had higher nutrient content, chemical score and NDP Cal%. Finally T_1 was selected as the best filling and fruit bars from pineapple, papaya and blended bar were the outer coats for the final product.

Table 5. Sensory evaluation of developed filling of granular fruit bar

Treatments	Appearance		Colour		Flavour		Texture		Taste		Over all acceptability	
	Mean rank	Mean Score	Mean rank	Mean Score	Mean rank	Mean Score	Mean rank	Mean Score	Mean rank	Mean Score	Mean rank	Mean Score
T_1	34.60	8.07	34.43	7.93	33.67	8.07	34.23	7.87	36.43	8.47	35.30	8.2
T_2	18.87	6.6	19.10	6.47	19.90	6.73	18.47	6.13	17.67	6.2	19.13	6.67
T_3	15.53	6.27	15.47	6.13	15.43	6.26	16.30	5.8	14.90	5.8	14.57	6.07
K value	19.35		48.44		17.129		17.55		24.69		22.01	
$\chi^2_{(0.05)}$	5.991											

4.3 Development of final RTE product

The formulated outer fruit bar coat was cut into pieces and best filling T_1 identified was pressed in layers and designated as granular fruit bars (GFB) coated with pineapple fruit bar (A_1) GFB coated with papaya fruit bar (A_2) and GFB coated with blended fruit bar (A_3). The products were packed in laminated covers for further investigation.

4.4 QUALITY EVALUATION OF GRANULAR FRUIT BARS (GFB)

Sensory acceptability, chemical and nutritional composition and shelf life of the products A_1, A_2 and A_3 were conducted. Sensory acceptability of the products were ascertained by a 10 semi trained panel members using hedonic rating scale. The results of the sensory appeal is presented in the Table 6.

4.4.1 Sensory evaluation of GFB

Appearance

Among the three GFBs, A_2 was observed with highest mean rank of 24.45. Lowest mean rank of 6.55 was noted with A_3. A_1 had mean rank of 15.50. Significant difference was observed among the three products.

Colour

Colour of three products varied in mean ranks. The maximum mean rank was recorded for A_2 (25.50). A_1 and A_3 obtained the same mean rank of 10.50.

Flavour

As per flavor evaluation, mean rank scores of three products ranged between 5.50 to 21.03. A_2 had the highest mean rank of 21.03. The mean rank scores of A_1 and A_3 were 20.01 and 5.50 respectively.

Table 6. Sensory evaluation of granular fruit bars

Treatments	Appearance	Colour	Flavour	Texture	Taste	Over all acceptability
	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank
A_1	15.50	10.50	20.01	8.50	18.50	15.80
A_2	24.45	25.50	21.03	25.50	22.50	25.20
A_3	6.55	10.50	5.50	12.50	5.50	5.50
K value	22.63	21.94	21.21	22.88	22.54	27.17
$\chi^2_{(0.05)}$	5.991					

Texture

The scores obtained for three GFBs varied significantly, texture scores ranged between 25.50 to 8.50. Highest mean rank was noted for A_2 (25.50) and least score observed with A_1 (8.50).

Taste

Taste of each GFB was assessed and the mean score was recorded. A_2 was distinguished with a superior score of 22.50, followed by A_1 (18.50) and A_3 (5.50).

Overall acceptability

From the sensory evaluation of three products of granular fruit bars, it was revealed that A_2 obtained the highest score for overall acceptability. A_1 and A_3 scored 15.80 and 5.50 respectively. In short, A_2that is GFB coated with papaya fruit bar was distinguished with high mean scores for appearance, colour, flavor, texture, taste and overall acceptability.

4.4.2 Chemical and nutritional composition

Chemical components

Chemical components provide information about the nature of the product, their quality and susceptibility deterioration. Chemical constitution of the granular fruit bars are presented in the table 7.

Table 7. Chemical components of GFB (100g)

Treatments	TSS (°Brix)	Reducing sugar (%)	Polyphenols (mg)	Acidity (%)
A_1	78.2	75.23	1.29	1.32
A_2	77	73.56	4.21	1.28
A_3	78	74.82	2.23	1.24
CD (0.05)	0.094	0.017	0.416	0.013

(Values are mean of three replications)

Total soluble solids (TSS)

Total soluble solids of granular fruit bars ranged from 77°B to 78.2°B. Highest TSS content was recorded for A_1 (78.2°B) and lowest content was noted for A_2 (77°B). The three treatments varied significantly.

Reducing sugar

Considering the reducing sugar levels of the three GFBs A_1 had75.23%, A_2had 73.56% and A_3 had 74.82%. Reducing sugar content of the three GFBs exhibited significant difference in their values.

Polyphenols

Polyphenols are secondary plant metabolites with an aromatic structure containing two or more hydroxyl groups. They are prevalent in fruits, vegetables, cocoa and beverages such as tea, coffee and wine (Han *et al.*, 2007).Polyphenol contents of three treatments varies significantly. A_2 had highest polyphenol content of 4.21mg. Polyphenol contents of other two treatments A_1 and A_3 were 1.29mg and 2.23mg respectively.

Acidity

Acidity of granular fruit bars were founds to lays between 1.24 to 1.32 per cent and the values were seen to vary significantly. Papaya coated granular fruit bar (A_1) showed the highest acidity of 1.32 percent while blended bar coated granular fruit bar showed the lowest acidity content of 1.24 per cent.

Nutrient composition of granular fruit bars

Nutrients are components of food that must be supplied to the body in suitable amounts. These include carbohydrates, fat, proteins, minerals, vitamins and water. Nutrient contents present in the granular fruit bars are presented in the table 8.

Table 8. Nutrient proportion of GFB (per 100g)

Treatments	**Moisture (%)**	**Protein (g)**	**Carbohydrate (g)**	**Energy (Kcal)**	**Fat (g)**	**Fiber (g)**
A_1	11.33	11.14	72.91	367.07	3.43	1.08
A_2	19.35	10.32	62.71	335.62	3.51	1.12
A_3	20.02	11.52	63.62	332.33	3.53	1.31
CD (0.05)	0.498	0.014	0.016	0.017	0.014	0.014

Moisture

Moisture content influences the physical and chemical aspects of food which in turn influence the freshness and stability. The ANOVA table indicates that there was significant difference between the three treatments of granular fruit bars. The highest moisture content was observed for A_3 (20.02%) and the lowest content was noted for A_1 (11.33%).

Protein

Protein is defined as a nitrogen containing constituent of food which means to take first place. It needed for growth, maintenance and repair of body tissues; it regulates the key processes within the body. The statistical analysis elicited that there was significant difference between the treatments of granular fruit bars. The protein content was found to be maximum for A_3 (11.52g) and minimum for A_2 (10.32).

Carbohydrate

Carbohydrates are sugars or polymers of sugars such as starch, that can be hydrolysed to simple sugars by the action of digestive enzymes or by heating with dilute acids. The ANOVA table revealed that there was significant difference among the carbohydrate content of the three products. High carbohydrate content was recorded for A_1 (72.91g)and lowest value was observed for A_2 (62.71g). A_3 had 63.62g.

Energy

Energy is a precisely defined property of chemical compounds and other physical systems. Granular fruit bars developed from three treatments were varied significantly in their energy content. Energy content was observed the maximum for A_1 (367.07 Kcal) and minimum content for A_3 (332.32 Kcal). A2 had 335.52Kcal.

Fat

The term fat is used to describe the fatty component of food. The fat content of granular fruit bars showed significant difference. Fat content was found to be higher in A_3 (3.53g) and lower in A_1 (3.43g) per 100g of product.

Fiber

Fibre is that portion of food derived from plant cells that is resistant to hydrolysis/ digestion by the elementary enzyme system in human beings. It

include hemicelluloses, cellulose, lignins, oligosaccharides, pectins, gums and waxes. Maximum fiber content was observed for A_3(1.31g)and minimum content was noted for A_1 (1.08g).

Mineral contents of granular fruit bars

Mineral contents in the three granular fruit bars were analysed and are presented in the table 9.

Table 9. Mineral content in GFB (per 100g)

Treatments	Total minerals (g)	Calcium (mg)	Iron (mg)	Sodium (mg)	Potassium (mg)
A_1	3.22	46.28	7.33	535.25	45.77
A_2	3.73	42.13	6.63	583.26	44.02
A_3	3.94	62.42	8.53	635.52	45.03
CD (0.05)	0.017	0.107	0.014	1.328	0.017

Total minerals

Ash content represents the total mineral content in foods. The total mineral contents of granular fruit bars varied significantly. Maximum value of 3.94g was present in A_3 and minimum observed for A_1 (3.22g).

Calcium

Calcium is a major element in the body and an adult man of 60kg has nearly one kilogram of calcium. Almost 99 per cent of this calcium is found in the hard tissues of the body namely the bones and teeth. Calcium content in GFBs revealed that A_3 (62.42mg)had the highest amount of calcium and A_2 had the lowest amount of calcium (42.13mg). The value for A1 was 46.28 mg.

Iron

Iron content of granular fruit bars varied significantly. The values ranged from6.63mg to 8.53mg per 100g. The highest iron content was noted for A_3 (8.53 mg) and least content was recorded for A_2 (6.63 mg).

Sodium

Sodium is a major cation in extracellular fluid, water balance and acid base balance. Sodium content of the three products varied significantly among the three treatments, maximum content was noted for A_3 (635.52 mg). Least content was found in A_1 (535.25 mg).

Potassium

Potassium is a major cation in intracellular fluid, water balance, protein synthesis and acid base balance. Potassium content of the three products ranged between 44.02 to 45.77mg. The highest potassium content was noted for A_1 (45.77 mg) and least content was noted for A_2 (44.02 mg).

Vitamin content in granular fruit bars

Vitamin content (vitamin C and β Carotene) present in the GFBs were analysed and presented in the table 10.

Table 10. Vitamin content in GFB (per 100g)

Treatments	Vitamin C (mg)	β Carotene (µg)
A_1	22.31	21.40
A_2	18.14	269.79
A_3	23.38	262.76
C.D (0.05)	0.19	1.030

Vitamin C

The chemical name for vitamin C is ascorbic acid and it is also known as hexuronic acid and antiscorbutic nutrient. The statistical analysis of data showed that vitamin C content of three granular fruit bars varied significantly. The mean vitamin C content of$A_1$was 22.31mg/100g, A_2 (18.14mg/100g) and A_3 (23.38mg/100g).

β – carotene

Beta carotene is widely available in fruits, vegetables and dairy fats and is converted to retinol in the body. Amount of protein and fat in the diet and variations in digestive function influence the bioavailability of β – carotene. The ANOVA table elicited that there was significant difference in β – carotene content of the three granular fruit bars vizA_1 (21.40µg/100g), A_2 (269.79µg/100g) and A_3 (262.76µg/100g).

4.4.3 Shelf life of granular fruit bars

The developed granular fruit bars were packed in laminated pouches and were stored at ambient temperature for 3 months. Changes in moisture, sensory appeal and microbial growth if any was recorded at monthly intervals.

Moisture content of stored granular fruit bars

Moisture can be very damaging to the stored life of food when it is found in inappropriate amounts. The moisture content of granular fruit bars were recorded periodically up to 3 months and the data presented in the table 11.

Table 11. Moisture content in stored GFB

Storage periods	Moisture (%)		
	A_1	A_2	A_3
Initial	11.33	19.35	20.02
First month	12.82	22.12	23.42
Second month	13.28	22.85	23.82
Third month	15.23	23.17	24.56
CD (0.05)	0.025	0.016	0.025

The data showed that the moisture content of three products varied from 11.33 to 20.02% during the initial period. Initially highest moisture content was recorded for A_3 (20.02%) and lowest was observed for A_3 (11.33%).

At the end of first month, moisture content of three treatments ranged between 12.82 and 23.42%. The highest moisture content was noted for A_3 (23.42%) and lowest value observed for A_1 (12.82%).

During the end of second month, moisture content ranged between 13.28 and 23.82%. Highest moisture content was recorded for A_3 (23.82%) and lowest noted for A_1 (13.28%).

At the end of third month, moisture content of granular fruit bars ranged between 15.23 and 24.56%. A_3 has highest moisture content 24.56 and A_1 has lowest moisture content 15.23%.

Moisture content of the products were found to be increased during the storage period. There was significant difference in the moisture content of the products during storage at 5 % level.

Changes in acidity of granular fruit bars during storage

Results of evaluation of the acidity of granular fruit bars during the storage period of 3 months are presented in Table 12.

Table 12. Changes in acidity of stored GFB

Storage periods	Acidity (%)		
	A_1	A_2	A_3
Initial	0.82	1.05	0.54
First month	1.24	1.15	0.86
Second month	1.28	1.19	1.12
Third month	1.33	1.28	1.24
CD (0.05)	0.016	0.096	0.016

In all the three treatments, acid content was found to increase gradually during storage period and these three products exhibited significant difference at 5 per cent level. Acidity of A_1 ranged between 0.82- 1.33%. In the case of $A_2$the acidity ranged between 1.05-1.28%. In A_3, the acidity ranged between 0.54-1.24%.

During the initial month of storage, acidity of A_2 (1.05%) was higher and lowest content noted for A_3 (0.54%). At the end of first month, highest acid content was recorded for A_1 and minimum content was observed for A_3 (0.86%). During the second month of storage, A_1 (1.28 %) recorded maximum value for acidity and A_3(1.12%) acquired minimum acidity. At the end of third month, high acidity of 1.33% was seen for A_1 and least acidity noted for A_3 (1.24%).

Changes in sensory appeal during storage of granular fruit bars

The products prepared were susceptible to changes in sensory parameters during storage due to various factors like temperature, packaging system. In order to check whether storage had any negative influence on the acceptability, the granular fruit bars prepared were assessed monthly interval for variations in sensory qualities like appearance, colour, flavor, texture, taste and overall acceptability by a panel of semi trained members.

The observations of sensory evaluation at various storage periods for A_1, A_2 and A_3 are given in the Table13., Table 14. and Table 15.

Appearance

Granular fruit bars showed a reduction in scores for appearance on storage. From the sensory evaluation of A1 during storage, it was observed that initial values 24.45 for appearance was decreased to 6.42 after second month of storage whereas in A_2 the initial score of 23.01, decreased to 5.50 in second month. In the case of A_3 the scores showed a decrease from 23.03 to 5.50. There was significant difference observed between the appearance scores of A_1, A_2 and A_3 during storage.

Colour

Statistical analysis of data in table.13.,14.,15.revealed that there was gradual decrease in colour scores during storage A_1 showed a decrease in scores from 25.05 to 6.62 by second month. A_2 and A_3 also showed the same trend. Significant difference was observed in the values of colour scores during storage period.

Flavour

A notable decline in the flavor rating of the products was experienced during the course of storage. The flavor scores of $A_1$and A_2 decreased from 25.50 to 5.50, A_3decreased from 21.50 to 5.50 scores. The mean value showed that there was significant difference in the scores during storage.

Texture

Acceptable scores of texture was found only in the initial months of storage, afterwards the scores were found to decrease. Statistical analysis showed significant difference among the scores. The texture of A_1 displayed a decrease in acceptability during the storage period. During the initial period of storage A_1 scored 24.60 for texture which decreased to 6.90 during the second month of

Table 13. Sensory evaluation of pineapple bar coated GFB (A_1) during storage

Particulars	Appearance	Colour	Flavour	Texture	Taste	Over all acceptability
	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank
Initial	24.45	25.05	25.50	24.60	24.72	25.50
First month	15.65	14.90	15.50	15.01	16.30	21.03
Second month	6.42	6.62	5.50	6.90	5.50	7.01
K value	22.80	23.80	27.04	22.16	25.67	25.11
$\chi^2_{(0.05)}$	5.991					

Table 14. Sensory evaluation of papaya coated GFB (A_2) during storage

Particulars	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Over all acceptability**
	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank
Initial	23.01	24.75	25.50	25.40	25.10	25.50
First month	18.02	16.25	15.50	15.60	15.90	15.50
Second month	5.50	5.50	5.50	5.50	5.90	5.50
K value	23.16	25.13	26.69	27.33	25.96	28.36
$\chi^2_{(0.05)}$	5.991					

Table 15. Sensory evaluation of blended bar coated GFB (A_3) during storage

Particulars	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Over all acceptability**
	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank
Initial	23.03	21.72	21.50	24.01	24.30	21.02
First month	18.02	19.30	19.50	17.03	16.70	20.03
Second month	5.50	5.50	5.50	5.50	5.50	5.50
K value	32.59	21.36	21.69	24.86	24.77	27.37
$\chi^2_{(0.05)}$	5.991					

storage. A_2 decreased from 25.40 to 5.50 and A_3 decreased from 24.01 to 5.50 scores.

Taste

On analysing taste scores of GFBs, it was seen that storage period badly affected the taste of granular fruit bars. Towards the second month of storage, a drastic decreasing in score noted for taste of A_1, A_2 and A_3.

Overall acceptability

A significant difference was seen in the overall acceptability of the products A_1,A_2 and A_3 during the storage period. Acceptability scores of the product declined with increase in storage period. Considering the overall rating of GFBs, product is well acceptable for one month.

Microbial evaluation of GFB

Microbial analysis of the stored products were done to ensure the shelf life of the products. Microbial evaluation of products is important because it determines the quality and safety of food products. The microbial safety of food was achieved by ascertaining the absence of pathogenic organisms and by all means of preventing their multiplication (Beckers, 1988).

The products were stored at ambient conditions for three months. The microbial evaluation was conducted initially and at 30 days intervals up to three months. Microbial population of granular fruit bars were evaluated by serial dilution of the samples followed by pour plating techniques suggested by Johnson and Curl (1972).The growth of bacteria, fungi, actinomycets and E-coli were determined using Nutrient Agar, Rosebengal, Kenights Agar and Eosin methylene blue (EMB). From the microbial evaluation it was revealed that bacterial and fungal colonies were present in the sample.

Table 16. Bacterial profile of granular fruit bars (cfu /g)

Products	Initial	After first month	After second month
A_1	ND	5	52
A_2	ND	5	45
A_3	ND	6	44

(Results are expressed as mean values of replications) ND-Not detected

From this table it is evident that in 1×10^{-7} dilution, no bacterial colonies were found to appear in the initial period. But after first month there was bacterial colonies seem to appear. It was observed that number of colonies were increased after second month and this exceeded the safe limit of microbial count for consumption. Safe limit of microbial count in food was found to be 45,000 I U suggested by (Microbial safety of Indian regulations, 2001).

Fungal profile of granular fruit bars (cfu /g)

Table 17. Fungal colonies present in GFB

Treatments	Initial	After first month	After second month
A_1	ND	ND	3
A_2	ND	ND	4
A_3	ND	4	2

(Results are expressed as mean values of replications) ND-Not detected

From the above table, it can be concluded that there was no fungal colonies in the initial period. But product (A_3) developed a few colonies after first month. After, second month fungal growth was seen in all products after second month.

4.5 CONSUMER ACCEPTANCE OF THE GRANULAR FRUIT BARS

The mean values of acceptability scores given by 50 consumers by testing various quality parameters of granular fruit bars using nine point hedonic rating scale are summarised in Table.

Table 18. Consumer acceptance of GFB

Rating scale	Scores	Number (%) of granular fruit bars		
		A_1	A_2	A_3
Like extremely	9	18(36)	25(50)	12(24)
Like very much	8	12(24)	15(30)	8(16)
Like moderately	7	8(16)	10(20)	10(20)
Like slightly	6	7(14)	–	5(10)
Neither like or dislike	5	–	–	15(30)
Dislike slightly	4	–	–	–
Dislike moderately	3	–	–	–
Dislike very much	2	–	–	–
Dislike extremely	1	–	–	–

Figures in parenthesis denote number of consumers

From the above table, it is clear that product A_2 (papaya bar coated granular fruit bar) was liked extremely by maximum number of subjects. Fifty per cent consumers liked papaya bar coated granular fruit bar, while 36 per cent liked pineapple bar coated GFB and 24 per cent liked blended bar coated GFB. It can be seen that papaya bar coated granular fruit bar (A_2) was found to be more acceptable to consumers when compared to the other two products of granular fruit bars.

4.6 COST ANALYSIS OF GRANULAR FRUIT BARS

Cost of the prepared products were calculated to realize the economic feasibility of the developed granular bars. The cost analysis was carried out based on the input cost, i.e. the cost of different ingredients used for the development of

GFB and output cost i.e. the total input cost with an addition 20 per cent as overhead charges for fuel and labour. Cost of granular fruit bars computed in given in the table 19.

Table 19. Cost of GFB

Name of the products	**Cost (Rs. per 100g)**
Pineapple granular bar (A_1)	36.63/-
Papaya granular bar (A_2)	18.75/-
Blended granular bar (A_3)	31.53/-

The cost of papaya bar coated GFB was comparatively less, that is Rs. 18.75/, the cost of pineapple bar coated granular fruit bar high Rs. 36.63/- and the cost of blended fruit bar coated GFB was Rs. 31.53/-.

Discussion

5. DISCUSSION

The results of present investigation entitled "Development and quality evaluation of granular fruit bars" are discussed below:

5.1 Step I. Development of outer coat of the granular fruit bar

5.2 Step II. Standardisation of filling for granular fruit bar

5.3 Step III. Development of final RTE product

5.4 Quality evaluation of the developed RTE product

5.4.1Sensory evaluation of granular fruit bar

5.4.2 Chemical and nutritional composition of the granular fruit bar

5.4.3 Shelf life of granular fruit bars

5.4.4 Consumer acceptance of the granular fruit bars

5.4.5 Cost analysis of the granular fruit bar

5. 1. STEP I. DEVELOPMENT OF OUTER COAT OF THE GRANULAR FRUIT BAR

Fruit leathers or bars can be simply defined as dried sheets of fruit pulp that have a soft, rubbery texture and a sweet taste. The edible portion of fruit is pulped, pureed, mixed with different ingredients to improve its physicochemicaland sensory characteristics. These are then heated, formed and dried on flat trays until cohesive fruit leather is obtained. Fruit leathers can be eaten as snack foods or added to a variety of food preparations (Raab and Oehler 1999).

Fully ripened pineapple and papaya were collected and extracted fruit pulp was used .individually and in combination in order to standardize outer coat of granular fruit bars adding food adjuncts such as sugar and pectin (1 to 2 per cent)

to obtain fruit bar of good texture. Three fruit bars were developed viz. pineapple fruit bar (T_1), papaya fruit bar (T_2) and blended fruit bar (T_3). Drying characteristics such as moisture loss, drying time, yield ratio and TSS of fruit pulp and fruit bars were recorded. Pineapple bar (T_1) and blended bar (T_3) were dried at 60°C for 20 hours while papaya bar (T_2) dried at 60°C for 12 hours. Moisture loss and TSS was found higher in T_1 39.50% and 76°B respectively. High yield ratio recorded for T_2 (0.81). TSS of fruit pulp was 14°B for pineapple and blended bar and 13°B for papaya bar.

5. 2. STEP II. STANDARDISATION OF FILLING FOR GRANULAR FRUIT BAR

Standardization is a process of ensuring uniformity in products and services by use of appropriate standards (Ombui, 2013). It is important to ensure standardization of products. When extra ingredients are added or are portioned incorrectly, there may be a change in the cost to produce that product (USDA, 2017). According to Liaqt *et al* (2009), standardisation is important to achieve optimal accuracy in determining the nutrient estimation. In the present study, the product was standardised by varying ingredients. T_1 developed with 30g rice flakes, 25g puffed rice, 10g oats, 5g puffed Bengal gram dhal, 5g ground nuts, 20g jaggery and 5g osmotically dehydrated jackfruit was chosen as the best filling based on sensory evaluation, nutrient content, chemical score and NDP Cal%.

5. 3. STEP III. DEVELOPMENT OF FINAL RTE PRODUCT

Snack bars are convenient products usable to healthy people and also they consist of a compact product to supply energy and micronutrients to people in areas of the world that suffer famine. The ingredients must be combined appropriately to ensure that they complement each other with regard to flavor, texture and physical properties (Izzo and Niness, 2001). Final RTE granular fruit bar (GFB) was produced by identified best filling pressed in layers with the formulated outer fruit bar coat.

5. 4. QUALITY EVALUATION OF GRANULAR FRUIT BARS (GFB)

Food quality is a major concept due to the food people choose largely based on the quality. Quality is difficult to define precisely, but it refers to the degree of excellence of a food and consists of all the characteristics of a food that are significant and that make the food acceptable (Vaclavik *et al.*, 2008). Food quality indicates both sensory parameters that are readily distinguished by the human senses and hidden attributes such as safety and nutrition that need sophisticated instrumentation to measure. In a marketing point of view, a product can be sold at better price if it is perceived to be a good quality product (Jha, 2010).

In the present investigation, developed granular fruit bars (A_1, A_2 and A_3) were assessed for its sensory acceptability, chemical and nutritional composition and shelf life of the products.

5. 4. 1. Sensory evaluation

The area of sensory analysis grew rapidly in the second half of twentieth century, along with the elaboration of the processed food and consumer products industries. Sensory evaluation aim at separate sensory properties of foods themselves and distributes important and useful information to product developers, food scientists, and managers about the sensory qualities of their products (Lawless and Heymann, 2010). Sensory evaluation has been defined as a scientific method used to evoke, measure, analyse and interpret those responses to products as perceived through the senses of sight, smell, touch, taste and hearing (Stone and Sidel, 2004). Sensory evaluation of RTE granular fruit bars revealed that there were differences in scores of each sensory characters.

5. 4. 2. Chemical and nutritional composition

All foods are made up of different chemical substances. Some of these substances are simple in nature while others are complex. Some substances are predominant while others are present in smaller amounts. All this together makes

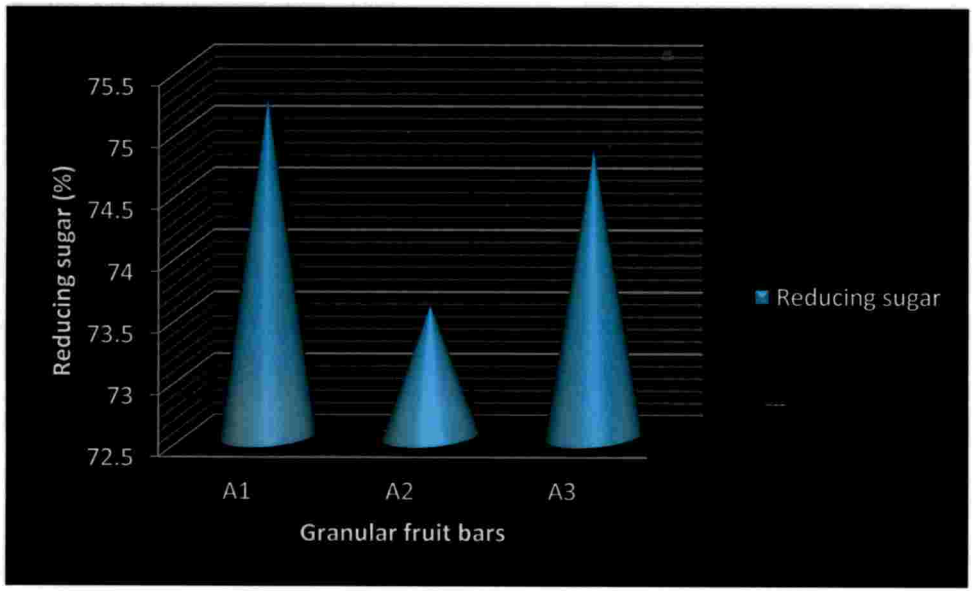
the food a very complex mixture (Sathe, 1999). Food analysis is a part in continuous evolution, which is especially impelled by the increasing demand of consumers for food safety and quality, the concern of food authorities to establish safe food of the highest nutritional quality, and the effort of producers and industry to acheive these demands (Pico, 2012). Carbohydrates, proteins and fat form the major class of compounds. Minerals and vitamins are present in lesser amounts in foods. Water is present in varying amounts ranging from very high amounts in some food to very low amounts in other foods.

The total soluble solids (TSS), showed as a percentage of fresh matter mass, shows high positive correlation with sugars content, and is thus generally accepted as an important quality trait of fruits (Silva *et al.*, 2006). Total soluble solids in the GFB in present study was ranged from 77°B to 78.2°B.

All monosaccharides, oligosaccharides (with a few exceptions) and other glucose polymers such as starch and cellulose are named 'reducing sugars' (RS) because they contain reducing ends (Campbell and Farrell, 2012) Measurements of the concentration of reducing ends in a sample can give very valuable information, such as concentrations of sugar in different foods and beverages, the lactose content in milk, the activity of an enzyme on cellulose and starch (Melander *et al.*, 2007). Reducing sugar content of GFB ranged from 73.56% to 75.23% (Fig. 3) and significant difference was observed between the values.

Polyphenols are compounds with aromatic structure, with one or more hydroxyl groups, which undergo physical and chemical changes by action of enzymes and chemical reactions in plants caused by the activity of other active components, such as coumaroyl and malonyl co enzyme A. These changes contribute to the process of maturation and physical alterations of the fruits (El-Ramady *et al.*, 2015). Significant difference was observed in the polyphenol contents of GFB and it was ranged from 1.29mg to 2.23mg.

Figure 3. Reducing sugar content in granular fruit bars



Litaf *et al* (2014) reported that acidity of apple leather developed using different concentration of apple pulp and sugar ranged from 0.15 to 0.20 per cent. In the present study acidity of GFB ranges from 1.24 to 1.32 per cent.

All foods contain between 60-95 per cent of moisture. In animal or plant tissue it remains present either in the free form (absorbed) or bound form (combined or absorbed). The free form is the most prevalent one and it can be liberated. In the bound form it can be present in combination with a protein or sugar molecule or can remain absorbed over colloidal particles (Sathe, 1999). Take *et al* (2012) reported that moisture content in fortified sapota-papaya fruit bar ranged from 14.64 to 15.91 per cent in 4 different treatments. Moisture content in GFB ranged from 11.33 to 20.02 per cent (Fig. 4).

Take *et al* (2012) opined that the protein content of sapota-papaya bar was increased gradually from 1.17 to 1.85 per cent with the increasing amount of skim milk powder whereas the protein content of fruit bar without addition of skim milk powder was found to be 0.8 per cent. Protein content in GFB was found to be maximum for A_3 (blended fruit bar coated GFB) i.e 11.52g/100g.

Durkee *et al* (2006) reported that total carbohydrate content in snack bars with bean-based filling ranges from 62 to 64g. According to Campagnol and Pereira (2016),the carbohydrates levels ranged from 71.33 to 72.80%, and this higher percentage was due to the high concentration of cereals, invert sugar, crystal sugar and glucose syrup in the cereal bars formulation. Lima *et al* (2012) found that carbohydrate levels ranging from 60 to 97% in cereal bars, due to the different ingredients and proportions used in each formulation. Carbohydrate content in GFB varies from 62.71g/100g to 72.91g/100g.

Sharanyarani (2011) pointed out that grain amaranth based nutrient rich snack bars contains 341.6Kcal of energy. GFB developed in present investigation contains energy which ranged between 332.32Kcal to 367.07Kcal.

Figure 4. Moisture content in granular fruit bars

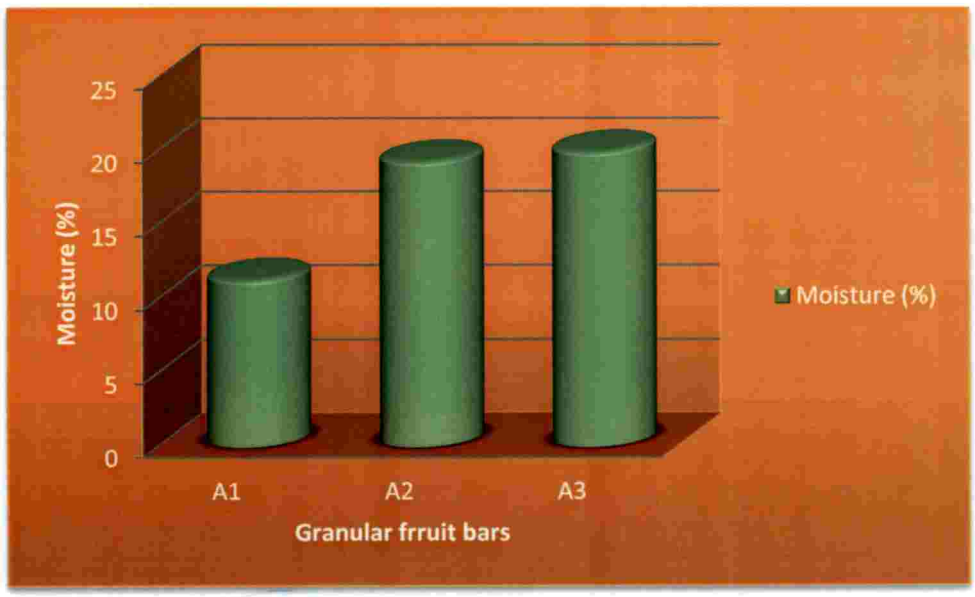


Figure 5. Major nutrients present in granular fruit bars

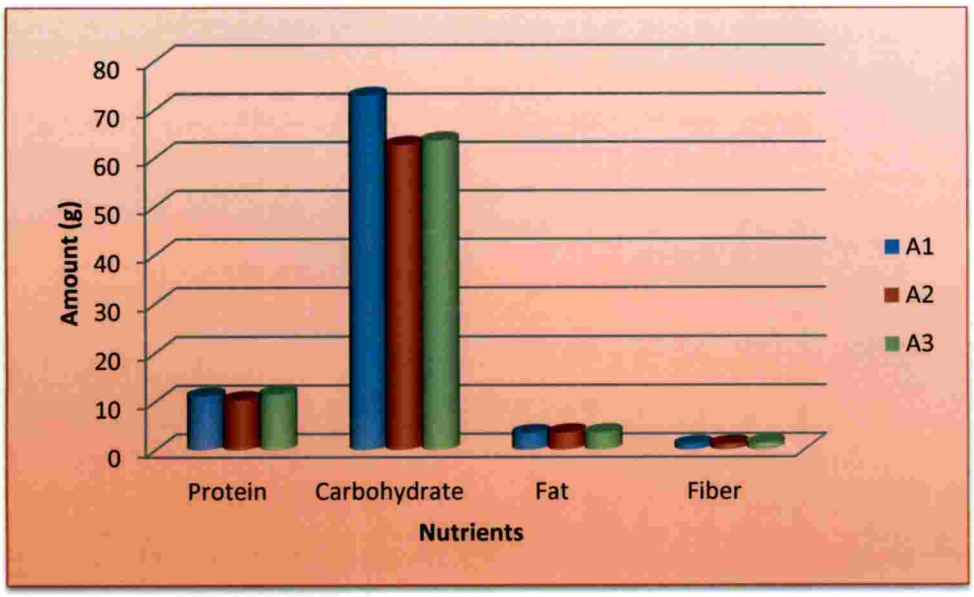
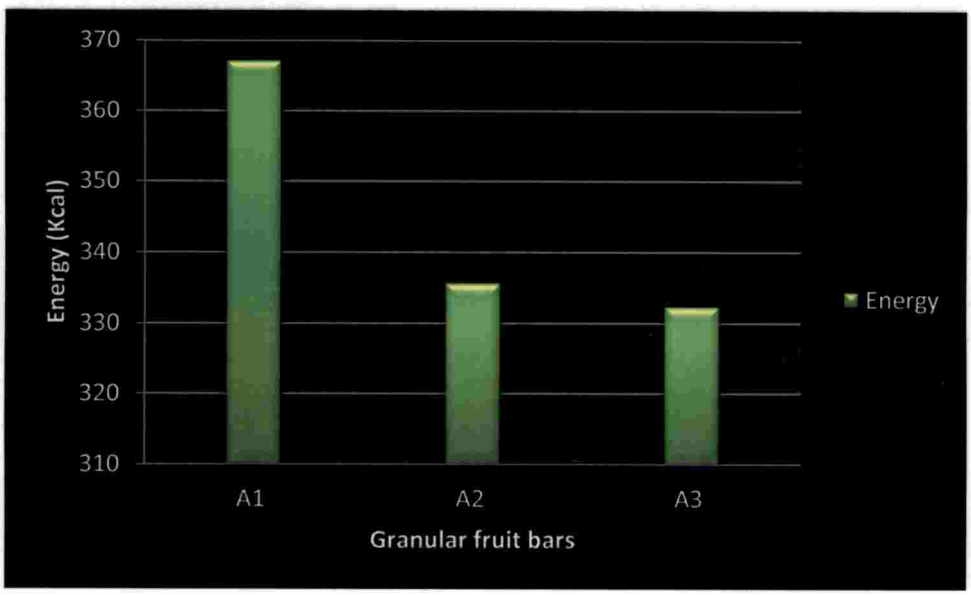


Figure 6. Energy content in granular fruit bars



Fat content in GFBS ranged from 1.08g/100g to 11.31g/100g. Sharanyarani (2011) found that grain amaranth based nutrient rich snack bars contains 2.8g of fat.

Campagnol and Pereira (2016) reported that a completely randomized design was used with four treatments, as follows: Control (0% flour); T1 (3% flour); T2 (6% flour); and T3 (9% flour), for the variables moisture, ash, protein, fat, crude fiber and carbohydrates. It was revealed that the higher the pineapple peel flour content, the greater the crude fiber content in the cereal bars was, evidencing the significant amounts of crude fiber in the pineapple peel. Higher fiber content was observed in A_3 (Blended fruit bar coated GFB).

Total mineral content in GFB ranged from 3.22g to 3.94g per 100g of the product (Fig.7). Gupta *et al* (2013) reported that sugar content lowers the ash content. This implies that temperature had no effect on the ash content of leathers. The ash content is a measure of the total amount of minerals present within a food. High mineral contents are sometimes used to retard the growth of certain microorganisms and can have beneficial effects on the physicochemical properties of foods.

A study conducted by Karki (2011) revealed that the cooking process required to make blueberry fruit leather resulted in a significant increase in several of the major minerals when compared to fresh fruit, magnesium increased 69%, calcium increased 39% and potassium increased 44%.

Calcium, iron, sodium and potassium contents in developed GFB ranged from 46.28mg-62.42mg, 6.63mg-8.53mg, 535.25mg-635.52mg respectively for 100g of the product.

Vitamins are a group of organic compounds, that are in very small amounts essential for the normal functioning of the human body (Ball, 2006). β carotene and vitamin C content in GFB were ranged from 21.40µg to 269.79µg (Fig. 8) and 18.14mg to 23.38mg (Fig. 9) respectively.

Figure 7. Total minerals present in granular fruit bars

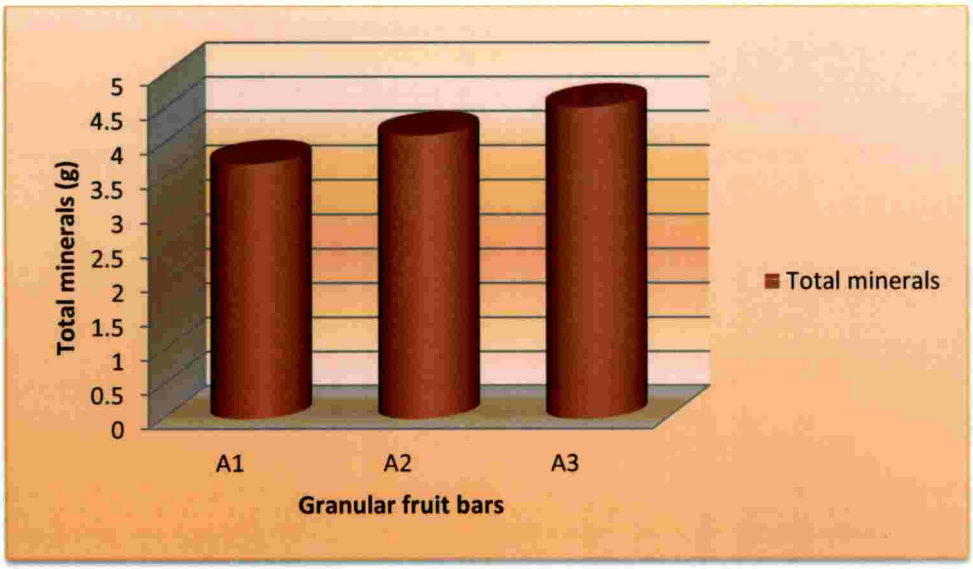


Figure 8. Vitamin C content in granular fruit bars

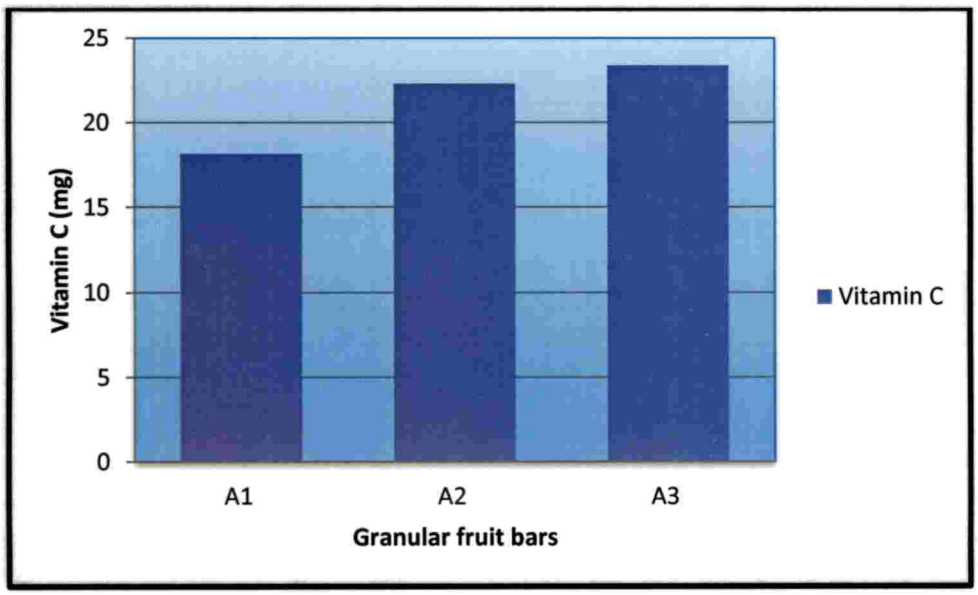
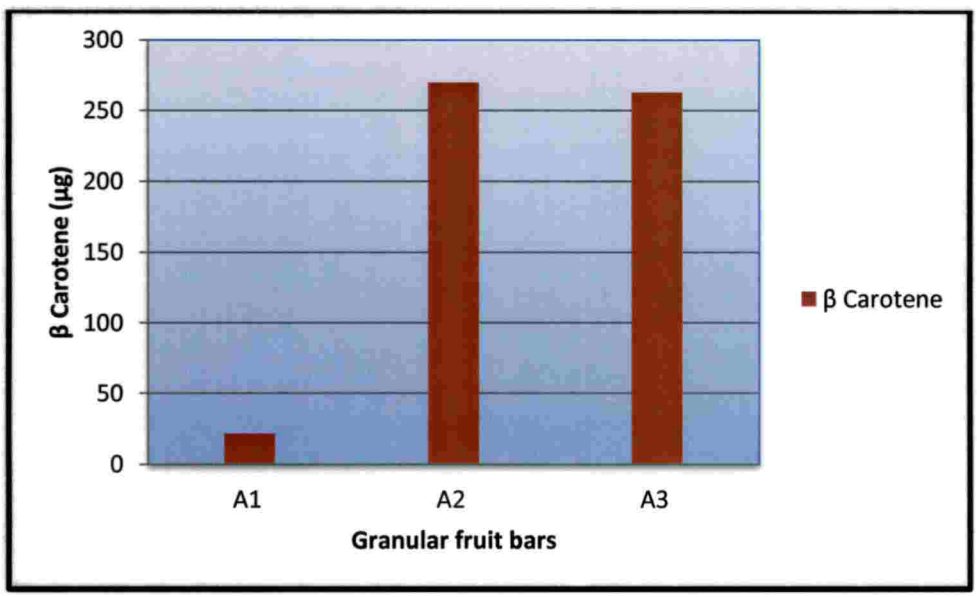


Figure 9. β – carotene content in granular fruit bars



5. 4. 2 Shelf life of GFB

Shelf life is a finite length of time, after manufacture and packaging, during which the food product retains a required level of quality acceptable for consumption (Nicoli, 2012). Changes in moisture, sensory appeal and microbial growth if any in GFB were examined monthly to a period of three months.

5. 4. 2. 1 Moisture content of stored GFB

The acceptable level of moisture vary in different food products and change in this amount can have serious effects on product quality. Moisture removal or dehydration as long been used as a technique for improving food storage stability. Small increase in the moisture of low and intermediate moisture food can reduce the shelf life of the products.

Litaf *et al* (2014) reported that the initial moisture content of apple leather was T_0 to T_5 was 15.30, 11.68, 14.80, 14.42, 13.97, and 30.40 which was gradually decreased to 12.6, 9.2, 11, 9.5, 6.53, and 20.46 respectively during storage. Attri *et al* (2014) reported that there was increase in the moisture content of papaya bar by 9.9 per cent during three months of storage. In the present study, moisture content of three GFB was found to be increased during the storage period. Moisture content of three products ranged between 12.82 to 23.42%, 13.28 to23.82% and 15.23 to 24.56% during first, second and third month of storage respectively (Fig.10).

5. 4. 2. 2 Changes in acidity of GFB during storage

According to Litaf *et al* (2014) the initial acidity of apple leather of T_0 to T_5 was 0.20, 0.17, 0.107, 0.15, 0.17, and 0.15 which was gradually increased to 3.15, 1.69, 1.165, 1, 0.57, and 0.71 for the period of storage. In all the three products of GFB, acidity was increased gradually during the period of storage. Acidity of A_1(pineapple bar coated GFB), A_2 (papaya bar coated GFB)andA_3 (blended bar coated GFB) were ranged from 0.82 to 1.33%, 1.05 to 1.28% and 0.54 to 1.24% respectively (Fig.11).

Figure 10. Changes in moisture content of granular fruit bars during storage

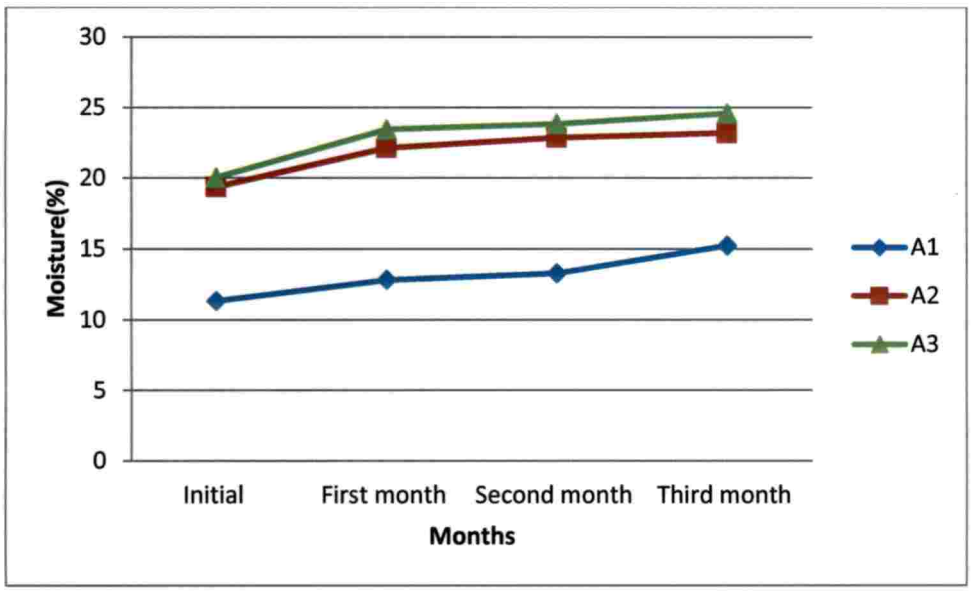
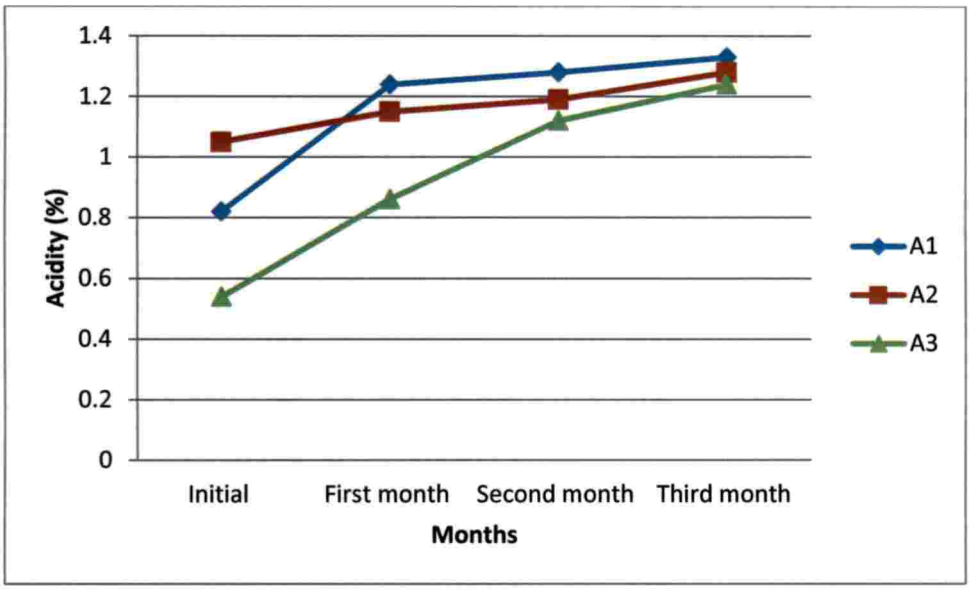


Figure 11. Changes in acidity of granular fruit bars during storage



5. 4. 2. 3. Changes in sensory appeal during storage of granular fruit bars.

Shelf life of the product can be assessed by examine the sensory parameters of the products and therefore sensory analysis considered as a easy method for testing the acceptability of the food products.

The three GFB packed in laminated covers kept for three months of storage. The acceptability of the products were checked periodically during each month of storage. The sensory parameters such as appearance, colour, flavor, texture and taste were found to be decreased with increase in the storage period. Midhila (2013) reported that all the sensory attributes of RTC dehydrated banana blossom was decreased after ninety days of storage.

5. 4. 2. 4. Microbial evaluation of GFB

Spoilage of food is occurred due to the microbial activity of a variety of microorganisms. The microflora that colonizes a particular food bases on the characteristics of the product (composition and pH) and the way it is processed and stored (Singh and Cadvallader, 2004).

Serial dilution followed by spread plating was used to detect the presence of microorganisms. In the present investigation, GFB packed in laminated covers stored at ambient condition showed growth of bacterial and fungal colonies by the end of first month. It was observed that number of colonies were increased after second month and this exceeded the safe limit for consumption. Safe limit of microbial count n food was found to be 45,000 I U suggested by (microbial safety of Indian regulations, 2001).

5.4.4 Consumer acceptance of the granular fruit bars

Consumer awareness and preference decide the success of standardised products. Consumer acceptance was tested among 50 consumers using hedonic rating. Consumer acceptance study of RTE GFB showed that 50 per cent consumers like extremely in papaya bar coated granular fruit bar, while 36 per cent like extremely for pineapple bar coated GFBand 24 per cent like extremely

for blended bar coated GFB. Similar results reported by Gaskell *et al* (2003). Deepika (2016) reported that multinutrient snack bars have been developed using flaked oats, puffed rice, germinated and flaked green gram, malted finger millets, milk powder, roasted peanut and papya was well accepted by consumers.

5.4.5 Cost analysis of the granular fruit bar

Cost of the developed GFBs were analysed based on input and output cost, and it was seen that Rs. 31.53/- (A_3) and Rs. 36.63/- for A_1.

Summary

6. SUMMARY

The present investigation entitled "Development and quality evaluation of granular fruit bars" was carried out for development of RTE granular fruit bars and to evaluate the quality of the product. The objective of study was to develop granular fruit bars using fruit pulp, grains, nuts and pulses and to ascertain sensorial quality, chemical and nutritional composition, shelf stability and consumer acceptability of the products. The experiment was conducted in the Department of Community Science, College of Agriculture, Vellayani, Thiruvananthapuram during the period of 2016-2017. Major findings of this study were summarized below.

In this study, outer coat of granular fruit bars (GFB) were developed using pineapple pulp (T_1), papaya pulp (T_2) and blended fruit pulp (T_3). Food adjuncts such as sugar and pectin were added to obtain good texture. Papaya and pineapple and other ingredients such as pectin and sugar were purchased from the market. Fruit bars were dried in tray drier at 60°C. TSS of fruit pulp and fruit bars were recorded separately. TSS of fruit pulp was ranged from 13 to 14°B and TSS of fruit bar ranged from 74.8 to 76°B. Drying characteristics like moisture loss, drying time and yield ratio was ascertained. Moisture loss was ranged from 19.42% to 39.50%. Drying time of T_1 was on par with T_3 (19.59 hrs). Drying time of T_2 10.84hrs. Yield ratio ranged between 0.66 to 0.81.

The filling for granular fruit bars were standardised using ingredients such as puffed rice, flaked rice, bengal gram dhal, jaggery and osmotically dehydrated jackfruit. These ingredients except osmotically dehydrated jackfruit were purchased from market. Osmotically dehydrated jackfruit developed using the method suggested by (Poornima, 2014). Six different treatments with varying amount of ingredients were formulated for standardisation of GFB. Sensory quality, nutritive value, chemical score and NDP Cal% of each proportion was computed to identify the best combination. Highest nutrient content, chemical score and NDP Cal% were noted for three treatments viz. T_1, T_2 and T_3 and Sensory evaluation was conducted in these three treatments using hedonic rating scale to obtain the best combination. T_1 was identified as best formulation with the highest score of 35.30 and was selected as best filling for GFB.

The formulated outer fruit bar coat was cut into pieces and filled with T_1 (30:25:10:5:5:20:5) and pressed into bars and designated as A_1 (pineapple coated GFB) A_2 (papaya coated GFB) and A_3 (blended bar coated GFB). These products were packed in laminated covers and stored at ambient conditions for three months. Quality parameters such as sensory acceptability, chemical and shelf life of final products were ascertained initially and monthly intervals. Sensory evaluation of final products revealed highest mean rank score for A_2. Chemical and nutritional components of GFB were determined. Polyphenol (4.21mg) was higher in A_2 and all the other chemical components were higher in A_1. TSS recorded for A_1 was 78.2°B, reducing sugar (43.02%) and acidity (1.32%). A_1 has highest fibre content of 0.46g per 100g. The other nutrients, moisture, protein, carbohydrate, energy and fat content were higher in A_3 and was 20.02%, 40.16 g, 115.06 g, 461.0 KCal and 7.71g respectively. A_3 had high total minerals (4.5 g) calcium, iron, sodium and potassium and the values were 2.36 mg, 2.52 mg, 635.52 mg and 45.03 mg respectively. High vitamin C content was observed for A_3 (23.38 mg) and high β carotene content was noted for A_2 (269.798 µg).

Changes in moisture, acidity, sensory appeal and microbial growth if any was recorded monthly. It was observed that there was a gradual increase in moisture and acidity in stored granular fruit bars. Moisture content of three products ranged between 12.82 to 23.42%, 13.28 to 23.82% and 15.23 to 24.56% during first, second and third month of storage respectively. Acidity of A_1 (pineapple bar coated GFB), A_2 (papaya bar coated GFB) and A_3 (blended bar coated GFB) were ranged from 0.82 to 1.33%, 1.05 to 1.28% and 0.54 to 1.24% respectively. A_3 showed highest moisture content and A_1 showed highest per cent of acidity throughout the storage period. Microbial evaluation of GFB, revealed that, no bacterial colonies were seen in (cfu 1×10^{-7}) in dilution initially. Few colonies of bacteria and fungus were seen in first month and number of colonies exceeded the safe limit in second month.

Consumer acceptance study of developed RTE GFB using hedonic rating scale and A_2 was found more acceptable when compared to A_1 and A_3. The product cost was computed and it was found to be Rs. 36.63/- for A_1, Rs. 18.75/- for A_2 and Rs. 31.53/- for A_3.

GFB were nutrient dense, ready to eat product with fruits, grains and pulses with shelf life of one month. The processing is simple, locally available raw materials were used and this can be done at cottage scale.

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ABSTRACT

DEVELOPMENT AND QUALITY EVALUATION OF GRANULAR FRUIT BARS

by

MEGHNA. K

(2015-16-004)

Abstract

Submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE IN HOME SCIENCE
(Food science and Nutrition)

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM-695522

KERALA, INDIA

2017

ABSTRACT

A study entitled "Development and quality evaluation of granular fruit bars" was conducted at the College of Agriculture, Vellayani during the period 2015-17, with the objective to develop granular fruit bars using fruit pulp, grains, nuts and pulses and to ascertain sensorial quality, chemical and nutritional composition, shelf life and consumer acceptability.

Papaya, pineapple and other ingredients such as puffed rice, oats, bengal gram dal, ground nuts, dried fruits and Jaggery were purchased from the market. Outer coat of granular fruit bars were developed using pineapple pulp (T_1), papaya pulp (T_2) and blended fruit pulp (T_3). Food adjuncts such as sugar and pectin were added to obtain good texture. Fruit bars were dried in tray drier at 55-60°C. After the development of three fruit bars, TSS was recorded. Drying characteristics like moisture loss, drying time and yield ratio was ascertained. Moisture loss was higher in T_1 (Pineapple bar) and low in T_2 (Papaya bar). Drying time of T_1 (Pineapple bar) was on par with T_2 (Papaya bar). Drying time required for T_3 (blended bar) was 10.84 hours. High yield ratio (0.81) was observed for T_2.

The filling for granular fruit bars were standardised using energy sources such as puffed rice, flaked rice and oats. Puffed bengal gram dhal and roasted groundnuts were serve as protein sources. Jaggery was used as the sweetening agent for the product. To standardise granular bar, different combinations of different ingredients were formulated. Sensory quality, nutritive value, chemical score and NDP Cal% of each proportion was computed to identify the best combination. Six treatments were formulated with varying amounts of ingredients (Rice flakes, puffed rice, oats, Bengal gram dhal, ground nuts, jaggery and osmotically dehydrated jackfruits). Three treatments with appreciable nutrient content, chemical score and NDP Cal% were selected for further study. T_1 obtained the highest chemical score of 109.97 followed by T_3 (98.65) and T_2 (93.72). T_1 was observed to have the highest value of NDP Cal% (12.38%) and T_2 had the lowest NDP Cal% (9.96%). Based on above parameters T_1, T_2 and T_3 selected for further study. T_1 was identified as best formulation with the highest score of 35.30 in sensory evaluation using hedonic rating scale.

The formulated outer fruit bar coat was cut into pieces and filled with T_1 (30:25:10:5:5:20:5) and pressed into bars and designated as A_1 (pineapple coated granular fruit bar) A_2 (papaya coated granular fruit bar) and A_3 (blended bar coated granular fruit bar), thus the final products were A_1, A_2 and A_3 GFB (granular fruit bars). The products (A_1, A_2 and A_3) were packed in laminated pouches and stored at ambient condition. Quality parameters such as sensory acceptability, chemical and shelf life of final products were ascertained initially and monthly intervals. Sensory evaluation of final products revealed highest mean rank score for A_2. Polyphenol (4.21mg) was higher in A_2 and all the other chemical components were higher in A_1. TSS recorded for A_1 was 78.2°B, reducing sugar (43.02%) and acidity (1.32%). A_1 has highest fibre content of 0.46g per 100g. The other nutrients, moisture, protein, carbohydrate, energy and fat content were higher in A_3 and was 20.02%, 40.16 g, 115.06 g, 461.0 KCal and 7.71g respectively. A_3 had high total minerals (4.5 g) calcium, iron, sodium and potassium and the values were 2.36 mg, 2.52 mg, 635.52 mg and 45.03 mg respectively. High vitamin C content was observed for A_3 (23.38 mg) and high β carotene content was noted for A_2 (269.798 µg).

Changes in moisture, acidity, sensory appeal and microbial growth if any was recorded monthly. It was observed that there was a gradual increase in moisture and acidity in stored granular fruit bars. A_3 showed highest moisture content and A_1 showed highest per cent of acidity throughout the storage period. Stored GFB showed gradual decrease in all sensory parameters. Microbial evaluation of GFB, revealed that, no bacterial colonies were seen in (cfu 1×10^{-7}) in dilution initially. Few colonies of bacteria and fungus were seen in first month and number of colonies exceeded the safe limit in second month. Consumer acceptance and preference study among 50 adolescents was rated high for A_2. The product cost was computed and it was found to be Rs. 36.63/- for A_1, Rs. 18.75/- for A_2 and Rs. 31.53/- for A_3. GFB were nutrient dense, ready to eat product with fruits, grains and pulses with shelf life of one month.

Appendices

APPENDIX I

Score card for Sensory Evaluation

Particulars	Score	Appearance			Colour			Flavour			Texture			Taste			Overall Acceptability		
		T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
Like extremely	9																		
Like very much	8																		
Like Moderately	7																		
Like Slightly	6																		
Neither Like or Dislike	5																		
Dislike Slightly	4																		
Dislike Moderately	3																		
Dislike Very Much	2																		
Dislike Extremely	1																		

Name: Signature

APPENDIX II

Nutritive value of fillings for granular fruit bars

Proportions	Nutrients per 100g of the product								
	Protein (g)	Fat (g)	Fibre (g)	Carbohydrate (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)	β-Carotene (µg)	Vitamin C (mg)
T_1	**7.97**	**3.41**	**0.97**	**71.45**	**350.55**	**41.70**	**8.36**	**8.32**	**2.02**
T_2	**9.47**	**4.15**	**2.65**	**114.01**	**356.25**	**83.41**	**8.41**	**1.85**	**0.70**
T_3	**9.85**	**3.17**	**11.26**	**127.99**	**351.95**	**41.55**	**8.13**	**7.95**	**0.75**
T_4	7.91	3.12	9.98	149.35	356.70	48.91	7.92	8.31	0.75
T_5	11.75	2.91	11.42	156.84	380.15	41.55	8.14	7.95	0.75
T_6	9.68	4.53	1.42	70.72	358.71	84.75	9.03	1.85	0.70

APPENDIX III

Chemical score and NDP Cal % of fillings for granular fruit bars

Treatments	Chemical score			NDP Cal%		
	Lysine	Threonine	Tryptophan	Lysine	Threonine	Tryptophan
T_1	49.27	78.03	**109.97**	5.51	8.73	**12.32**
T_2	41.53	64.33	**93.72**	4.41	6.84	**9.96**
T_3	44.20	69.43	**98.65**	4.95	7.77	**11.04**
T_4	42.89	66.61	68.98	3.80	5.90	6.11
T_5	34.04	49.40	75.74	4.21	6.11	9.36
T_6	39.86	61.18	89.94	4.30	6.60	9.71