STANDARDISATION AND QUALITY EVALUATION OF MILLET BASED NUTRI FLAKES

By

RIYA K. ZACHARIA

(2018-16-003)

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF HORTICULTURE

KERALA AGRICULTURAL UNIVERSITY

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THESIS

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DECLARATION

I, hereby declare that the thesis entitled "**Standardisation and quality evaluation of millet based nutri flakes**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed during the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that the thesis entitled **"Standardisation and quality evaluation of millet based nutri flakes"** is a bonafide record of research work done independently by **Ms. Riya K. Zacharia** under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

"To eat is a necessity but, to eat intelligently is an art.
(La Rochefoucauld)

Convenient foods have become a part of modern life for people who lead demanding and hectic lifestyles in which food is no longer consumed solely for hunger satisfaction but also for nutrition and health promotion. Convenient foods are commercially prepared tertiary processed foods, which are designed to save time in food acquisition, preparation, and cleanup The consumption of convenient foods has increased significantly in recent years revealing a trend of change in lifestyle of the society. The market value of convenient foods in India is estimated to reach 2.9 billion by 2020 (MOFPI, 2017). Currently, convenient foods forms the largest segment in the overall food industry.

The changes in life style and dietary pattern, increasing awareness about healthy food habits with adequate nutritional requirements has made healthy convenient foods a perfect choice as a quality source of energy. As a major source of energy, cereals have important role in our daily diets. Millets are small seeded cereals known as nutri cereals which represent rich sources of phytochemicals and micronutrients (Singh *et al*. 2012).

Millet grain is now receiving increasing interest from food scientists and nutritionists because of their important contribution to national food security and potential health benefits. Supplementation of millet grains with natural food products to enhance their nutritive value is promising and cost-effective strategy to combat micro nutrient deficiencies. Millets contain carbohydrates (60-70%), proteins (7-11%), fat (1.5-5%), and crude fibre (2-7%) and are also rich in vitamins and minerals. They are excellent source of B vitamins, magnesium and antioxidants (Singh *et al*., 2012). Even though millets have enough potential to contribute to food and nutritional security, they still remain underutilised.

Processing technologies for improving nutritional characteristics of millets increase their digestibility, absorption and reduce anti-nutritional factors (Sarita and Singh, 2016). Utilisation of millets is restricted due to non-availability of refined and processed foods in convenient form. One possible way of extending their utilisation could be by blending them with composite flour using suitable processing techniques. Blending of different source of nutrients can also improve nutritional quality of food. Preservation of food in ready-to-eat form has achieved considerable success in food industry.

Finger millet (*Eleusine coracana*) and barnyard millet (*Echinochloa frumentaceae*) are minor millets which are good source of micro nutrients and have nutraceutical components. Their consumption has a positive effect on health with regards to several life style diseases. Increasing demand from consumers for nutritious convenient foods can enhance the utilization of millets in daily diets of people. Hence, it is desirable to develop novel and value added products from millets.

Flakes are one of the ready to eat convenient food products which is directly edible and does not require additional treatments to make it safe. These are processed or extruded cereal products with expanded light and crispy texture and is generally made from a variety of cereals including rice, corn, and wheat. Millets are also receiving importance in these type of foods. In the Directorate of Sorghum Research in Hyderabad, millets are being explored recently for flakes preparation (Chavan *et al*., 2015). Millet based flakes are expanded processed products that have high versatility, digestibility and have low levels of anti - nutritional factors which provide high nutritional quality. Nutritious flakes can be considered as one of the breakfast cereals. Breakfast cereals are a "nutrient dense" food that supply a modest amount of energy (calories) and essential nutrients. Breakfast cereals and bars are products are added with functional ingredients to satisfy the palate of consumers seeking a balanced, tasty and healthy food, even allying a diet rich in fibre and carbohydrates with a low amount of calories and fats.

Hence, the present study entitled 'Standardisation and quality evaluation of millet based nutri flakes' was proposed to develop nutri flakes with different composite mixes and to evaluate organoleptic, nutritional and storage qualities of the developed nutri flakes. The study also envisaged to assess the suitability of the nutri flakes for the preparation of different value added food products such as ready to eat instant breakfast mixes and ready to eat nutri bars.

Review of Literature

2. REVIEW OF LITERATURE

The literature pertaining to the study entitled “Standardisation and quality evaluation of millet based nutri flakes” is presented under the following sub headings.

2.1. Convenient foods – Concept and significance

2.2. Types of convenient foods

2.3. Use of millets in convenient foods

2.4. Health and nutritional qualities of millet based convenient foods

2.5. Quality aspects of millet based flakes

2.1. Convenient foods – Concept and significance

Convenient foods are commercially prepared tertiary processed foods, which are designed for ease of preparation consumption and to save consumers time. Busy life style, time constraints and efforts needed makes people to go for better convenient choices, which is gaining acceptance in day to day life.

Convenient foods are those that help consumers to reduce time as well as physical and mental efforts required for food preparation, consumption and clean-up (Brunner *et al*., 2010). The food processing industry has been catalysed by the evolving lifestyle and altered eating patterns of increasing metropolitan population. It is estimated that over 30 million Indians in the upper and middle class eat branded meals and the amount is expected to raise to over 200 million in the coming years (Kotagi, 2011).

The major thrust of convenience food is to provide convenience by way of saving the cooking time and labour in the kitchen. In addition, long shelf-life, reduction in weight, good quality, easy commercial availability are of prime concern. Simplicity, time saving, minimal packaging and good taste are the key characteristics of convenience foods. Convenience foods are fully or partially prepared foods in which a significant amount of preparation time, culinary skills or energy inputs, have been transferred from the home kitchen to the processor and distributor and these can be packaged for a long shelf life with little loss of flavour and nutrients over a period of time (Kok *et al*., 2003).

Ryan *et al.* (2004) stated that, convenience food products are items that help people save time by planning and preparing meals. According to Simelane (2008), convenience foods are described as foods intended to save peoples time in the kitchen and decrease the spoilage and economies of scale.

The intended role of convenience foods is to transfer from the kitchen to the food service provider with minimum attributes of preparation skills and energy inputs. De Boer *et al.* (2004) defines comfortable meals as fully prepared or partly prepared food products in which the food processor, provide some or all of the preparation moment, culinary skills or energy sources. Convenient foods decreases physical and mental activity involving food-specific activities and ensues more quality time.

In recent years, new lifestyle determines are food shopping behaviour and preferences, increasing the number of nuclear double income families and the demand for quality foods have resulted in increased need for convenience foods. The shifting demographics, rising buying authority, expanding women's workforce and staying away from home have resulted in enhanced demand for products which can be consumed or prepared easily. Instant meals, fast foods, breakfast foods and other packaged and branded foods are also available even in India's small rural outlets (Das, 2015).

Pendse and Patil (2016) also stated that, the improving consumer lifestyle, rapid urbanization and high disposable income are increasing demand for convenient foods and thereby fuelling the convenient food market growth. Changing food consumption behaviour among consumers, increased willingness to spend on such food and the lack of time to cook at home are a result of the rapid urbanization. Urbanization also helps in increasing the disposable income, which increases the food expenditure of the consumers. The unexpected rise of working women due to urbanization and nuclear family, increased dual income from increased working couple, impact of western culture and media and easiness of convenient foods makes change in consumer preference towards convenient foods.

Global convenient food market is projected to grow at a compound annual growth rate of 4.3 per cent during the forecast period 2016 - 2024. The young consumers spend most of their income on convenient food products. Young customers are the easiest targets for the giants of convenient food processing. The level of convenience of such foods helps to increase the overall consumer demand worldwide. North America has the highest market share for convenient goods, and because of technological advances, busy lifestyles, and high disposable incomes, the United States is the largest market in North America. (Mordor Intelligence, 2019).

In India, the size of the convenience food industry is 1 billion, rising at the rate of 20 per cent per year. Due to its enormous input potential and importance in the development of the country, the food processing industry is known as a sun-rising industry (Berry, 2014). India's Convenient food market in India in terms of market value, grew at a double digit compound annual growth rate of 14.80 per cent during the period 2011-16. The market value of this high- growth segment was at INR 880.57 million in 2011 and increased to INR 1, 755.89 million by 2016. It is expected that the convenient food market in India would continue to grow at a compound annual growth rate of approximately 12.36 per cent during the period 2016-21 and reach INR 2, 901.53 million by 2020 (MOFPI, 2017).

Srinivasan and Shande (2015) found that convenient foods helped to prepare off seasonal foods for majority of respondants and another 81 per cent of working women reported that it helped in emergency situations. Easiness in preparation was found to be the most important reason for their choices. There is also a change in the attitude of women towards cooking and the meals they serve with the nuclear family. Adolescents also become influenced by the changes in the meal pattern of their family (Gupta and Singh, 2016).

A survey done in major metropolitan cities in India showed that nearly 72.6 per cent of bachelors preferred convenient foods because of less cost, time and energy saving, convenience in preparation and consumption in the busy and hectic life. About 76 per cent of working women in nuclear family also preferred convenient foods. The share of urban residents is about 80 per cent while semi urban and rural residents consumed over 40 per cent (ASSOCHAM, 2011).

Due to changes in social and economic patterns buying power, knowledge of health foods and changes in current food habits, demand for convenience foods is increasing at a faster rate. Urban consumers are the primary consumers of breakfast because they favor a quick breakfast scheme because of their hectic lifestyles. The main driving factors in the sector are changing demographics and breakfast preferences in emerging economies. Market growth has been increased by the increasing acceptance of Western dietary patterns and by shifting consumer preferences towards healthier food. With a CAGR of 22.07 percent over the last five years , India's breakfast cereal market has been rising. The three leading firms, Kellogg's India, Bagrry and PepsiCo-Quaker, capture more than 75% of the market. Western India has the largest market share in breakfast cereals, followed by north and south, owing to urbanisation and increased people's income (Trent, 2017).

During the 2011-16 period, the breakfast cereal market in India grew at a very promising compound annual growth rate of 21.28 per cent. In 2011, the market size of this high-growth segment was at INR 5,588 million, nearly tripling to INR 14,661 in 2016. In addition, the breakfast cereal market is projected to continue to expand at a CAGR of 19.23 percent and is estimated to cross INR 29,466.255 (MOFPI, 2017). Oliveira *et al*. (2018) reported that 39.47 per cent eat cereals once a week and 73.68 per cent take cereals as breakfast and 33.33 per cent take evening snacks as the second preferred time of day for eating.

Consumers have become more health-conscious over the last ten to 15 years and prefer snack items that are healthier and more nutritious than those previously accessible. Rising cases of chronic diseases such as diabetes and heart diseases drive the demand for fiber-rich diets due to unhealthy food habits (Trent, 2017). Food producers are seeking to find growth opportunities, including foods that are aimed at customers who are more health-conscious. The needs and desires of these customers must be satisfied by the creation of a new product that captures the healthy ready-to-eat cereal market.

2.2. Types of convenient foods

Convenience foods refer to a heterogeneous group of foods varying in composition, shape size method of processing and even in their function. According to Devarya, (1996) convenience foods are of three types such as solid foods, concentrates and liquids. Solid foods. Tillotson (2003) categorised convenience foods according to the processing technology used as canning, freezing, dehydration, chilling and chemical preservation.

According to Monterio *et al*. (2010), convenient foods can be classified according to nova classification on the basis of extent and purpose of industrial processing. The nova classification system defines industrial processing as completely specific processing which is distinct from domestic processing and preparation. Nova is completely coherent and there is a continuum in the nature, extent, and purpose of processing from ‘unprocessed’ to ‘ultraprocessed’.

Products labelled as "ready-to-use or requiring minimal preparation" are not usually consumed as purchased, but only a small amount of time or effort from the customer and no cooking ability or attention is required during their preparation, such as microwave heating or thawing the addition of water (Costa *et al*., 2001). In order to preserve the food and make it suitable for storage, facilitate its culinary preparation and enhance its nutritional quality, minimal food processing is carried out. Processed culinary ingredients are highly durable but not usually consumed by themselves. Usually, packaged food products that are ready-to-consume or in combinations and ultra-processed products are formulated to be convenient and intensely palatable. (Monterio *et al*., 2010).

Gupta *et al*. (2019) stated that ultra-processed products are different from processed foods. They are formulations of substances derived from foods and typically contain little or even no whole foods, which are processed by sophisticated methods like extrusion, pasteurization, retorting, hybrid drying technologies and high temperature short time treatments.

Ready-to - eat products are defined as any food for consumption without further heating or processing. This concept encompasses all ready-to-eat items that are open and pre-wrapped. Further heating or processing is not expected to involve tasks of food preparation carried out by the user, such as light washing, slicing, cutting, portioning, marinating or preservation. A number of processed foods, including biscuits, crisps, breads, pies, sandwiches and rolls, dairy products, prepared salads, vegetables and fruits, can be considered to be RTE products under this definition (Food Standards Agency, 2011)

New food processing methods and evolving lifestyles have boosted demand for convenient products such as ready-to-eat, quick cooking, instant meals, etc. The aim is to assemble different nutrients in the required ratio and use of appropriate process technology to impart the organoleptic characteristics at a suitable price. Due to convenience of consumption, ease of preparation, storage and market appeal factors, such as convenience, value, attractive appearance and texture, ready-to-eat foods are increasingly popular with the market. (Patel and Rathod, 2017).

Various snack foods, such as fried chips, wafers, flakes, granules, extruded and spiced goods, popcorn, puffed cereals, etc., have become central to consumer food preferences in today's modern life. Popping or puffing is one of the typical methods of food processing used to prepare light and crisp RTE products (Ushakumari *et al.*, 2007). There is a rising customer preference for ready-to - eat food items for fast and easy consumption to accompany lifestyle changes (Sundaram, 2012).

There is a wide range of snack foods available with a wide variety of sizes, shapes, colours and flavours designed to attract consumers. The snack food sector is generally dominated by potato crisps / chips from this market, followed by maize chips. The majority of snacks are made from maize, wheat, rice, oats, and potato such starch products. In terms of vitamins, minerals, amino acids and fibre, these products are typically high in starch but low in nutritional value. Indeed, many RTE snack items are known as energy-dense and nutrient-poor food products (Brennan *et al.*, 2013).

One of the convenience food market's most important sectors is the cereal RTE segment. For example, breakfast cereals, extruded cereal products and cereal bars are dominated by extruded snack products. Many of the RTE products available to the consumer on the supermarket shelves are in the form of extruded snack products.

Extruded products may be appealing to the consumers in terms of enhanced crispiness or crunchiness (Robin *et al*., 2011). The processing of extruded foods such as chips, pastas, breakfast cereals, baby foods, *etc*. has become increasingly involved in recent years (Yadav and Chandra, 2015).

Breakfast cereals are split into two different classifications such as, hot cereals and ready-to-eat (RTE) cereals. Hot cereals include products such as oats, oat bran, grain bran and porridge, while cold cereals ready-to-eat (RTE) include cornflakes, wheat flakes, chocolate flakes, muesli, *etc* (Fast, 1999).

2.3. Use of millets in convenient foods

Although millets are nutritionally superior to cereals, their utilization is not wide spread. Now convenient foods have major role in our food habits and also people are more concerned about health and nutrition. Millet based convenient foods provide adequate energy, protein, iron calcium and other micro nutrients. Utilization of millets is restricted due to non-availability of refined and processed foods in convenient form. One possible way of extending their utilisation could be by blending them with composite flour and adopting suitable processing techniques such as malting and popping.

Jha *et al*. (2013) standardised kheer mix, with 18.49 per cent dairy whitener and 6.0 per cent pearl millet as major ingredients. Balasubramanian *et al*. (2014) developed upma mix, a common breakfast traditionally made from wheat in Southern India, was produced using pearl millet semolina. To minimise antinutritional factors and inactivate lipase activity, Pearl millet grains were hydrothermally treated. Ajisha, (2017) developed an instant payasam mix with 70% of raw jack fruit based vermicelli. It was highly acceptable with score of 8.4 for overall acceptability.

Adensina *et al*., (1998) developed ready to eat extruded snack foods incorporating the maize soy mix (75:25) extruded at 150^0 C. Eight composite mixes were formulated using popped cereals (40% wheat, finger millet, pearl millet or sorghum), legumes (20 or 10% defatted soy flour or 10 % bengal gram dhal), jaggery (30 %) and vegetable fat (5%) (Bhaskaran *et al*., 2001). Suneeta *et al*. (2005) developed finger millet based ready to eat extruded products using defatted soy flour, refined flour and skimmed milk powder. All sensory parameters of the product were appropriate and had a reasonable shelf life of three months.

Singh *et al*. (2000) developed crisp extruded snacks by adding composite flour with 15% wheat bran. Appropriate salty and sweet snacks ready to eat were prepared using maize, green gram dhal, bengal gram dhal roasted (Lakshmi *et al*., 2005). Enwere and Nuten (2005) standardised acceptable breakfast cereals from mixtures of corn flour, soy flour and cassava flour containing ripe banana, pineapple and pawpaw pulps at different levels from upto 28 per cent.

Noodles and pasta products are also considered as convenience foods that are prepared after drying by means of a cold extrusion device that becomes hard and brittle. Sorghum and pearl millet have been successfully used for noodles, puffs, cookies, a parboiled rice like product and snack foods (Schober *et al*., 2005).

Pasta can be made with composite flour of finger millet, wheat and soy flour formulated at 50, 40, and 10 percent ratios (Devaraju *et al*., 2006). Prasad *et al*. (2007) prepared sorghum and defatted soy flour in a proportion of 80: 20 and was extruded at 150 ° C. The product showed increased protein content (16.4%). Finger millet incorporated noodles was developed by Shukla and Srivastava (2011). The finger millet flour was blended into refined wheat flour in varying proportions (30 to 50 %) and was used for noodle preparation. Dhumal *et al.* (2014) developed extrudate by adding 55 per cent barnyard millet flour in combination with potato mash and was puffed to get highly acceptable ready to eat foods.

Sumathi *et al*. (2007) developed acceptable RTE extruded food using pearl millet and legumes. Acuna *et al.* (2008) developed breakfast cereals incorporating maize bran as a novel source of complex polysaccharide. Extruded snacks were developed by Deshpande and Poshadri (2011) using foxtail millet, amaranth, rice, bengal gram, cow pea in the ratios of 60:05:05:20:10 had significantly better appearance (7.8), colour (7.9), flavour (7.8),texture (8.9), taste (8.2) and overall acceptability (8.5).

Sangeetha and Devi (2012) developed pasta from finger millet powder incorporated with refined flour at various proportions (50%, 70% and 90%) and found that the combination of 70:30 is highly acceptable. Yadav *et al.* (2014), reported that acceptable non-wheat pasta could be obtained from pearl millet by incorporating barley flour (13.80 g / 100 g of pearl millet flour), whey protein concentrate (12.27 g / 100 g of pearl millet flour), carboxy methyl cellulose (3.45 g/ 100 g pearl millet flour) and water (27.6 ml /100).

Millet based highly acceptable extruded produsts were developed from incorporating with 42.03% ragi, 14.95% sorghum, 12.97% soy and 30% rice flour blend by Seth and Rajamanickam, (2012). Devi and Narayanasamy (2013) explored the possibility of preparing composite millet powder with a combination of finger millet flour and pearl millet flour to prepare RTC extruded products and obtained acceptable products. Highly extruded snack foods based on millet were prepared using twin-screw kodo millet chickpea flour blend extruders in the 70:30:30 ratio (Geetha *et al*., 2014).

Semasaka *et al*. (2010) produced extruded products from corn flour mixtures (44%), millet flour (36%) and soybean flour mixtures (20%). By combining the flour from popped pearl millet and legumes, a ready-to-eat nutritious snack mix was made. The sensory evaluation of the product showed that with a mean score of 6.8, colour, taste, texture, scent, appearance and overall consistency were in an acceptable range (Pradeep, 2014).

Jaybhaye *et al*. (2011) developed acceptable RTE puffed product from barnyard millet flour, potato mash and tapioca powder in the ratio of 60:37:3, using HTST puffing process. Geetha *et al*. (2014) developed acceptable extrudates by twin-screw extrusion using kodo millet flour and chickpea flour mixture (70:30). It has been reported that desirable crispy extrudates were obtained with high over all acceptability.

Sawant *et al.* (2013) developed RTE foods using finger millet, maize, rice and soybean in the ratios of 20:50:20:10 which had significantly better appearance (7.87), colour (7.40), texture (7.27), taste (8.47) and overall acceptability (8.87). The overall acceptability of the product revealed that the coarse millet grains and pulses can be successfully mixed to produce desirable qualities of the extrudates with acceptable sensory properties.

Composite flour (little millet; rice; maize 10:45:45 ratio) could be used for the production of high-quality extrudates with sufficient sensory properties (Saini and Yadav, 2018)

2.4. Health and nutritional qualities of millet based convenient foods

Food scientists and nutritionists are now becoming increasingly interested in millet grain because of its major contribution to national food security and possible health benefits. A promising and cost-effective approach to combat micro nutrient deficiencies is the supplementation of millet grains with natural food products to improve their nutritional value. (Saleh *et al*., 2013).

Most convenient foods consist of refined flour that is devoid of many nutrients, especially minerals and fibre. Convenience foods have been popular over the past few years and such foods may emerge as promising products on the market (Singh and Sehgal, 2008). The requirement of people for high quality, ready-to-eat foods of traditional nature with modern technological application has become a necessity.

One of the common food processing techniques used for the preparation of expanded cereals and legumes to prepare ready-to - eat items is popping or puffing. The content of crude fat and crude fibre of popped foxtail millet was found to be significantly lower than raw millet, while the carbohydrate and energy values were significantly higher (Mishra *et al.* 2014).

Srivastava *et al*. (2001) developed malted and popped convenience mixes based on proso millet, soybean and peanut flours. Popped mix contained significantly higher amounts of fat (5.43 g/100g), protein (15.98 g /100g) and energy (336 kcal /100g) compared to malted mix (5g, 14.35g, and 328 kcal/ 100 g respectively). Bhaskaran *et al*., (2001) indicated that composite mixes from fortified popped cereals contained 10.4 to 12.5g protein, 4.2 to 5.9g fat, 10 to 13 g dietary fibre, 1.8 to 3.6g ash, 64 to 67g carbohydrates and 340 to 398 kcal of energy. The developed mixes could meet one third RDA for children. Singh *et al*. (2004) studied the nutritional properties of popped, flaked, extruded and roller-dried foxtail millet and observed protein content of (12.7%), fat (4.6%), total dietary fibre (11.8%), ash (2.9%), calcium (38%) and phosphorus (289).

Singh *et al*. (2004) produced extruded crisp snack from broken rice and wheat bran blends and the results showed that increased inclusion of wheat bran increased protein content from 9.1 per cent to 16.9 per cent and fat content from 0.9 per cent to 5.4 per cent, with significant decreases in carbohydrate content from 89.1 per cent to 73.1 per cent.

Extruded sweet and salty snacks were produced for institutionalised elderly people using maize, green gram dhal, roasted bengal gram dhal and enriched with vitamins and iron (Lakshmi *et al*., 2005). The results showed that the protein and iron content of the sweet products (10.1% and 19.80 mg/100 g) respectively and salty (11.5% and 22.23 mg/100 g, respectively) were significantly higher.

Suneeta *et al*. (2005) produced acceptable and shelf stable finger millet based ready to eat extruded products using soy flour, refined flour, and skimmed milk powder. The product was stated to meet one third of the recommended protein (16.40 g) and calcium (275 mg) dietary allowances for school kids.

Prasad *et al*. (2007) evaluated the protein content of sorghum and soy blend extruded snacks. Products showed significantly low moisture content (6.9%), fat content (2.1%) and carbohydrate content (68.9%) relative to sorghum content (8.4%, 3.1% and 73.3% respectively for moisture content, fat content and carbohydrate content).

Yadav *et al*. (2014) developed pearl millet non-wheat pasta supplemented with 10-30% barley flour and 5-15% whey protein concentrate. 16.47 g protein, 98.53 mg calcium, 5.43 mg iron, 315.5 mg phosphorus and 0.33 g β-glucan per 100 g of pasta were present in the produced pasta. Pradeep, (2014) reported that ready-to-eat nutritious snack mix was made by blending the flour from popped pearl millet and legumes contained protein 14.02 g, fat 14.50g, carbohydrates 59.00 g and dietary fiber 6.30 g per 100 g of mix.

Singh *et al*. (2005) observed that adding milled millet flour to wheat flour increased protein, fat and ash concentrations but decreased carbohydrate concentrations. Addition of milled barnyard millet flour raised the protein, crude fat and total levels substantially. With the increase in finger millet flour content in the blend, protein content decreased from 11.59 per cent to 10.99 per cent while fat and ash content rose from 1.06 per cent to 1.37 per cent and 0.55 per cent to 1.37 per cent, with no significant variation in carbohydrate content.

Composite mixes were developed by Kurahatti, (2010) and found that mixtures based on little millet contained moisture (5.58 %), protein (13.79 %), ash (2.03 %), crude fat (7.60 %), carbohydrates (70.12%) energy (404 kcal), total fibre (16.55%) and insoluble fibre (11.25%). The research also reported greater iron content (6.61 to 8.76mg/100 g) in amaranthus mixes.

Saini and Yadav (2018) reported that extrusion mixture caused an increase in moisture content (4.45-5.70) per cent, ash content (0.75-1.45) per cent, protein content (3.25-4.38) per cent, fat content (0.82-1.17) per cent, fiber content (1.05-2.88) per cent, carbohydrate content (89.65-84.42) per cent and calorific value (378.98-365.73) kcal.

Galvin *et al*. (2002) reported that consumption of breakfast cereals increased the mean daily intake of carbohydrates (8.1%), starch (10.8%), dietary fibre (9.8%) and non- starch polysaccharides (10.8%). In addition, the consumption of fortified breakfast cereals increased iron intake by 18%, thiamine by 14%, riboflavin by 17%, niacin by 15% and total folate by 18% among adults (18-64 years).

Priebe and Monagle (2016) documented nutrient composition of 60 commercial breakfast cereals, and reported that breakfast cereals based on maize and rice contained nearly similar protein levels (4.00 to 8.00 %), carbohydrates (80.00 to 87.00%), fat (0.50 to 3.00%) and fibre (1.50 to 4.20%). Breakfast cereals based on wheat and mixed cereals showed a higher range of protein, fat and fibre content (4.00 to 15.00 per cent, 1.00 to 15.00 per cent and 1.00 to 32.00 per cent respectively) relative to cereals based on maize and rice.

Enwere and Nuten (2005) evaluated breakfast cereals made from mixtures of maize, soy and cassava with banana, pawpaw and pineapple for nutritional quality. It has been reported that there was a substantial increase in vitamin A (12.80 to 30.50mg/100 g, respectively) and vitamin C (36 to 42mg/100 g, respectively).

Camire *et al*. (2007) reported that added fruit powders in extruded corn breakfast cereals contain soluble phenol (138.5ppm) and anthocyanin (0.46mg/100 g) in blueberry-based breakfast cereals. Yeu *et al.* (2008) discussed the possibilities of increasing the protein content in breakfast cereals by adding soy protein per 30 g serving. The total protein content ranged from 8.60 to 11.20 g and claiming high protein content compared to commercial cereals.

Holguin *et al*. (2008) evaluated maize bran incorporated breakfast cereals (0 to 50 per cent) as a novel source of antioxidant and complex polysaccharide. Results revealed that moisture content from 9.8 to 6.3 per cent, protein content from 13.0 to 9.8 per cent, fat content from 5.8 to 3.1 per cent, and β glucan content from 2.3 to 0.7 per cent. Moreover, due to the addition of maize bran, there was a significant increase in crude fibre content from 0.7 per cent to 6.3 per cent and carbohydrate content from 68 per cent to 72 per cent.

2.5. Quality aspects of millet based flakes

Flakes are generally made from a variety of cereals including rice, corn, sorghum and wheat. Whole grains are used for rolled flakes, extruded flakes, puffed and popped products. Nutritional quality of flakes can be improved through composite flour technology by addition of different nutrient sources such as millets and legumes. Such nutri flakes are developed by high temperature short time heat processing technology.

Lorsuriyont (1993) evaluated the acceptability of flakes containing pigeon pea flour, corn flour, sugar, skim milk, cocoa, salt and glucose syrup among 200 consumers in Bangkok. Results revealed that 81 per cent of the consumers liked the flakes moderately and 46 per cent were willing to purchase the product. Protein (16.35 %), iron (3.65 mg %), thiamine (1.75 mg %), niacin (4.40 mg %) and vitamin A (216.67 retinol equivalent) were recorded in the developed flakes. The developed product could reach 10 percent of RDA for thiamine, vitamin A, niacin and proteins. Storage studies have shown that goods can be stored in metallized polypropylene pouches at ambient (37 ° C) and controlled temperatures (20 ° C) for up to 10 weeks with good sensory properties.

Cheewapranmong *et al*. (2002) produced ready to eat flakes by replacing maize cones with roasted or non-roasted partially defatted peanut flour at different levels of

10, 20 and 30 per cent. The prepared flakes were highly acceptable with 20 per cent peanut incorporation. Rai and Chauhan (2008) developed papaya cereal flakes and found that total sugars (60.52%), reducing sugars (56.78%), ascorbic acid (241.61 mg/100g) and total carotenoid contents (7.34 mg/100g). The substance was acceptable for storage for up to 40 days when stored at 4 ° C.

Lenkannavar (2010) developed ready to use rolled barnyard millet flakes having moisture (9.59%), protein (6.44%), fat (1.67%), total carbohydrates (70.06%) and total minerals (1.04%). Total dietary fibre content in rolled barnyard millet flakes was reported to be 11.20 per cent and the energy value was 321 kcal/100g. It was indicated that iron, copper, zinc and manganese content in rolled barnyard flakes was 15.17, 0.34, 3.07 and 0.24 mg/100g, respectively.

Kotagi (2011) developed RTE little millet flakes using extrusion technology and RTC (ready-to-cook) rolled little millet flakes. It was reported that RTE little millet flakes recorded low moisture content (1.45%), protein (7.45%), low fat (0.14%), high carbohydrates and low total mineral contentof 66.14 and 0.72 per cent respectively. The dietary fibre was found to be significantly higher in RTE millet flakes (24.10%). Zinc and manganese contents of RTE little millet flakes were 2.76 and 0.29 mg/100 g. The RTC flakes exhibited protein and fat content of 7.51 and 0.44 per cent, respectively. Total carbohydrates and total mineral contents were 59.10 and 0.44 g / 100 g. The RTC flakes were reported to be rich source of iron (32.23 mg/100g), zinc (3.06 mg/100g) and calcium (22.35 mg/100 g).

Itagi *et al*. (2012) developed ready-to-eat flakes from cereals such as maize grits, pearled barley, hulled oats, wheat, pearl millet and sorghum. Flaking resulted in more than 50 per cent reduction in soluble polyphenol content. Blistered cereal flakes was reported to be excellent ready-to-eat snacks with good polyphenol content (16-58 mg gallic acid equivalents/100 g) and exhibited high anti-oxidant activity and possessed good functional properties. *In vitro* starch digestibility and glycemic index of the millet flakes were 63.23% and 67.16, respectively. The sensory qualities of millet flakes were highly acceptable even after storage period of three months (Aigal, 2014).

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled 'Standardisation and quality evaluation of millet based nutri flakes' was proposed to standardise millet based nutri flakes and to evaluate the organoleptic, nutritional, health and shelf life qualities of the developed nutri flakes. The study also aims to develop value added products using the developed nutri flakes. The study was carried out in the Department of Community Science, College of Horticulture, Kerala Agricultural University during the year 2018-2020. The methods followed and materials used are given under following headings.

3.1. Collection of raw ingredients

3.1.1. Preparation of ingredients

3.1.1.1. Standardisation of jackfruit seed flour

3.1.1.2. Organoleptic evaluation

3.2. Standardisation of millet based nutri flakes

3.3. Organoleptic evaluation of nutri flakes

3.3.1. Selection of judges

3.3.2. Preparation of score card

3.4. Quality evaluation of the selected nutri flakes

3.4.1. Nutritional qualities

3.4.2. Shelf life qualities

3.5. Suitability of nutri flakes for value added products

3.5.1. Preparation of ready to eat instant breakfast mix

3.5.2. Preparation of ready to eat nutri bars

3.5.3. Organoleptic evaluation

3.6. Cost of the production

3.7 Statistical analysis

3.1. Collection of raw ingredients

Finger millet (*Eleusine coracana*) and barnyard millet (*Echinochloa esculenta*) were selected as the major ingredients for developing nutri flakes and were collected from local market. Tapioca and jackfruit seed flour were also used in combination with millet flours for developing nutri flakes. Tapioca and jackfruit seed were collected from homesteads. Defatted soya flour, cocoa powder and rice bran were used as the other ingredients and were collected from local market.

Ingreidients needed for preparation of value added products such as liquid glucose, brown sugar, cashwnuts, peanuts, raisins, banana, papaya and mango were also collected from local market and fruits were dehydrated by standard procedures (Sheela *et al.*, 2018).

3.1.1 Preparation of raw ingredients

The collected millets were cleaned, washed and germinated by following the standard procedure by Reshma, (2016). The millets were soaked for 10 hr and tied in moist cloth. After of 24hrs, the germinated millets were dried, powdered and sieved to get a uniform flour. Tapioca flour was prepared by slicing and blanching the raw tapioca in boiling water for 5-10 minute and was dried (Nambisan, 1994). The dried chips were milled into flour and sieved to get uniform flour.

3.1.1.1 Standardisation of jackfruit seed flour

For jackfruit seed (JFS) flour preparation, the seeds were cleaned under running water and then boiled for 15 min. The seeds were cooled before the outer skin (hilum) was peeled off manually. The seeds were sliced and dried in air drying oven. The dried seeds were then grounded into flour with 60 mesh of particle size (Faridah and Aziah, 2012).

Jackfruit seeds are underutilised waste products and it can be effectively utilised in foods. The proper aroma and fruity flavour can be developed by suitable treatments before preparation. According to Spada *et al.* (2017) three different treatments were executed. For dry jackfruit seed flour, seeds were dried in an oven at 60˚C with air circulation, for 48 hours. Dried seeds were roasted at 154˚C for 35 minutes. For the acidified jackfruit seeds, the seeds were treated with 1% acetic acid. After five days, the solution was removed and the seeds were dried and roasted using the same method. For fermented jackfruit seed flour, seeds were fermented with pulp and banana leaves and the fermented seeds were dried and roasted at 154˚C for 35 min. Fermented jackfruit seeds were alkalised by using alkalisation method of coco beans (Shahanas, 2019), soaking fermented jackfruit seeds in one per cent sodium bicarbonate solution. After three hours, the solution was removed and the seeds were dried and roasted using the same method. The best method of jackfruit seed preparation was selected by organoleptic evaluation. The different treatments for preparation of jackfruit seed flour is given below

Treatments	Preparation methods
T_1	Roasted jackfruit seed flour
T_2	Acidified and roasted jackfruit seed flour
T_3	Fermented and roasted jackfruit seed flour
T_4	Fermented alkalised and roasted jackfruit seed flour

3.1.1.2. Organoleptic evaluation

Organoleptic qualities like appearance, colour, flavour, texture taste and overall acceptability were evaluated by selected panel of judges. Based on organoleptic scores the best treatments were selected.

3.1.1.2.1. Selection of judges

As suggested by Jellinek (1985) a series of organoleptic trials were conducted using simple triangle test at laboratory level to choose a team of ten judges aged between 18 to 35 years.

3.1.1.2.2. Preparation of score card

The sensory evaluation of the products were performed using score card method (Swaminathan, 1974). Score card containing six parameters like appearance, colour, flavour, texture, taste and overall acceptability were used for the evaluation of the nutri flakes. Nine- point hedonic scale was used to assess each of above mentioned qualities. The score card for the evaluation of nutri flakes is given in Appendix-I

3.1.1.2.2. Selection of the most acceptable treatment

The best treatment was selected based on sensory parameters by applying Kendall's coefficient of concordance.

3.2. Standardisation of millet based nutri flakes

Four sets of nutri flakes, based on finger millet flour and two sets based on barnyard millet flour. The first set of nutri flakes was developed based on finger millet flour (FMF) incorporated with tapioca flour (TF). The second set of nutri flakes contain finger millet flour as the major ingredients and was incorporated with jackfruit seed flour (JSF). The third set of nutri flakes contain barnyard millet flour (BMF) as major ingredient and was incorporated with tapioca flour and the fourth set of nutri flakes contain barnyard millet flour and was incorporated with jackfruit seed flour.

3.2.1. Finger millet based nutri flakes

Nutri flakes based on finger millet was standardised with finger millet flour, tapioca flour, and other ingredients in various proportions as given below (Set.1).

Treatments	Combination
T_0 (Control)	100% FMF flour (control
T_1	80% FMF + 10% TF + 10% OI
T_2	70% FMF+ 20% TF + 10% OI
T_3	60% FMF + 30% TF + 10% OI
T_4	50% FMF + 40% TF + 10% OI
T_5	40% FMF + 50% TF + 10% OI

FMF – Finger millet flour, TF- Tapioca flour, OI – Other ingredients

The other ingredients were kept in a fixed proportion (10%) which comprised 5% defatted soya flour, 2 % rice bran and 3 % cocoa powder.

Set.2: Treatments T_1 to T_5 were done by replacing tapioca flour with jackfruit seed flour (JSF) also.

3.2.2. Barnyard millet based nutri flakes

Nutri flakes based on barnyard millet were standardised with barnyard millet flour, tapioca flour and other ingredients in various proportions given as below (Set.3).

Treatments	**Combination**
T_0 (Control)	100% BMF flour (control
T_1	80% BMF+ 10% TF + 10% OI
T_2	70% BMF + 20% TF + 10% OI
T_3	60% BMF + 30% TF + 10% OI
T_4	50% BMF + 40% TF + 10% OI
T_5	40% BMF + 50% TF + 10% OI

BMF – Barnyard millet flour, TF- Tapioca flour, OI – Other ingredients

The other ingredients were kept in a fixed proportion (10%) which comprised 5% defatted soya flour, 2% rice bran and 3% cocoa powder.

Set.4: Treatments T_1 to T_5 were done by replacing TF with jackfruit seed flour (JSF) also.

All the ingredients were measured and mixed well with hot water, A dough was prepared with desirable consistency, then rolled and pressed to get sheets. Then it was steamed in steam cooker and cut into small pieces, Further the cut pieces were dried in a cabinet dryer (70^{o} C for 20 min) and puffed through puffing machine. The method of preparation of nutri flakes represented in flow chart and also in Plate.1.

Flow chart for the preparation of millet based nutri flakes

Conditioning of composite flour

Make into dough

Sheeting

Steaming

Cut into desired shapes

Drying (Cabinet dryer 70^{o}c for 20 min)

Puffing

Nutri flakes

Plate 1: Flowchart of preparation of nutri flakes

3.3. Organoleptic evaluation of nutri flakes.

The organoleptic qualities of the nutri flakes was conducted by score card method using nine-point hedonic scale by a panel of fifteen selected judges as per the procedures mentioned in 3.1.1.2.

3.4. Quality evaluation of the selected nutri flakes

3.4.1. Nutritional qualities

The nutritional qualities of the developed nutri flakes were evaluated initially and after end of the storage period using standard procedures. The details are as follows.

3.4.1.1. Moisture

Moisture content of nutri flakes was estimated by the method of A.O.A.C (1980). To determine the moisture content of the products, five gram of flakes was taken in a petridish and dried at 60^0c to 70^0c in a hot air oven, cooled in a desicator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the flakes was calculated from the loss in weight during drying.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.4.1.2. Energy

Energy content of the selected nutriflakes were calculated according to Gopalan *et al*. (1989) and expressed as kilocalories (kcal). The energy present in flakes was calculated as per the formula given below.

$$\text{Energy (kcal)} = (\text{CHO x 4}) + (\text{Protein x 4}) + (\text{Fat x 9})$$

3.4.1.3. Total Carbohydrate

The total carbohydrate content was analysed colourimetrically using anthrone reagent (Sadasivam and Manikam, 1992). Nutri flakes sample of 100 mg was hydrolysed with 5 ml of 2.5 N HCl and then cooled to room temperature. Later the residue was neutralized with solid carbonate until the effervescence ceases and the volume was made up to 100 ml and centrifuged. Pipetted 0.1 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for eight minutes, cooled rapidly and the intensity of green to dark green colour was read at 630 nm.

A graph was prepared using serial dilutions of standard glucose. From the standard graph the amount of total carbohydrate present in the sample was estimated and expressed in grams.

3.4.1.4. Protein

Protein was estimated by the method of A.O.A.C. (1980). Sample (0.2 g) was digested with 6 ml concentrated H_2SO_4 after adding 0.4 g of $Cuso_4$ and 3.5 g K_2SO_4 in a digestion flask until the colour of sample was converted to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. The distillate was collected in two per cent boric acid containing mixed indicators and then titrated with 0.2N HCl to determine the nitrogen content. The nitrogen content thus estimated was multiplied with a factor of 6.25 to get the protein content.

3.4.1.5. Fat

The fat content of the nuti flakes was estimated using the method given by Sadasivam and Manickam (1997). Five gram of sample was taken in a thimble and stoppered with cotton. The material was extricated with petroleum ether for six hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was then cooled and ether was separated by heating and the weight was noted. The fat content was expressed in gram per 100g of the sample.

3.4.1.6. Fibre

The crude fibre of products was estimated using method given by Sadasivam and Manickam (1992). Two grams of dried and powdered sample was boiled with 200 ml of 1.25 per cent sulphuric acid for 30 minutes. It was filtered using muslin cloth and washed with boiling water. The residue was again boiled with 200ml of 1.25 per cent of sodium hydroxide for 30 minutes. Repeated the filtration through muslin cloth and residue was washed with 25ml of boiling 1.25% of sulphuric acid, three 50 ml portion of water and 25ml of alcohol. Then obtained residue was taken in ashing dish (W_1) dried at 130^0 C for 2 hours, cooled the dish in a desiccator and weigh (W_2). The residue was again ignited in muffle furnace at 600^0 C for 30 minutes, cooled in a desiccator and reweighed (W_3).

% crude fibre in ground sample:

$$\frac{\text{Loss in weight on ignition } (W2 - W1) - (W3 - W1)}{\text{Weight of the sample}} \times 100$$

3.4.1.7. Starch

The starch content was estimated colorimetrically using the anthrone reagent as suggested by Sadasivam Manickam (1992). The sample (0.5g) was extracted repeatedly with 80 per cent ethanol to remove sugars completely. The residue was dried over a water bath and 5 ml water and 6.5 ml 52 per cent perchloric acid were added and extracted at 0^o C for 20 minutes. The sample was centrifuged and re extracted with fresh perchloric acid. The supernatant was pooled and made up to 100 ml. Pipetted out 0.2 ml of the supernatant and made up to 100 ml. Pipetted out 0.2 ml of the supernatant and made up to 1 ml with water and 4 ml of anthrone reagent, heated for 8 minutes, cooled and read the OD at 630 nm.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was computed and multiplied by a factor 0.9 to arrive at the starch content and expressed in percentage.

3.4.1.8. Calcium

Calcium content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). The diacid was prepared by mixing 70 per cent perchloric acid in the ratio 9:4. Two gram of flakes samples was digested in this diacid and the extract was made up to 100 ml. This solution was read directly in atomic absorption spectrophotometer. Calcium content was expressed in mg per 100 g of the sample.

3.4.1.9. Iron

Iron content of the sample was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). The diacid solution was directly read in atomic absorption spectrophotometer to find the iron content and expressed in mg per 100 g sample.

3.4.1.10. Sodium

The nutri flakes were estimated for sodium content by using flame photometer as suggested by Jackson (1973). Sample of one gram was digested using diacid solution and made up to 100 ml with distilled water. From this made up solution, one ml was directly fed in to the flame photometer and reading was noted. The sodium content was expressed in mg per 100g of the sample.

3.4.1.11. Magnesium

Magnesium content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). Two gram of flakes samples was digested in this diacid and the extract was made up to 100 ml. This solution was read directly in atomic absorption spectrophotometer. Magnesium content was expressed in mg 100 g of the sample.

3.4.1.12. Potassium

Potassium present in nutri flakes was estimated using method suggested by Jackson (1973) with the help of flame photometer. One gram of the flakes sample was digested using diacid solution. The pre-digested sample was used to measure potassium content in flame photometer and it was expressed as mg per 100g of the sample.

3.4.2. Shelf life studies

The selected treatments of nutri flakes were packed in laminated aluminium pouches (250 gauge) and were kept in ambient conditions. The nutri flakes incorporated with tapioca flour were stored for 3 months. The nutri flakes incorporated with jackfruit seed flour were stored for 1 month. The following aspects were studied in the selected samples initially and at the end of the storage.

3.4.2.1. Sensory qualities of the selected nutri flakes

The organoleptic qualities of the nutri flakes was conducted by score card method using nine-point hedonic scale by a panel of fifteen selected judges following the procedure mentioned in 3.1.1.2.

3.4.2.2. Enumeration of total microflora

The microbial population present in the nutri flakes sample were estimated using serial dilution plate count method as suggested by Agarwal and Hasija (1986). The microbial analysis was carried out in nutri flakes samples initially and at the end of storage.

3.4.2.2.1. Preparation of samples and media for microbial enumeration

The sample was prepared by mixing 90 ml of distilled water with 10 g of sample and shaken well using a shaker to obtain suspension. The serial dilutions were carried out in the prepared water blank. To nine ml of water blank, transfer one ml of the prepared suspension with a dilution of 10^{-2}. This is then diluted to 10^{-3} followed by 10^{-4}, 10^{-5} and 10^{-6} using serial dilution techniques. Bacteria, fungi and yeast count were assessed using Nutrient Agar (NA), Potato Dextrose Agar (PDA) and Sabouraud's Dextrose Agar (SDA) media respectively and results were given as cfu/g.

3.4.2.2.2. Enumeration of bacterial colony

Total number of bacterial colony was computed in 10^{-5} dilution in nutrient agar medium. In a sterile petriplate, one ml of 10^{-5} dilution was erupted using a micropipette. To petriplate poured about 20 ml of the nutrient agar medium which was uniformly spread in petriplate by rotating in clockwise and anticlockwise directions. For bacterial colony, the enumerated petriplates were kept for 48 hrs at room temperature. The total number of bacterial colonies were counted and expressed as cfu/g.

3.4.2.2.3. Enumeration of fungal colony

Total number of fungal colony was enumerated in 10^{-3} dilution in. Potato Dextrose Agar medium. In a sterile petriplate, pour one ml of 10^{-3} dilution using a micropipette. To petriplate pour about 20 ml of the Potato Dextrose Agar medium was uniformly spread. For fungal colony enumeration, the petriplates were incubated for 4 to 5 days at room temperature. The total number of fungal colonies were counted and expressed as cfu/g.

3.4.2.2.4. Enumeration of yeast colony

Total number of yeast colony was enumerated in 10^{-3} dilution in Sabouraud's Dextrose Agar medium. In a sterile petriplate, pour one ml of 10^{-3} dilution using a micropipette. To petriplate about 20 ml of the Sabouraud's Dextrose Agar medium was erupted and was uniformly spread in the petriplate by rotating. For enumeration of yeast population, the petriplates were incubated for 4 to 5 days in room temperature. The total number of yeast colonies were counted and expressed as cfu/g.

3.4.2.3. Insect infestation of nutriflakes

Insect infestation of the stored nutri flakes were observed and recorded initially and at the end of the storage. Insect infestations were assessed by visual examination.

3.5. Suitability of nutri flakes for value added products

3.5.1. Preparation of ready to eat instant breakfast mix

Instant breakfast mixes were prepared with 75 g of nutri flakes, 10 g of toasted nuts (5 g cashew nuts and 5 g pea nuts), 15 g of dry fruits (5 g banana, 5 g papaya and 5 g mango). The prepared ready to eat instant breakfast mix were organoleptically evaluated by adding 200 ml of hot milk.

3.5.2. Preparation of ready to eat nutri bars

Nutri bars were prepared using the developed nutri flakes as the major ingredient. The main ingredient for the preparation of nutribars were selected nutri flakes. The flakes were used at a level of 50 per cent in all treatments. Dried fruits like dehydrated banana, raisins and nuts like pea nuts and cashew nuts were used up to 10 per cent. For preparing binder syrup, liquid glucose (5 g) and brown sugar (25g) were previously weighed and heated to a temperature of 100º C by adding 10 ml of water. The mixture was concentrated until one thread stage. The ingredients like nutri flakes, dried fruits and nuts, were added one by one and mixed well. Later the mixture was moulded and after cooling the bars were organoleptically evaluated.

3.5.3. Organoleptic evaluation

The organoleptic qualities of the ready to eat instant breakfast mix and ready to eat nutri bar was conducted by score card method using nine-point hedonic scale by a panel of fifteen selected judges following the procedure mentioned in 3.1.1.2.

3.6. Cost of production of the selected products

Cost analysis of the products was done to assess the extent of expenses for the preparation of products. The cost of production was worked out based on the market rates of different ingredients used for the preparation of the products. The cost was calculated for 100g of the product.

3.7. Statistical analysis of the data

The observations were recorded and analysed statistically as completely randomised design (CRD). The scores of organoleptic evaluation were assessed and best treatment were identified by Kendall's coefficient of concordance (W) and the nutritional qualities of the each treatments were compared using ANOVA.

Results

4. RESULTS

The results of the present study entitled "Standardisation and quality evaluation of millet based nutri flakes" are presented under the following headings.

4.1. Standardisation of millet based nutri flakes

4.1.1. Organoleptic qualities of jackfruit seed flour

4.1.2 Organoleptic evaluation of finger millet based nutriflakes with tapioca flour.

4.1.3 Organoleptic evaluation of finger millet based nutriflakes with jackfruit seed flour.

4.1.4. Organoleptic evaluation of barnyard millet based nutriflakes with tapioca flour.

4.1.4 Organoleptic evaluation of barnyard millet based nutriflakes with jackfruit seed flour

4.2. Quality evaluation of selected nutri flakes

4.2.1. Nutritional qualities

4.2.2. Shelf life qualities

4.3. Quality evaluation of the products prepared with nutri flakes

4.3.1. Organoleptic evaluation of ready to eat instant breakfast mix

4.4.2 Organoleptic evaluation of ready to eat nutri bars

4.4. Cost of production

4.1. Standardisation of millet based nutri flakes

Two types of nutri flakes, one based on finger millet flour, and the other one based on barnyard millet flour were standardised in combination with tapioca flour and jack fruit seed flour. Defatted soya flour, cocoa powder and rice bran were the other ingredients used in nutri flakes. The amount of other ingredients were kept in a fixed proportion of 10 per cent which comprises 5 per cent defatted soya flour, 2 per cent rice bran and 3 per cent cocoa powder. The organoleptic quality attributes for each type of nutri flakes were evaluated separately and were ranked based on their mean scores using Kendall's (W) test.

4.1.1. Organoleptic qualities of jackfruit seed flour prepared using different treatments

For developing good aroma and appealing flavour for jackfruit seed flour different treatments were given. After treatments, organoleptic evaluation of the flour was conducted. The most acceptable treatment was selected for the preparation of nutri flakes. The mean scores for different quality attributes of jackfruit seed flours are presented in Table.1.

The mean and mean rank scores for appearance of different treatments of jackfruit seed flour varied from 7.45 (T_4) to 8.7 (T_1) and 1.61 to 3.50, respectively. The highest mean score and mean rank score for colour among different treatments of jackfruit seed flour obtained were 8.3 and 3.17 for treatment T_1. The mean rank score of colour varied from 2 to 3.17 for T_4 to T_1 and for flavour it was 1.77 to 3.80. The mean score for flavour was the highest in T_1 (8.06) and the least score were 6.4 for (T_4). The mean scores and mean rank score for taste varied from 6.06 (T_1) to 8.06 (T_4) and 3.83 (T_0) to 6.06 and 1.67 (T_3) respectively. The mean scores for taste was the highest in T_1 (8.06) and the least value was 6.77 for T_4. The texture for different treatments of jackfruit seed flours obtained mean scores of 8.33 (T_1) followed by 7.86 (T_2), 7.73 (T_3) and 7.2 for T_4 and mean rank score varied from 1.73 (T_4) to 3.40 (T_1). The mean scores for overall acceptability varied from 6.46 (T_4) to 8.1 (T_1). The mean scores for overall acceptability was the highest in T_1 (8.1) followed by T_2 (7.13), T_3 (6.82), T_4 (6.46), respectively. The mean rank scores varied from 1.63 (T_4) to 3.90 (T_1). The highest overall acceptability was observed for roasted jackfruit seed flour (T_1) and hence it was selected as the best treatment for jackfruit seed flour preparation and was used in standardising nutri flakes.

From this, it was observed that acidification, fermentation and alkalisation did not improved the flavour considerably. Simple roasting was found to be effective in developing good aroma in the preparation of jackfruit seed flour.

Table.1. Mean score for organoleptic qualities of jackfruit seed flour prepared using different treatments

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_1 (Roasted)	8.7 (3.50)	8.3 (3.17)	8.06 (3.80)	8.33 (3.40)	8.06 (3.83)	8.1 (3.90)
T_2(Acidified and roasted)	8.14 (2.29)	8 (2.27)	6.95 (2.43)	7.86 (2.53)	6.82 (2.57)	7.13 (2.50)
T_3(Fermented and roasted)	8.19 (2.26)	8.06 (2.57)	6.62 (2)	7.73 (2.33)	6.22 (1.93)	6.82 (1.97)
T_4(Fermented alkalised and roasted)	7.45 (1.61)	7.95 (2)	6.4 (1.77)	7.2 (1.73)	6.06 (1.67)	6.46 (1.63)
Kendall's value	.564**	.188**	.552**	.437**	.622**	.671**

Value in parentheses are mean rank score based on Kendall's W

** Significant at 1% level

4.1.2. Organoleptic evaluation of finger millet based nutri flakes with tapioca flour

The nutri flakes based on finger millet flour were standardised with different proportions of tapioca flour are shown in plate.2. The mean scores and the mean rank scores for different quality attributes of finger millet based nutri flakes are presented in Table 2.

The mean scores and mean rank scores for appearance of finger millet based nutri flakes with tapioca flour varied from 7.46 (T_5) to 7.88 (T_3) and 3.07 to 4.40 respectively. The mean scores for colour varied from 7.00 (T_0) to 8.02 (T_3). The highest mean rank score for colour obtained were 4.9 for treatment T_3. The mean scores for flavour varied from 7.22 (T_5) to 7.85 (T_3). The mean rank scores for flavour was the highest in T_3 (4.30). The mean scores for texture of finger millet based nutri flakes ranged from 7.21 (T_5) to 8.08 (T_3) with mean rank scores in the range of 1.48 to 4.70. The mean scores for taste varied from 6.77 (T_5) to 7.84 (T_3). The highest mean rank score for taste obtained was

4.72 for treatment T_3. The mean scores for overall acceptability varied from 7.22 (T_5) to 7.92 (T_3) with mean rank scores in the range of 1.90 to 4.48.Among various treatments, the highest mean scores of 7.88 (appearance), 8.02 (colour), 7.85 (flavour), 7.84 (taste), 8.08 (texture), and 7.92 (overall acceptability) were obtained for T3 (60% finger millet flour and 30% tapioca flour). Considering highest scores of organoleptic qualities finger millet based nutri flakes added with tapioca flour (T3-60% FMF + 30% TF +10% other ingredients) was selected as the best treatment for further studies and the developed nutri flakes are shown in Plate .6.

4.1.3 Organoleptic evaluation of finger millet based nutri flakes with jackfruit seed flour

The nutri flakes based on finger millet flour were standardised with different proportions of jackfruit seed flour and are shown in Plate.3. The mean scores and the mean rank scores for different sensory attributes of finger millet based nutri flakes are presented in Table 3.

The mean scores and mean rank scores for appearance of finger millet based nutri flakes with jackfruit seed flour varied from 6.92 (T_5) to 7.85 (T_3) and and 4.07 to 2.43, respectively. The mean scores for colour varied from 7.00 (T_0) to 7.9 (T_3). The highest mean rank score for colour obtained was 4.07 for treatment T_3. The mean scores for flavour varied from 7.14 (T_5) to 8.07 (T_3). The mean rank score for flavour was the highest in T_3 (4.86). The texture of finger millet based nutri flakes obtained a mean scores from 6.38 (T_5) to 7.28 (T_3) with mean rank score in the range of 2.28 to 4.86. The mean scores for taste varied from 6.50 (T_5) to 7.66 (T_3). The highest mean rank score for taste obtained were 4.75 for treatment T_3. The mean scores for overall acceptability varied from 6.92 (T_5) to 7.85 (T_3) with mean rank scores in the range of 1.39 to 5.37.

Among various treatments, highest mean scores of 7.85 (appearance), 7.9 (colour), 8.07 (flavour), 7.66 (taste), 7.28 (texture) and 7.85 (overall acceptability) were obtained for T_3 (60 % finger millet flour and 30% jackfruit seed flour). Based on organoleptic scores, finger millet based nutri flakes added with jackfruit seed flour T_3 (60% FMF + 30% JSF+ 10% other ingredients) was selected as the best treatment for further studies and the developed nutri flakes are shown in Plate .5

Table.2. Mean score for organoleptic qualities of finger millet based nutri flakes with tapioca flour

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0 (100% FMF)	7.53 (3.17)	7 (2.20)	7.73 (4.50)	7.64 (3.03)	7.57 (4.43)	7.64 (2.9)
T_1 (80% FMF + 10% TF +10% OI)	7.68 (3.77)	7.62 (3.07)	7.57 (3.00)	7.91 (3.70)	7.46 (3.38)	7.64 (2.90)
T_2 (70% FMF + 20% TF +10% OI)	7.75 (4.00)	7.75 (3.63)	7.68 (3.44)	8.02 (4.40)	7.56 (3.72)	7.74 (4.25)
T_3 (60% FMF + 30% TF+ 10%OI)	7.88 (4.40)	8.02 (4.90)	7.85 (4.30)	8.08 (4.70)	7.84 (4.72)	7.92 (4.48)
T_4 (50% FMF + 40% TF+ 10%OI)	7.64 (3.33)	7.68 (3.70)	7.53 (3.63)	7.26 (1.53)	7.17 (2.72)	7.54 (3.50)
T_5 (40% FMF + 50% TF+10% OI)	7.46 (3.07)	7.34 (2.57)	7.22 (2.19)	7.21 (1.48)	6.77 (1.75)	7.22 (1.90)
Kendall's value	.081*	.251**	.238**	.413**	.404**	.278**

FMF- Finger millet flour, TF- Tapioca flour, OI- Other ingredients, Value in parentheses are mean rank score based on Kendall's W ** Significant at 1% level

Table.3. Mean score for organoleptic qualities of finger millet based nutri flakes with jackfruit seed flour

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0 (100% FMF)	7.64 (3.61)	7 (2.57)	7.85 (4.36)	7.21 (4.28)	7.57 (4.43)	7.64 (2.92)
T_1 (80% FMF + 10% JSF +10% OI)	7.75 (4.00)	7.46 (3.30)	7.28 (3.14)	7.22 (4.13)	7.26 (3.50)	7.75 (4.39)
T_2 (70% FMF + 20% JSF+ 10% OI)	7.78 (4.04)	7.88 (4.07)	7.35 (3.18)	7.22 (3.80)	7.28 (3.68)	7.78 (4.32)
T_3 (60% FMF + 30% JSF+ 10% OI)	7.85 (4.07)	7.9 (4.07)	8.07 (4.86)	7.28 (4.23)	7.66 (4.75)	7.85 (5.37)
T_4 (50% FMF + 40% JSF+ 10% OI)	7.25 (2.86)	7.8 (3.8)	7.21 (2.96)	6.54 (2.30)	6.87 (2.75)	7 (2.61)
T_5 (40% FMF + 50% JSF+ 10% OI)	6.92 (2.43)	7.53 (3.20)	7.14 (2.50)	6.38 (2.28)	6.50 (1.90)	6.92 (1.39)
Kendall's value	.180**	.129**	. 418**	.311**	.343**	.622**

FMF- Finger millet flour, JSF- Jackfruit seed flour, OI- Other ingredients

Value in parentheses are mean rank score based on Kendall's W, ** Significant at 1% level

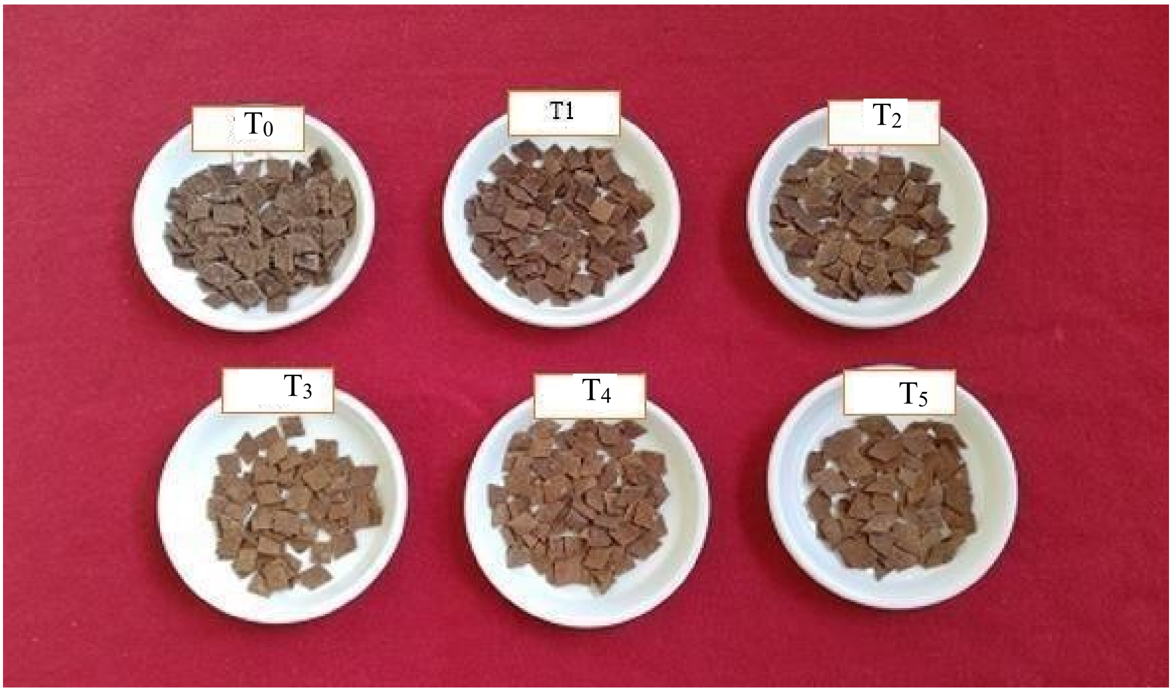

Plate.2. Finger miillet based nutri flakes with tapioca flour

Plate.3. Finger miillet based nutri flakes with jackfruit seed flour

4.1.3. Organoleptic evaluation of barnyard millet based nutri flakes with tapioca flour

Nutri flakes based on barnyard millet flour were standardised with different proportions of tapioca flour (Plate.4) The mean scores and the mean rank scores for different quality attributes of barnyard millet based nutri flakes are presented in Table.4.

The mean scores and mean rank scores for appearance of barnyard millet based nutri flakes with tapioca flour varied from 6.86 (T_0) to 8.17 (T_5) and 1.70 to 5.43, respectively. The mean scores for colour varied from 6.48 (T_0) to 7.77 (T_5). The highest mean rank score for colour obtained were 5.50 for treatment T_5. The mean scores for flavour varied from 6.37 (T_0) to 7.24 (T_5). The mean rank score for flavour was the highest in T_5 (5.07). The texture of barnyard millet based nutri flakes obtained a mean scores from 6.42 (T_0) to 7.66 (T_5). The highest mean rank score for texture obtained was 5.30 (T_5). The mean scores for taste varied from 4.68 (T_0) to 7.15 (T_5). The highest mean rank score for taste obtained were 5.73 (T_5). The mean scores for overall acceptability varied from 5.8 (T_0) to 7.61 (T_5). The highest mean rank score for overall accceptability obtained was 5.93 (T_5). The mean scores for overall acceptability was the highest from T_5 (7.61) followed by T_4 (7.23), T_3 (6.99), T_2 (6.69), T_1 (6.32) and T_0 (5.8) respectively.

Among various treatments, highest mean scores of 8.17 (appearance), 7.77 (colour), 7.24 (flavour), 7.15 (taste), 7.66 (texture), and 7.61 (overall acceptability) were obtained for T_5 (40% barnyard millet flour and 30% tapioca four) The best treatment was selected based on the organoleptic scores. Hence, barnyard millet based nutri flakes with tapioca flour T_5 (40% BMF + 50% TF) was selected for further studies and are shown in Plate .6

4.1.4. Organoleptic evaluation of barnyard millet based nutri flakes with jackfruit seed flour.

Nutri flakes based on barnyard millet flour were standardised with different proportions of jackfruit seed flour. The mean scores and the mean rank scores for different quality attributes of barnyard millet based nutri flakes are presented in Table.5. The developed nutri flakes are shown in Plate 5.

The mean scores and mean rank scores for appearance of barnyard millet based nutri flakes with jackfruit seed flour varied from 6.48 (T_0) to 8.20 (T_5) and 1.50 to 5.44 respectively. The highest mean score and mean rank score for colour of barnyard millet based nutri flakes obtained were 7.81 and 5.56 for the treatment T_5. The mean rank score of colour varied from 1.47 (T_0) to 5.56 (T_5) and for flavour it was 2.14 (T_0) to 5.22 (T_5). The mean score for flavour was the highest in T_5 (7.25) and the least score was 6.09 (T_0). The texture of barnyard millet based nutri flakes obtained a mean scores of 5.96 (T_0) to7.66 (T_5) and mean rank score of 1.83 (T_0) to 5.39 (T_5). The mean scores for taste was the highest in T_5 (7.15) and the lowest value was 4.68 for T_0. The mean scores for overall acceptability varied from 5.92 (T_0) to 7.62 (T_5). The mean scores for overall acceptability was the highest in T_5 (7.62) followed by T_4 (7.19), T_3 (6.88), T_2 (6.57), T_1 (6.15) and T_0 (5.5) respectively. The mean rank scores varied from 5.92 (T_5) to 1.11 (T_0).

Among various treatments, the highest mean score of 8.20 (appearance), 7.81 (colour),7.25 (flavour), 7.15 (taste), 7.66 (texture), and 7.62 (overall acceptability) were obtained for T_5. The best treatment was selected based on the overall acceptability. Hence, barnyard millet based nutri flakes with jackfruit seed flour T_5 (40% BMF + 50% JSF) was selected for further studies and is shown in Plate.5.

Table.4.Mean score for organoleptic qualities of barnyard millet based nutriflakes with tapioca flour

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0 (100% BMF)	6.86 (1.70)	6.48 (1.50)	6.37 (2.20)	6.42 (1.93)	4.68 (1.23)	5.8 (1.13)
T_1 (80% BMF + 10% TF+ 10% OI)	7.2 (2.13)	6.86 (2.37)	6.53 (2.30)	6.55 (2.00)	5.66 (2.63)	6.32 (2.10)
T_2 (70% BMF + 20% TF+ 10%OI)	7.62 (3.67)	7.22 (3.20)	6.82 (3.33)	7.15 (3.43)	5.8 (2.93)	6.69 (3.00)
T_3 (60% BMF + 30% TF+ 10%OI)	7.68 (3.77)	7.51 (4.27)	6.77 (3.17)	7.42 (4.23)	6.06 (3.77)	6.99 (4.03)
T_4 (50% BMF + 40% TF+ 10%OI)	7.84 (4.30)	7.48 (4.17)	7.22 (4.93)	7.37 (4.10)	6.73 (4.70)	7.23 (4.80)
T_5 (40% BMF + 50% TF+10% OI)	8.17 (5.43)	7.77 (5.50)	7.24 (5.07)	7.66 (5.30)	7.15 (5.73)	7.61 (5.93)
Kendall's value	.651**	.686**	.538**	.753**	.566**	.904**

BMF- Barnyard millet flour, TF- Tapioca flour, OI- Other ingredients

Value in parentheses are mean rank score based on Kendall's W
** Significant at 1% level

Table.5. Mean score for organoleptic qualities of barnyard millet based nutriflakes with jackfruit seed flour

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0 (100% BMF)	6.48 (1.50)	6.18 (1.47)	6.09 (2.14)	5.96 (1.83)	4.68 (1.22)	5.5 (1.11)
T_1 (80% BMF + 10% JSF +10% OI)	7.05 (2.22)	6.72 (2.44)	6.33 (2.28)	6.24 (2.00)	5.66 (2.50)	6.15 (2.11)
T_2 (70% BMF + 20% JSF+10% OI)	7.40 (3.47)	7.12 (3.31)	6.64 (3.22)	6.79 (3.31)	5.8 (3.03)	6.57 (3.03)
T_3 (60% BMF + 30% JSF +10% OI)	7.62 (3.89)	7.37 (4.14)	6.68 (3.36)	7.18 (4.22)	6.06 (3.78)	6.88 (4.00)
T_4 (50% BMF + 40% JSF+10% OI)	7.87 (4.47)	7.40 (4.08)	7.07 (4.78)	7.25 (4.25)	6.73 (4.72)	7.19 (4.83)
T_5 (40% BMF + 50% JSF+10% OI)	8.20 (5.44)	7.81 (5.56)	7.25 (5.22)	7.66 (5.39)	7.15 (5.75)	7.62 (5.92)
Kendall's value	0.703**	0.674**	0.564**	0.614**	0.778**	0.912**

BMF- Barnyard millet flour, JSF- Jackfruit seed flour, OI- Other ingredients

Value in parentheses are mean rank score based on Kendall's W
** Significant at 1% level

Plate.4. Barnyard miillet based nutri flakes with tapioca flour

Plate.5. Barnyard miillet based nutri flakes with tapioca flour

4.1.5. Selection of nutri flakes

Based on the organoleptic qualities, the most acceptable treatment from each set was selected. The selected nutri flakes and their combinations are summerised in Table.6.

Table.6. Combinations of selected nutri flakes

	Nutri flakes	Combination
1	Nutri flake. 1 (NF.1)	T3 (60 % FMF + 30% TF + 10 % OI)
2	Nutri flake. 2 (NF.2)	T3 (60 % FMF + 30% JSF + 10 % OI)
3	Nutri flake. 3 (NF.3)	T5 (40 % BMF + 50% TF + 10 % OI)
4	Nutri flake. 4 (NF.4)	T5 (40 % BMF + 50% JSF + 10 % OI)

The above selected combinations of nutri flakes from set 1,2,3,4 were specified as nutri flake 1(NF.1), nutri flake 2(NF.2), nutri flake 3(NF.3), nutri flake 4 (NF.4) which are shown in Plate.6.

Plate.6. Selected nutriflakes

4.2. Quality evaluation of the selected nutri flakes

4.2.1. Nutritional qualities

The selected millet based nutri flakes were analysed for the nutritional qualities. The nutritional qualities of millet based nutri flakes such as moisture, total fibre, starch, total carbohydrate, protein, fat, energy, calcium, iron, sodium, magnesium and potassium were assesed.

4.2.1.1. Moisture

Moisture is an important parameter of quality determination and shelf life in food products. The total moisture content present in the selected nutri flakes were analysed and are presented in Table 7.

The moisture content of selected millet based nutri flakes varied from 3.17 per cent (NF.3) to 8.49 per cent (NF.2). Finger millet based nutri flakes with jackfruit seed flour showed the highest moisture content of 8.49 per cent (NF.2), followed by finger millet based nutri flakes with tapioca flour (NF.1) which had seven per cent moisture content. Barnyard millet based nutri flakes with jackfruit seed flour (NF.4) had 5.35 per cent moisture content. The lowest moisture content 3.17 per cent was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference was observed among moisture content of different nutri flakes.

4.2.1.2. Total fibre

The total fibre content present in the selected nutri flakes were analysed and are presented in Table 7.

Total fibre of the selected nutri flakes varied from 2.86 per cent (NF.1) to 5.76 per cent (NF.4). Barnyard millet based nutri flakes with jackfruit seed flour (NF.4) showed the highest total fiber content of 5.76 per cent, followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) (4.09 %). Barnyard millet based nutri flakes with tapioca flour (NF.3) had fibre content.of 3.82 per cent. The lowest fibre content of 2.85 per cent was observed in finger millet based nutri flakes with tapioca flour (NF.1). A significant difference was observed among fibre content of different nutri flakes.

4.2.1.3. Starch

The starch content present in the selected nutri flakes were analysed and are presented in Table 7.

Starch content of the selected nutri flakes varied from 24.62 g/100 g (NF.3) to 43.11 g/100 g (NF.2). Finger millet based nutri flakes with jackfruit seed flour showed the highest starch content of 43.11 g/100 g (NF.2), followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (38.04 g/100 g) and finger millet based nutri flakes with tapioca flour (NF.1) (34.49 g/100 g). The lowest value of starch content 24.62 g/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference was observed among different nutri flakes.

4.2.1.4. Total carbohydrate

The total carbohydrate content present in the selected nutri flakes were analysed and are presented in Table 7.

Total carbohydrate content of the selected nutri flakes varied from 36.54 g/100 g (NF.3) to 50.46 g/ 100 g (NF.2). Finger millet based nutri flakes with jackfruit seed flour had the highest carbohydrate content of 50.46 g/100 g (NF.2), followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (47.12 g/100 g). Finger millet based nutri flakes with tapioca flour (NF.1) (44.31 g/100 g). The lowest carbohydrate content of 36.54 g/100 g was showed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference was observed in carbohydrate content of different nutri flakes.

4.2.1.5. Protein

The protein content present in the selected nutri flakes were analysed and are presented in Table 7.

Protein content of selected nutri flakes varied from 6.88 g/100g (NF.3) to 13.68 g/100g (NF.4). Barnyard millet based nutri flakes with jackfruit seed flour had the highest protein content of 13.68 g/100 g (NF.4), followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) (12.85 g/100 g) and finger millet based nutri flakes with tapioca flour (NF.1) 7.73 g/100 g protein content. The lowest value of protein content of 6.88 g/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference was observed among different nutri flakes.

4.2.1.6. Fat

The fat content present in the selected nutri flakes were analysed and are presented in Table 7.

Fat content of selected nutri flakes varied from 1.26 g/100 g (NF.1) to 1.99 g/100 g (NF.4). Barnyard millet based nutri flakes with jackfruit seed flour showed the highest fat content of 1.99 g/100 g (NF.4), followed by barnyard millet based nutri flakes with tapioca flour (NF.3) with 1.72 g/100 g of fat content and finger millet based nutri flakes with jackfruit seed flour (NF.2) with 1.39 g/100 g. The lowest value of fat content 1.26 g/100 g were observed in finger millet based nutri flakes with tapioca flour (NF.1). A significant difference in fat content among nutri flakes.

4.2.1.7. Energy

The energy present in the selected nutri flakes were computed and are presented in Table 7.

Energy present in selected nutri flakes varied from 189.16 kcal/100g (NF.3) to 265.78 kcal/ 100 g (NF.2). Finger millet based nutri flakes with jackfruit seed flour showed highest energy content of 265.78 kcal/100 g (NF.2), followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (261.14 kcal/100 g) and finger millet based nutri flakes with tapioca flour (NF.1) (219 kcal/100 g). The lowest energy content of 189.16 kcal/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference in energy content was observed among different nutri flakes.

4.2.1.8. Calcium

The calcium content present in the selected nutri flakes were analysed and are presented in Table 8.

Calcium content of selected nutri flakes varied from 23.63 mg/100 g (NF.3) to 199 mg/100 g (NF.2). Finger millet based nutri flakes with jackfruit seed flour showed the highest calcium content of 199 mg/100 g (NF.2), followed by finger millet based nutri flakes with tapioca flour (NF.1) (195 mg/100 g) and barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (28.89 mg/100 g). The lowest calcium content of 23.63 mg/100 g were observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference in calcium content was observed among different nutri flakes.

4.2.1.9. Iron

The iron content present in the selected nutri flakes were analysed and are presented in Table 8.

Iron content of selected nutri flakes varied from 2 mg/100 g (NF.3) to 5.58 mg/100 g (NF.1). Finger millet based nutri flakes with tapioca flour showed the highest iron content of 5.58 mg/100 g (NF.1), followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) (5.12 mg/100 g and barnyard millet based nutri flakes with jackfruit seed flour (NF.4) had 2.4 mg/100 g iron. The lowest iron content 2 mg/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference in iron content was observed among different nutri flakes.

4.2.1.10. Sodium

The sodium content present in the selected nutri flakes were analysed and are presented in Table. 8.

Sodium content of selected nutri flakes varied from 10.08 mg/100 g (NF.3) to

13.66 mg/100 g (NF.2). Finger millet based nutri flakes with jackfruit seed flour showed highest the sodium content of 13.66 mg/100 g (NF.2), followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (13.4 mg/100g) and f inger millet based nutri flakes with tapioca flour (NF.1) (13 mg/100 g). The lowest sodium content 10.08 mg/100g were observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference in sodium content was observed among different nutri flakes.

4.2.1.11. Magnesium

The magnesium content present in the selected nutri flakes were analysed and are presented in Table 8.

Magnesium content of selected nutri flakes varied from 31.10 mg/100 g (NF.3) to 87 mg/100 g (NF.2). Finger millet based nutri flakes with jackfruit seed flour showed the highest magnesium content of 87 mg/100 g (NF.2), followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (82.5 mg/100 g) and finger millet based nutri flakes with tapioca flour (NF.1) with (59.1 mg/100 g). The lowest magnesium content of 31.1 mg/100g were observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference in magnesium content was observed among different nutri flakes.

4.2.1.12. Potassium

The potassium content present in the selected nutri flakes were analysed and are presented in Table 8.

Potassium content of selected nutri flakes varied from 153.50 mg/100 g (NF.3) to 396 mg/100 g (NF.4). Barnyard millet based nutri flakes with jackfruit seed flour showed the highest potassium content of 396 mg/100 g (NF.4), followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) (370 mg/100 g) and finger millet based nutri flakes with tapioca flour (NF.1) (214 mg/100 g). The lowest potassium content of 153.5 mg/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). A significant difference in potassium content was observed among different nutri flakes.

Table.7. Nutritional qualities of selected nutri flakes

Types of Nutri flakes	Moisture (%)	Total fibre (%)	Starch (%)	Carbohydrate (g / 100 g)	Protien (g / 100 g)	Fat (g /100 g)	Energy (kcal / 100 g)
NF. 1 (60% FMF + 30%TF nutri flakes + 10% OI)	7.00[b]	2.86[c]	34.49[c]	44.32[c]	7.73[b]	1.26[d]	219.54[b]
NF. 2 (40% FMF + 50% JSF nutri flakes + 10% OI)	8.49[a]	4.09[b]	43.11[a]	50.46[a]	12.85[a]	1.39[c]	265.78[a]
NF. 3 (60% BMF + 30% TF nutri flakes + 10% OI)	3.17[d]	3.82[b]	24.62[d]	36.54[d]	6.88[b]	1.72[b]	189.16[c]
NF. 4 (40% BMF+ 50% JSF nutri flakes + 10% OI)	5.36[c]	5.76[a]	38.04[b]	47.12[b]	13.68[a]	1.99[a]	261.14[a]
C.D (0.05)	**1.048***	**0.603***	**0.960***	**2.593***	**1.074***	**0.122***	**11.107***

FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, JSF- Jackfruit seed flour, NF- Nutri flakes

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Table.8. Mineral content of selected nutri flakes.

Types of Nutri flakes	Calcium	Iron	Sodium	Magnesium	Potassium
	(mg 100 / g)				
NF. 1 (60% FMF+ 30% TF nutri flakes +10% OI)	195[b]	5.58[a]	13[a]	59.1[c]	214[c]
NF. 2 (40%FMF + 50% JSF nutri flakes+10% OI)	199[a]	5.12[a]	13.66[a]	87.00[a]	370[b]
NF. 3 (60% BMF + 30% TF nutri flakes +10% OI)	23.63[d]	2.00[c]	10.08[b]	31.0[d]	153.5[d]
NF. 4 (40% BMF+ 50% JSF nutri flakes +10% OI)	28.89[c]	2.4[b]	13.4[a]	82.5[b]	396[a]
C.D (0.05)	**2.89***	**2.04***	**2.54***	**2.19***	**2.70***

FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, JSF-Jackfruit seed flour

4.2.2. Shelf life qualities

4.2.2.1. Organoleptic evaluation of millet based nutri flakes incorporated with tapioca flour during storage

Nutri flakes incorporated with tapioca flour were kept for three months of storage. The nutri flakes packed in laminated aluminium pouches were presented in Plate 7. The organoleptic qualities of the selected nutri flakes during storage are given in Table 9.

The mean scores for the appearance of finger millet based nutri flakes incorporated with tapioca flour (NF.1) was observed as 7.88 initially, which gradually decreased into 7.66 at the end of storage. Initially, the mean score for colour was observed as 8.02 which decreased to 7.83 at the end of the storage.

The mean scores for flavor and texture of finger millet based nutri flakes incorporated with tapioca four were initially observed as 7.73 and 8.08 respectively which decreased upto 7.5 and 7.66. The mean score for taste was observed as 7.84 initially, which decreased to 7.16. The mean scores for overall acceptability was observed as 7.92 and at the end of the storage, which decreased upto 7.78. Slight decrease was observed in all organoleptic parameters at the end of the storage.

Initially, the mean scores for the appearance of barnyard millet based nutri flakes (NF.3) incorporated with tapioca flour was observed as 8.17 which gradually decreased to 7.41 after 3 months of storage. The mean score for colour was observed as 7.77 which decreased to 7 at the end of the study.

The mean scores for flavour and texture of barnyard millet based nutri flakes incorporated with tapioca flour, were observed as 7.24 and 7.16 initially which decreased to 6.91 and 6.83. The mean score for taste was observed as 7.15 which decreased to 6.88 at the end of the study. Initially, the overall acceptability was observed as 7.61 and at the end of the storage, which decreased upto 6.75.

4.2.2.2. Organoleptic evaluation of millet based nutri flakes incorporated with jackfruit seed flour during storage.

The nutri flakes incorporated with jackfruit seed flour were kept for one month of storage. The nutri flakes packed in laminated aluminium pouches were presented in

Plate.7. The organoleptic qualities of the selected nutri flakes during storage were tabulated and given in Table 10.

For finger millet based nutri flakes were incorporated with jackfruit seed flour (NF.2), the appearance obtained an initial mean score of 7.85 which gradually decreased to 7.66 within one month of storage. The mean score for colour was observed as 7.9 which decreased to 7.83 at the end of the storage study.

The mean scores for flavour and texture of finger millet based nutri flakes incorporated with jackfruit seed flour (NF.2), was initially observed as 8.07 and 7.5 which decreased upto7.33 and 7.28. The mean score for texture was observed as 7.5 which decreased to 7.28 at the end of the study. The mean score for overall acceptability was observed as 7.85 initially and at the end of the storage, which decreased to7.67.

The mean score for the appearance of barnyard millet based nutri flakes incorporated with jackfruit seed flour (NF.4), was 8.20 initially, which gradually decreased to 7.96 after one month of storage.

The mean score for flavour and texture of barnyard millet based nutri flakes incorporated with jackfruit seed flour (NF.4) was observed as 7.25 and 7.15 initially which decreased to 6.83 and 6.25. The mean score for taste was observed as 7.15 which decreased to 6.25 at the end of the study. The mean score for overall acceptability was observed as 7.62 initially and at the end of the storage, which decreased to 7.1

Table.9. Mean score for organoleptic qualities for selected nutri flakes with tapioca flour during storage.

Treatments / Parameters	NF.1 (60% FMF+ 30% TF nutri flakes)		NF.3 (60% BMF + 30% TF nutri flakes)	
	Initial	Final	Initial	Final
Appearance	7.88	7.66	8.17	7.41
Colour	8.02	7.83	7.77	7.00
Flavour	7.73	7.5	7.24	6.91
Texture	8.08	7.66	7.66	6.83
Taste	7.84	7.16	7.15	6.08
Overall acceptability	7.92	7.78	7.61	6.75
Total score	47.59	45.59	45.6	40.98

FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, NF- Nutri flakes

Table.10. Mean score for organoleptic qualities for selected nutri flakes with jackfruit seed flour during storage.

Treatments / Parameters	NF.2 (40% FMF+ 50%JSF nutri flakes)		NF.4 (40% BMF + 50%JSF nutri flakes)	
	Initial	Final	Initial	Final
Appearance	7.85	7.66	8.20	7.96
Colour	7.9	7.83	7.81	7.63
Flavour	8.07	7.33	7.25	6.83
Texture	7.5	7.28	7.66	6.86
Taste	7.66	7.16	7.15	6.25
Overall acceptability	7.85	7.67	7.62	7.1
Total score	46.61	45.15	45.69	42.63

FMF- Finger millet flour, BMF- Barnyard millet flour, JSF- Jackfruit seed flour, NF- Nutri flakes.

4.2.2.3. Enumeration of total microflora in tapioca flour incorporated nutri flakes

The microbial population of the selected nutri flakes were assessed initially and also at the end of the storage. Nutri flakes incorporated with tapioca flour (NF.1 and NF.2) were kept for three months of storage. The results are presented in Table 11.

As revealed in Table 11, initially the bacterial count was noticed as 0.28×10^{-5} cfu/g in finger millet based nutri flakes incorporated with tapioca flour (NF.1) which increased gradually to 0.85×10^{-5} cfu/g. Barnyard millet based nutri flakes incorporated with tapioca flour (NF.3) was observed as 0.15×10^{-5} cfu/g initially, which increased to 0.65×10^{-5} cfu/g. Initially, fungal count were not detected in finger millet and barnyard millet based nutri flakes incorporated with tapioca flour (NF.1) and (NF.3). Later by the end of the storage, the fungal count was found to be 0.35×10^{-3} cfu/g in finger millet based nutri flakes (NF.1) and 0.18×10^{-3} cfu/g in barnyard millet based nutri flakes (NF.3). Yeast growth was not detected in the selected nutri flakes throughout the storage period.

4.2.2.4. Enumeration of total microflora in jackfruit seed flour incorporated nutri flakes.

The microbial population of the selected jackfruit seed flour incorporated nutri flakes were assessed initially and after one month of storage. Nutri flakes incorporated with jackfruit seed flour (NF.2 and NF.4) were kept for one months of storage.

As revealed in table 12, initially the bacterial count was noticed as 0.4×10^{-5} cfu/ g in finger millet based nutri flakes incorporated with jackfruit seed flour (NF.2) and which increased gradually to 1.15×10^{-5} cfu/g. Barnyard millet based nutri flakes incorporated with jackfruit seed flour (NF.4) was observed as 0.26×10^{-5} cfu/ g initially, which was increased to 0.8×10^{-5} cfu/ g. Initially, the fungal count was detected as 0.08×10^{-3} cfu/ g in finger millet based nutri flakes incorporated with jackfruit seed flour (NF.2) and 0.13×10^{-3} cfu/g in barnyard millet based nutri flakes incorporated with jack fruit seed flour (NF.4). Later by the end of the storage, the fungal count was found to be increased into 0.43×10^{-3} cfu/g in finger millet based nutri flakes (NF.2) and which was 0.33×10^{-3} cfu/g in barnyard millet based nutri flakes (NF.4). Yeast growth was not detected in selected nutri flakes throughout the storage period.

Table 11. Total microbial count of the selected nutri flakes incorporated with tapioca flour during storage

Treatments	Microbial population (cfu/g)					
	Bacteria (10^{-5}cfu/g)		Fungi (10^{-3}cfu/g)		Yeast (10^{-3}cfu/g)	
	Initial	Final	Initial	Final	Initial	Final
NF. 1 (60%FMF + 40% TF nutri flakes)	0.28	0.85	ND	0.35	ND	ND
NF. 3 (60% BMF + 40% TF nutri flakes)	0.15	0.65	ND	0.18	ND	ND

Table 12. Total microbial count of the selected nutri flakes incorporated with jackfruit seed flour during storage

Treatments	Microbial population (cfu/g)					
	Bacteria (10^{-5}cfu/g)		Fungi (10^{-3}cfu/g)		Yeast (10^{-3}cfu/g)	
	Initial	Final	Initial	Final	Initial	Final
NF.2 (40%FMF + 50% JSF nutri flakes)	0.4	1.15	0.08	0.43	ND	ND
NF.4(40%BMF+ 50% JSF nutri flakes)	0.26	0.8	0.13	0.33	ND	ND

FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, JSF- Jackfruit seed flour, NF- Nutri flakes

4.2.2.5. Insect infestation

The insect infestation of the selected nuriflakes were assessed initialy and at the end of the storage. There was no insect infestation in any of stored nutri flakes until the end of storage.

4.3. Quality evaluation of the value added products from the selected nutri flakes

The products like ready to eat instant breakfast mixes and nutri bars were prepared using the selected nutri flakes. The products were prepared using developed nutri flakes that is finger millet based nutri flakes with tapioca flour (NF.1), finger millet based nutri flakes with jackfruit seed flour (NF.2), barnyard millet based nutri flakes with tapioca flour (NF.3), and barnyard millet based nutri flakes with jackfruit seed flour (NF.4). The products were evaluated organolepticaly for different attributes such as appearance, colour, flavour, taste, texture and overall acceptability. The results of organoleptic evaluation of these products are presented in this section.

4.3.1. Organoleptic evaluation of the ready to eat instant breakfast mix

Ready to eat instant breakfast mixes (IBM) were prepared using four types of nutri flakes (Plate.8). The ready to eat instant breakfast mixes after adding hot milk were shown in Plate.9. The mean scores and the mean rank scores for different quality attributes of ready to eat instant breakfast mixes are presented in Table.13.

The mean scores and mean rank scores for appearance of each ready to eat instant breakfast mixes varied from 7.54 (IBM- NF.4) to 7.90 (IBM- NF.1) and 2.18 to 2.86 respectively. The mean scores and mean rank scores for colour varied from 7.63 to 8 and2.45 to 2.86 in mix prepared with NF.3 and NF.1 respectively. The highest mean rank score for colour obtained were 2.86 for IBM- NF.1. The mean scores for flavour varied from 7.27 (IBM- NF.4) to 7.81 (IBM- NF.1). The mean rank score for flavor was the highest in IBM- NF.1 (2.86). The mean scores for taste varied from 6.90 (IBM-NF.4) to 7.81 (IBM-NF.1). The highest mean rank score for taste obtained were 3.14 for treatment set.1. The texture of ready to eat instant breakfast mixes obtained a mean scores from 7.18 (IBM- NF.4) to 7.72 (IBM-NF.1). The highest mean rank score for texture obtained were 2.77 for treatment IBM- NF.1. The mean scores for overall acceptability varied from 6.82 (IBM- NF.4) to 7.46 (IBM- NF.1). The highest mean rank score for overall accceptability obtained were 3.27 for IBM- NF.1.

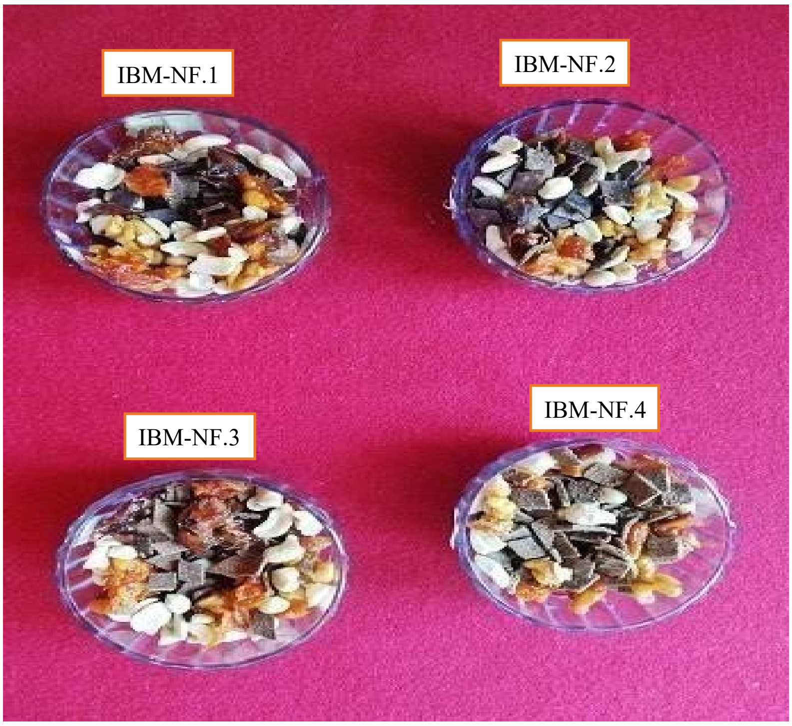

Plate.8. Ready to eat instant breakfast mixes

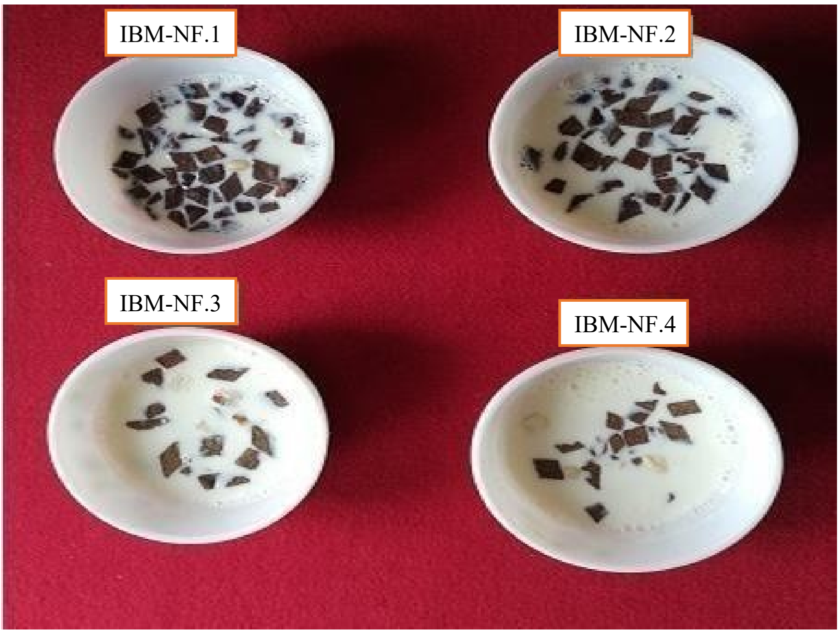

Plate.9. Ready to eat instant breakfast mixes by adding milk

IBM- Instant breakfast mix, NF- Nutri flakes.

4.3.2. Organoleptic evaluation of the ready to eat nutri bar

Ready to eat nutri bars (NB) were prepared from the developed nutri flakes and are shown in Plate.10. The mean scores and the mean rank scores for different quality attributes of ready to eat nutri bars are presented in Table.13.

The mean scores and mean rank scores for appearance of nutri bars varied from 8 (NB- NF.4) to 8.25 (NB-NF.1) and 2.28 to 2.91 respectively. The highest mean score and mean rank score for colour of nutri bars obtained were 8 and 2.71 for NB-NF.1 The mean scores for flavour varied from 7.56 (NB- NF.4) to 8.18 (NB-NF.1). The mean score for flavour was the highest in NB-NF.1 (8.18). The mean scores for texture varied from 7.56 (NB-NF.4) to 7.81 (NB-NF.1). The highest mean rank score for texture obtained were 2.63 for NB-NF.1. The mean scores for taste varied from 7.43 (NB- NF.4) to 7.87 (NB-NF.1). The highest mean rank score for taste obtained were 3.14 for NB-NF.1. The mean scores for overall acceptability varied from 7.43 (NB-NF.4) to 8.12 (NB-NF.1). The highest mean rank score for overall accceptability obtained were 3.03 for NB-NF.1 and lowest of 1.93 for NB- NF.4.

Plate.10. Ready to eat nutri bars
NB – Nutri bar, NF- Nutri flakes

Table.13. Mean score for organoleptic qualities of ready to eat instant breakfast mixes.

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
IBM-NF.1 (60% FMF + 30% TF)	7.90 (2.86)	8 (2.86)	7.81 (2.86)	7.72 (2.77)	7.81 (3.14)	7.46 (3.27)
IBM- NF.2 (60% FMF + 30% TF)	7.63 (2.50)	7.72 (2.50)	7.72 (2.82)	7.54 (2.68)	7.72 (2.59)	7.33 (2.86)
IBM- NF. 3 (60% FMF + 30% TF)	7.63 (2.45)	7.63 (2.27)	7.36 (2.23)	7.27 (2.32)	7 (2.23)	7.19 (2.32)
IBM- NF. 4 (60% FMF + 30% TF)	7.54 (2.18)	7.72 (2.36)	7.27 (2.09)	7.18 (2.23)	6.90 (2.05)	6.82 (1.55)
Kendall's value	.140**	.099*	.163**	.083*	.212**	.418**

IBM- Instant breakfast mix, NF- Nutri flakes, FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, JSF- Jackfruit seed flour, NF-Nutri flakes

Value in parentheses are mean rank score based on Kendall's W ** Significant at 1% level * Significant at 5% level

Table.14. Mean score for organoleptic qualities of nutri bars

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
NB-NF.1 (60% FMF + 30% TF)	8.25 (2.91)	8 (2.71)	8.18 (2.96)	7.81 (2.63)	7.87 (3.14)	8.12 (3.03)
NB-NF.2 (60% FMF + 30% JSF)	8.12 (2.59)	8 (2.68)	8.12 (2.72)	7.75 (2.53)	7.81 (2.59)	8.05 (3.03)
NB-NF.3 (40% BMF + 50% TF)	8.01 (2.22)	7.78 (2.32)	8 (2.22)	7.62 (2.47)	7.5 (2.23)	7.60 (2.00)
NB-NF.4 (40% BMF + 50% JSF)	8 (2.28)	7.78 (2.29)	7.56 (2.09)	7.56 (2.38)	7.43 (2.05)	7.43 (1.93)
Kendall's value	.105**	.087*	.244**	.083*	.014*	.308**

NB – Nutri bar, NF- Nutri flakes FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, JSF- Jackfruit seed flour, NF-Nutri flakes

Value in parentheses are mean rank score based on Kendall's W

** Significant at 1% level * Significant at 5% level

4.4. Cost of production of the selected nutri flakes and value added products

The cost of production of the selected nutri flakes was estimated per 100g of the finished product and the details are furnished in Table 15.

The cost for selected nutri flakes varied from 21.3 (NF.3) to 24.3 (NF.4). The cost of production of finger millet based nutri flakes incorporated with tapioca flour (NF.1) was Rs. 21.55 and for finger millet based nutri flakes incorporated with jackfruit seed flour (NF.2) was Rs. 24.1. The cost for for selected barnyard millet based nutri flakes incorporated with tapioca flour (NF.3) was Rs. 21.3 and for barnyard millet based nutri flakes incorporated with jackfruit seed flour (NF.4) was 24.3.

The cost for ready to eat breakfast mixes varied from 30.7 (IBM - NF.3) to 33.77 (IBM - NF.4). The cost of production of instant breakfast mix prepared with NF.1 (FMF +TF) was Rs. 31 and for instant breakfast mix prepared with NF.2 (FMF +JSF) was Rs.33.57. The cost for ready to eat breakfast mix prepared with NF.3 (BMF+TF) was Rs. 30.7 and for ready to eat breakfast mix prepared with NF.4 (BMF+JSF) was Rs. 33.77.

The cost for ready to eat nutri bar varied from 38.5(NB - NF.3) to 41.6(NB-NF.4). The cost of production of ready to eat nutri bar prepared with NF.1 (FMF +TF) was Rs. 38.8 and for ready to eat nutri bar prepared with NF.2 (FMF +JSF) was Rs. 41.37. The cost for ready to eat nutri bar prepared with NF.3 (BMF+TF) was Rs. 38.5 and for ready to eat nutri bar prepared with NF.4 (BMF+JSF) was Rs. 41.6.

Table 15. Cost of production for selected nutri flakes and value added products

Treatments	Cost (Rs/100 g)		
	Nutri flakes	RTE Breakfast mix	RTE Nutribar
NF.1 (60% FMF+30% TF)	21.55	31	38.8
NF.2 (60% FMF+30% JSF)	24.1	33.57	41.37
NF.3 (40% BMF+50% TF)	21.3	30.7	38.5
NF.4 (40% BMF+50% JSF)	24.3	33.77	41.6

FMF- Finger millet flour, BMF- Barnyard millet flour, TF- Tapioca flour, JSF- Jackfruit seed flour, NF-Nutri flakes

Discussion

5. DISCUSSION

The discussion pertaining to the study entitled ‘Standardisation and quality evaluation of millet based nutri flakes’ is presented in this section under the following headings.

5.1. Standardisation of millet based nutriflakes

5.1.1. Quality attributes of ingredients

5.1.2. Organoleptic qualities of finger millet based nutri flakes

5.1.3. Organoleptic qualities of barnyard millet

based nutri flakes 5.2.Nutritional qualities of millet

based nutri flakes.

5.3. Storage qualities of nutri flakes

5.4. Organoleptic qualities of products developed with nutri flakes.

5.1. Standardisation of millet based nutriflakes

Two types of nutri flakes, one based on finger millet (*Eleusine coracana*) and the other one based on barnyard millet (*Echinochloa esculenta*) were standardised in combination with tapioca flour and jack fruit seed flour. Defatted soya flour, cocoa powder, and rice bran were the other ingredients used in nutri flakes.

5.1. 1. Quality attributes of ingredients

Composite flours can be developed by adding flours of millets, selected protein sources and functional ingredients to provide adequate energy, protein, iron calcium and other micro nutreints. Millets are unique because its richness in calcium, dietary fiber. Millet proteins are strong sources of essential amino acids, except for lysine and threonine and are relatively high in methionine. Millets are rich sources of phytochemicals and micronutrients (Singh *et al* 2012). Barnyard millet is nutritionally rich but the utilisation of whole grain and value added products are limited.

The barnyard millet flour can be effectively utilised for value added products. The barnyard millet flour is slightly bitter in taste due to the presence of phenolic compounds (Sarker, 2015).

The millets used in the study were malted for improving the nutritional qualities The Improvement in protein digestibility after germination, soaking, debranning and dry heating can be due to the reduction of antinutrients known to bind with proteins to form complexes such as phytic acid, tannins and polyphenols (Hassan *et al.*, 2006). Millet germination improves nutritional efficiency by inducing biochemical alteration and reducing the anti-nutritional factors. Germination of millets generaly increases the sensory quality, bio availability and digestibility of nutrients and hence it is an inevitable strategy in food processing for the preparation of nutrient rich formulations (Platel *et al.*, 2010)

In this study, both finger millet and baryard millet flour prepared with 10 hrs soaking followed by 24 hrs germination. It was reported that optimum germination without off odours was obtained in millets soaked for 10 hrs. Swami *et al.* (2013) reported that malt prepared at germination time of 24 hrs had the highest protein content and other nutritional factors. Rawat *et al.* (2016) reported that 10 hrs of soaking increased the vitamin c content with gradual decrease in the antinutritional factors

Tapioca and jackfruit seeds are the most important starch resources in food formulations. Tapioca roots have high nutritional value, and are rich in carbohydrates. The carbohydrate content is 40 per cent and 20 per cent higher than that in rice and corn, respectively. Because of its high carbohydrate content, low production costs and the unique functional properties of its flour and starch, tapioca is suitable for partial or complete replacement of wheat flour. Cyanogenic glycoside in tapioca can be removed through blanching without affecting its nutritional and sensory qualities (Bala, *et al.* 2015). Jackfruit seed flour is a nutritious ingredient which is having favourable properties for extensive food applications. However, jackfruit is still underutilised due to seasonality, and low consumption due to a high sensory intensity of taste and aroma.

The jackfruit seed, which is a fruit industry waste, has commercial application potential as a cheap source of nutrients. In the present study, jackfruit seeds are treated with different methods for preparing jackfruit seed flour for good sensory qualiltes. The highest overall acceptability were observed for roasted jackfruit seed flour (T_1) and it was selected as the best treatment for jackfruit seed preparation. Roasting dryed jackfruit seeds produced changes in the aroma and sensory profile that resulted in an exceptional sensory qualities. The volatile composition in jackfruit seeds which improve sensory qualities are pyrazines, aldehydes, alcohols and esters (Spada, 2017). JSF flour can be substituted for wheat flour at various levels to meet consumer demands for increased fiber content in food products.

Jackfruit seed flour has been proven to be an excellent filling agent in various products. Mollu (2018) reported that incorporation of 35 per cent jackfruit seed flour along with 45 per cent hydrogenated palm oil resulted in nutri spread with high sensory qualities. Faridha and Aziah (2012) developed a highly acceptable low calorie cake incorporated with JSF (18 per cent) and wheat flour. The prepared product was highly acceptable for sensory qualities. Incorporation of 25 per cent of jackfruit seed flour bread showed good sensory qualities with a score of 7.15 for overall acceptability. Cake prepared using 25 per cent of JSF (20 to 25 per cent replacement of wheat flour) had the highest overall acceptability.

In the present study, nutri flakes were incorporated with 10% of other ingredients which include 5 percent of defatted soy flour as a protein source 2 percent of rice bran and 3 percent of coco powder. Composite flour technology with protein rich materials like soybean could be an approach to overcome the malnutrition. Mollu, (2018) reported that, 20 per cent incorporation of defatted soya flour was found to be desirable for enrichment of JSF nutri spread. Defatted soya flour incorporation up to the level of 20 per cent in formulating composite flour for biscuits enhanced the overall acceptability and physical quality characteristics of biscuits (Aleem *et al.*, 2012).

Cocoa and cocoa derived products comprise one of the most popular foods use globally and it contain essential nutrients like energy, carbohydrate, protein, fat, polyphenol and minerals. Cocoa substitutes are substances which can be used in biscuits, cakes, snacks or chocolates for the total or partial replacement of cocoa in order to reduce the fat content, or to provide different characteristics and sensory qualities the final product (Rosa *et al.*, 2015).

Rice bran is a rich source of vitamins, minerals, essential fatty acids, dietary fiber and other sterols. It has been documented that rice bran has many biological activities, including lowering blood cholesterol and preventing colon cancer (Hu *et al.*, 2013). Hu *et al.* (2009) developed bread enriched with high content fibre from defatted rice bran. Sensory evaluation revealed that the breads incorporated with rice bran dietary fibre were acceptable and had great potential in food applications.

5.1.2. Organoleptic qualities of finger millet based nutri flakes

Nutri flakes are one of the highly demanded breakfast cereals with light crispy texture in the present convenient life style. Composite flour technology is applicable to nutri flakes which improves sensory and nutritional qualities of the products. The suitability of finger millet and barnyard millet for the development of nutri flakes in combination with tapioca flour and jackfruit seed flour was assessed in this study

Among finger millet based nutri flakes prepared with tapioca flour (TF), the treatment T_3 (60 % FMF + 30% TF+ 10% OI) secured a mean score of 7.92 and for overall acceptability. High organoleptic scores were observed for all quality attributes like appearance (7.88), colour (8.02), flavour (7.85), texture (8.08) and taste (7.84). Incorporation of 30 per cent tapiocaflour with 60 % of finger millet flour and 10 per cent of other ingredients was found to be providing good sensory qualities for the finger millet based nutri flakes.

Among finger millet based nutri flakes prepared with jackfruit seed flour (JSF), the mean scores and mean rank scores for sensory parameters was the highest for treatment T_3 (60% + FMF + 30% JSF+ 10% OI) than the other treatments and secured a mean score of 7.85 and for overall acceptability. High organoleptic scores were observed for all quality attributes like appearance (7.85), colour (7.9), flavour (8.07), texture (7.28) and taste (7.66). Incorporation of 30 per cent jackfruit seed flour with 60% of finger millet flour and 10 per cent of other ingredients was found to be successful and it produced good sensory qualities for the finger millet based nutri flakes.

Devaraju *et al.* (2008) have been used finger millet flour to improve functional qualities of pasta, finger millet composite flour with defatted soy flour and whey protein showed higher sensory qualities. Shukla and Srivastava (2011) developed millet noodles in which the finger millet flour (FMF) was blended in various proportions (30 to 50%) in refined wheat flour The best sensory qualities were observed in noodles incorporated with 30% finger millet flour.

Malted finger millet flour provided chocolate brown colour which is an acceptable appearance and colour to the nutri flakes. Verma and Patel (2013) developed finger millet based composite flour. It was reported that, the product were dark in colour and was highly acceptable by the consumers. Giridhar (2019) observed that an increase in the level of finger millet flour in *roti* decreased the scores for color and appearance slightly.

Among finger millet based nutri flakes, the highest score for flavour (8.07) was obtained for the product in which JSF is incorporated. This may be due to the characteristic flavour of JSF. Abraham and Jayamuthungai (2014) reported that with the addition of jackfruit seed flour, the firmness of the pasta increased. Ten percent of jackfruit seed flour replaced pasta was more appropriate to consumers in terms of flavour, mouth feel, appearance, colour and overall acceptability. The highest score for texture (8.08) was obtained for the product in which tapioca flour is incorporated nutri flakes. Ramaperasad *et al* (2003) developed extrudates with 95 per cent of tapioca flour and 5 per cent of pigeonpea flour which provided hard to crisp texture to the product and showed good physico chemical and sensory qualities.

In tapioca flour added combinations, the highest score for taste was 7.84 (T_3 – 60% FMF+ 30% TF) In jackfruit seed flour added combinations, the highest mean score was 7.66 (T_3- 60% + 30% JSF) Substitution of 30% TF and JSF to finger millet flour found to be improving the taste of nutri flakes. The taste of finger millet flour was found to be reduced due to the addition of other tasty starch sources like tapioca flour and jackfruit seed flour. Swant *et al.* (2012) found that, In the ratio of 20:50:20:10, the composite mix consisting of brown finger millet flour, maize flour, rice flour and full fat soybean flour provided the most suitable sensory qualities to RTE extrudates (8.87). Shirmi (2012) developed germinated finger millet based biscuits and found that the replacement of 40% germinated finger millet flour resulted in biscuits with acceptable sensory attributes.

Germination of finger millet improves carbohydrate digestability and sweetness which shows high mean score of taste in finger millet based nutri flakes and overall acceptability. Among tapioca flour added combinations, the highest score for overall acceptability was 7.92 (T_3 – 60% FMF + 30% TF). In jackfruit seed flour added combinations, the highest mean score was 7.85 (T_3 - 60% + 30% JSF) Substitution of 30 per cent TF and JSF to finger millet flour found to be improving the overall acceptability of nutri flakes.

5.1.3. Organoleptic qualities of barnyard millet based nutri flakes

Barnyard millet characterised by high nutritive and therapeutic qualities which can be utilised to develop convenient foods with good sensory qualities. In the present study, barnyard millet based nutri flakes prepared with tapioca flour (T5 - 40 % BMF + 50% TF+ 10% OI) secured highest mean score of 7.61 for overall acceptability. Mean scores of 8.17, 7.77, 7.24, 7.66 and

7.15 was obtained for appearance, colour, flavor, texture and taste, respectively. Incorporation of 50 per cent tapioca flour with 40 per cent of barnyard millet flor and 10 per cent of other ingredients was found to be provided good sensory qualities for the barnyard millet based nutri flakes.

Among barnyard millet based nutri flakes prepared with jackfruit seed flour (JSF), the treatment T5 (40 % BMF + 50% JSF+ 10% OI) secured mean scores of 8.20, 7.81, 7.25, 7.66, 7.15 and 7.61 for appearance, colour, flavor, texture and taste, respectively. Incorporation of 50 per cent jackfruit seed flour with 40 per cent of barnyard millet flour and 10 percent of other ingredients was found to be providing good sensory qualities for the barnyard millet based nutri flakes.

Lenkannavar (2010) developed barnyard millet based flakes, which was acceptable with the mean score for taste, texture, aroma and overall acceptability of barnyard millet flakes were 7.12, 7, 7.13 and 7 respectively. The mean score of colour and appearance was significantly low as six for barnyard millet flakes.

Devi *et al.* (2012) prepared barnyard millet based extruded products with 50 per cent wheat flour was highly acceptable with a mean score of 7.24. Barnyard millet considered to be an appropriate replacer for wheat flour for the development of extruded products with functional and nutraceutical properties.

In this study, barnyard millet based nutri flakes incorporated with TF, the treatment T_5(40 % BMF + 50% TF+ 10% OI) was fond to be having the highest mean score for appearance, colour, flavour, texture, taste and overall acceptability. From this, it is clear that 50 per cent substitution of tapioca flour along with barnyard millet flour considered by improved the organoleptic qualities of the barnyard millet based nutri flakes.

In this study, barnyard millet based nutri flakes incorporated with JSF, the treatment T_5 (40 % BMF + 50% JSF+ 10% OI) was found to be having the highest mean score for appearance, colour, flavour, texture, taste and overall acceptability. From this, it is clear that 50 per cent substitution of jackfruit seed flour along with barnyard millet flour considered by improved the organoleptic qualities of the barnyard millet based nutri flakes.

Malted barnyard millet flour with a high sugar content, decreases the bitter taste and provide sensory qualities. Barnyard millet based nutri flakes incorporated with tapioca flour and jackfruit seed flour showed mean score of 7.15 for taste. Higher concentration of tapioca and jackfruit seed flour increases the taste and acceptability of consumers. Substitution of 50 per cent per cent of other starch sources like tapioca flour and jackfruit seed flour considerably reduced the characteristic bitter taste of barnyard millet. Both tapioca flour and jackfruit seed have good sensory qualities so that it will contribute desirable qualities to the products. Both tapioca and jackfruit seed flour incorporated nutri flakes showed good overall acceptability, 7.61 and 7.62 respectively.

Ajisha (2017) developed jackfruit seed (30%) incorporated vermicelli which had high mean score of 8.4, 8.35, 8.33, 8.26, 8.2 and 8.31 for appearance, colour, flavour, texture, taste and overall acceptability. Ozioma (2010) prepared nutrient rich biscuits based on jackfruit seed flour, The prepared products were highly acceptable for sensory qualities like flavour (7.4), taste (7.3) colour (7.3).

Deepali *et al*. (2013) standardised vermicelli with barnyard millet flour, wheat flour and defatted soya flour in the ratio of 45:45:10 which was highly acceptable with a mean score of 7.80 (appearance and colour), 7.90 (taste), 7.50 (texture), 8.00 (flavour) and 7.84 (overall acceptability). Ranganna et al. (2014) developed vermicelli with small millets like, barnyard millet, kodo millet, proso millet, foxtail millet, foxtail millet and little millet. The combination of 50 per cent millet flour, 40 per cent wheat flour and 10 per cent defatted soya flour was highly acceptable. Nazni and Karuna (2016) developed barnyard incorporated rusk in different proportion. Twenty five per cent incorporation of barnyard millet flour in rusk had the highest score for appearance (7.85) and colour (7.57).

5.2. Nutritional qualities of millet based nutri flakes.

Nutritional qualities of both finger millet and barnyard millet nutri flakes incorporatd with tapioca flour and jackfruit seed flour were estimated. The various nutrients like moisture, total fibre, starch, total carbohydrate, protein, fat, energy, calcium, iron, sodium, magnesium and potassium were assessed in this study.

Moisture is an important parameter of quality determination in food products. The dried and dehydrated products with low moisture content which have long shelf life and less microbian contamination (Abraham and Jaumuthungai, 2014). In the present study the moisture content of the developed nutri flakes were in the range of 3.17 per cent to 8.49 percent. The moisture content was maximum (8.48) in finger millet based nutri flakes with jackfruit seed flour (NF.2), followed by finger millet based nutri flakes (NF.2) which had 7 per cent moisture content and barnyard millet based nutri flakes with jackfruit seed flour (NF.4) had 5.35 per cent moisture content. The lowest moisture content of 3.16 per cent was observed in barnyard millet based nutri flakes incorporated with tapioca flour (NF.3) (Fig.1).

Prasad *et al.* (2007) revealed that, the 80:20 blend of sorghum-soy recorded significantly low moisture of 6.9 per cent. Acuna *et al.* (2008) revealed that incorporation of maize bran significantly decreased moisture content from 6.3 to 9.8 per cent in maize bran incorporated breakfast cereals. Lenkavar *et al* (2010), developed barnyard millet flakes and observed that barnyard millet flakes had 1.47 per cent moisture content. Ready-to-eat puffed product from barnyard millet using high temperature short time(HTST) puffing process and the texture of puffed product was dependent on moisture content (Jaybhaye *et al*., 2011).

In the present study, the fibre content of the developed nutri flakes were in the range of 2.85 per cent to 5.76 per cent. Total fibre content was maximum (5.76g %) for barnyard millet based nutri flakes with jackfruit seed flour (NF.4), followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) with 4.09 per cent fibre content. Barnyard millet based nutri flakes with tapioca flour (NF.3) had fibre content.of 3.82 per cent. The lowest fibre content of 2.85 per cent was observed in finger millet based nutri flakes with tapioca flour (NF.1). (Fig.1). Nandkule *et al.* (2015) reported that 20 per cent incorporation of jackfruit seed flour vermicelli improved the fiber content from 1.4 g $100g^{-1}$ to 1.6 g $100g^{1}$. Butool and Butool (2015) developed jackfruit seed incorporated backed products which had 0.75 and 2.78 per cent of fibre content which helps to increase dietary fibre and decrease calorie of the products. The study also observed that jackfruit seed flour is a good source of dietary fibre can be incorporated into functional food products without affecting eating quality. Ajisha (2017) developed jackfruit seed incorporated vermicelli which showed fiber content ranging from 2.2 to 3.89 g / 100 g. Veena (2004) reported that, barnyard millet contain 13 per cent total dietary fibre with 4.66 and 18.18 soluable fractions. Total dietary fiber content in rolled barnyard millet flakes was reported to be 11.20 per cent (Lenkannavar, 2010). Barnyard millet flour incorporated cookies had fibre content of 7.08 as reported by Surekha *et al.* (2013) than vegetable cookies. The fibre content in food products helped to protect the colon mucous membrane by decreasing exposure time as well as binding to cancer causing chemicals in the colon (APAARI, 2012).

In the present study, the starch content of the developed nutri flakes were in the range of 24.62 g/100g to 43.11 g/100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest starch content of 43.11 g/100g, followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) with

38.04 g/100g starch content and finger millet based nutri flakes with tapioca flour (NF.1) (34.49 g/100 g). The lowest value of starch content 24.62 g/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). (Fig.2).

Kittipongpatana and Kittipongpatana (2011) reported that, the amylose content of jackfruit starch is around 24 32 per cent. Madruga *et al.* (2014), observed that starch content of jackfruit seed flour was 92.8 to 94.5 per cent. During roasting, starch content present in flours undergo degradation to form simple units as dextrins.

Total carbohydrate content of the selected nutri flakes (fig.2) varied from 36.54 g/100g to 50.46 g/100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) obtained the highest carbohydrate content of 50.46 g/100g, followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (47.12 g/100g) and finger millet based nutri flakes with tapioca flour (NF.2) (44.31 g/100g). The lowest carbohydrate content of 36.54 g/100g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). Lenkannavar (2010) developed ready to use rolled barnyard millet flakes which contain 70.06 per cent of total carbohydrate.

Protein content of the selected nutri flakes varied from 13.67 g/100 g to 6.87 g/100 g. Barnyard millet based nutri flakes with jackfruit seed flour (NF.4) observed the highest protein content of 13.67 g/100g, followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) with 12.84 g/100g of protein content and finger millet based nutri flakes with tapioca flour (NF.1) 7.73 g/100 g protein content. The lowest value of protein content of 6.88 g/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3) (Fig.3). Frame (1999) suggested that, the protein content of breakfast cereals should be in the range of 3.50 to 14.10 per cent in the final product. Lenkannavar (2010) reported protein content was of 6.44 per cent in ready to use rolled barnyard millet flakes. The study reported a reduction in protein content in millet flakes during processing. This might be due to the high heat induced in millard reaction in presence of reducing sugars, which make lysine unavailable, and reduce the protein quality (Tamanna and Mahmood, 2015). Surekha *et al.* (2004) formulated barnyard millet based health mix had observed a protein content of 12 per cent. Kulkarni *et al.* (2012) observed 7.60 g 100 g ^{1} of protein content in malted ragi flour. Chandraprabha (2017) observed protein content of 7.96 to 9.34 g ^{1} in barnyard millet based vermicelli. In this study, higher protein content was observed in nutri flakes, prepared with jackfruit seed flour. As jackfruit seed flour is a good source of protein, the flakes prepared also obtained high protein content. In support to this, Meethal *et al.* (2017) reveald that jackfruit seed flour contain around 13.96 per cent protein content.

Fat content of selected nutri flakes varied from 1.99 g/100g to 1.26g/100g. Barnyard millet basednutri flakes with jackfruit seed flour (NF.4) observed the highest fat content of 1.99 g/100 g, followed by barnyard millet based nutri flakes with tapioca flour with 1.72 g/100g of fat content and finger millet based nutri flakes with jackfruit seed flour (NF.2) with 1.39 g/100 g. The lowest value of fat content 1.26 g/100 g were observed in finger millet based nutri flakes with tapioca flour (NF.1). (Fig.3). Takhellambam *et al.* (2016) developed millet flakes with 0.85 g 100 g^{-1} of fat content. Lenkannavar (2010) reported fat content of 1.67 per cent in barnyard millet flakes. Fat content of 1.91 to 2.16g 100 g^{-1} were observed in barnyard millet based vermicelli developed by Chandraprabha (2017).

Energy present in the selected nutri flakes varied from 189.16 kcal/100g to 265.78 kcal/ 100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest energy value of 265.78 kcal/100g, followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) with 261.14 kcal/100g and finger millet based nutri flakes with tapioca flour (NF.1) (219 kcal/100 g). The lowest energy content of 189.16 kcal/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). (Fig.4). Takhellambam *et al.* (2016) observed, energy value of around 277 kcal/100 g and 254 kcal/100 g for barnyard millet and finger millet based flakes respectively. Chandraprabha (2017) reported that, calorific value ranges from 256.93 to 272.17 kcal 100 g^{1} in barnyard millet based vermicelli. Longvah *et al.* (2017) reported that caloric value of jackfruit seed and tapioca around 322 kcal /100 g and 334 kcal /100 g, respectively.

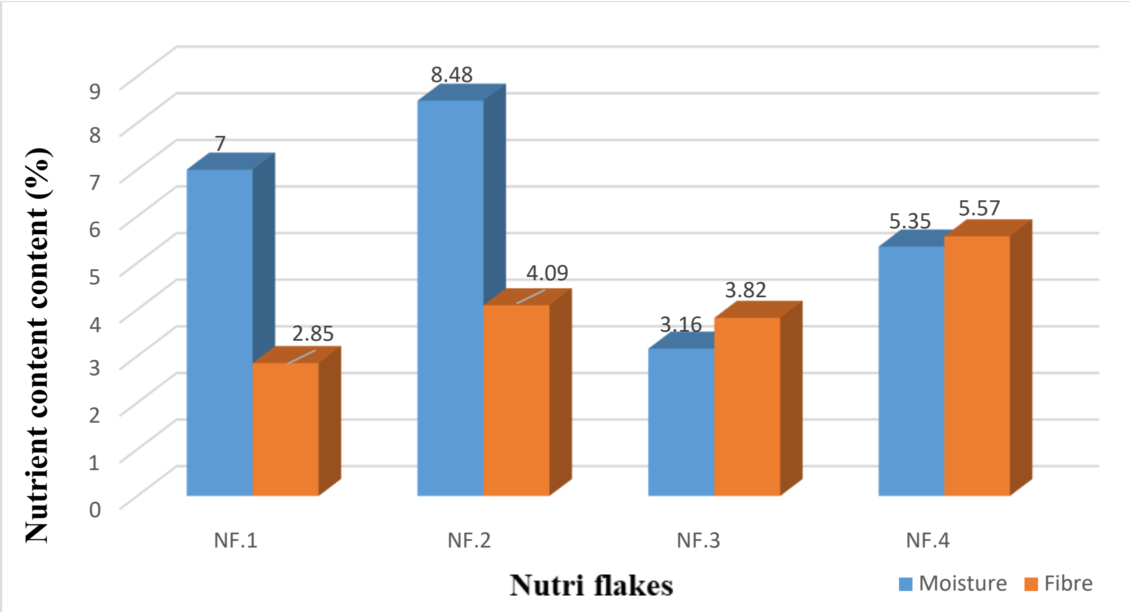

Fig.1. Moisture and fibre content (%) of nutri flakes

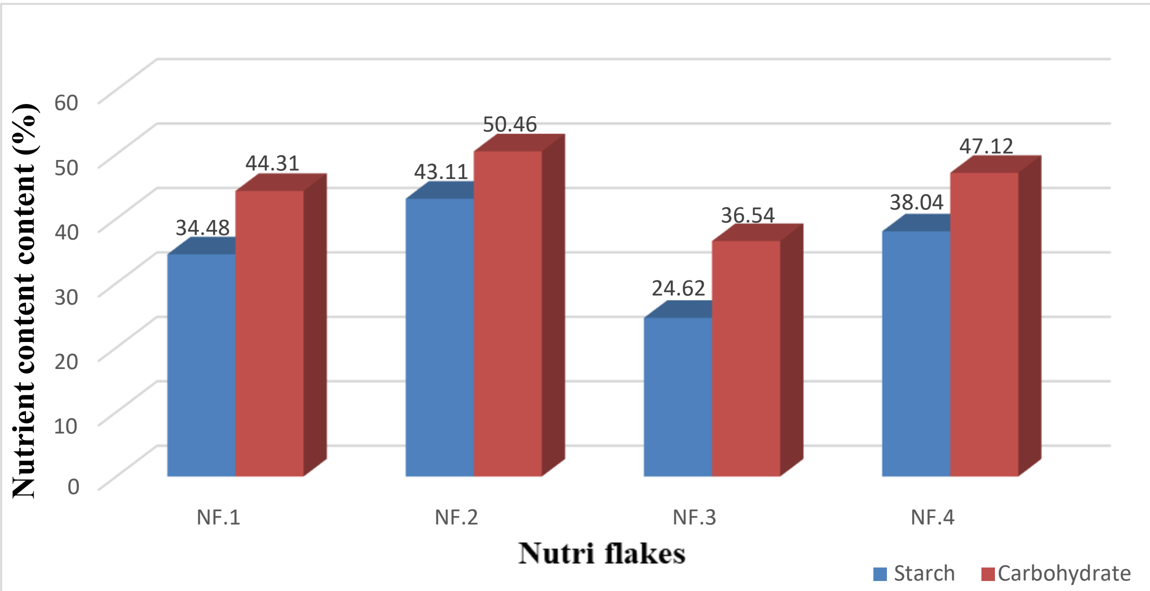

Fig.2. Starch and carbohydrate content (g/100 g) of nutri flakes

NF. 1 - Nutri flakes. 1

NF. 2 - Nutri flakes. 2

NF. 3 - Nutri flakes. 3

NF. 4 - Nutri flakes.4

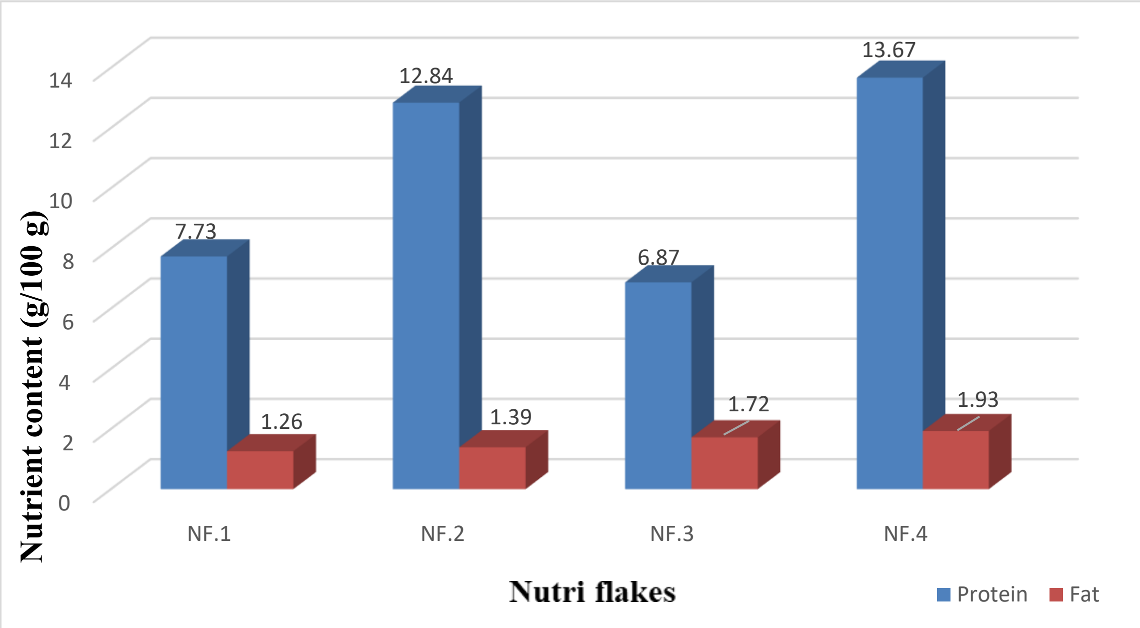

Fig.3. Protein and fat content (g/100 g) of nutri flakes

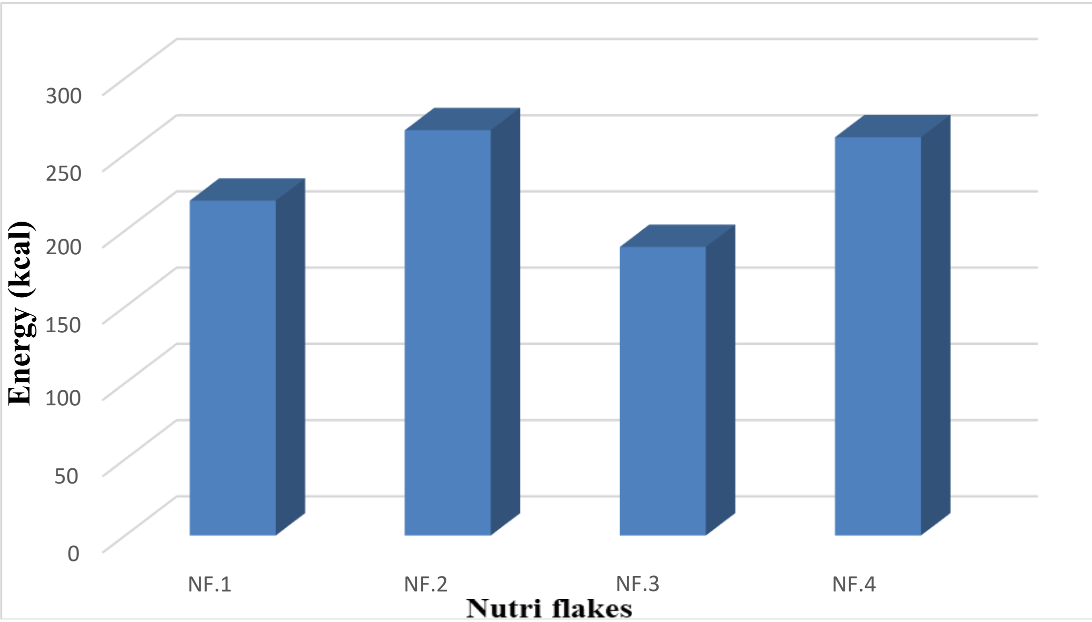

Fig. 4. Energy content (kcal /100 g) of nutri flakes

NF. 1 - Nutri flakes. 1

NF. 2 - Nutri flakes. 2

NF. 3 - Nutri flakes. 3

NF. 4 - Nutri flakes.4

The proper function of the human physiological system requires a good mineral balance. A deficiency, overdose or surplus of inorganic nutrients has a detrimental impact on wellbeing (Soetan *et al.*, 2010). Millets are rich source of minerals, which can be well exploited for combating the deficiency of micronutrients whereas processing and heat treatment causes significant decrease in mineral content of final products.

Calcium content of selected nutri flakes varied from 23.63 mg/100 g to 199 mg/100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) had the highest calcium content of 199 mg/100 g, followed by finger millet based nutri flakes with tapioca flour (NF.4) with 195 mg/100 g calcium content and barnyard millet based nutri flakes with jackfruit seed flour (NF.4) (28.89 mg/100 g). The lowest calcium content of 23.63 mg/100 g were observed in barnyard millet based nutri flakes with tapioca flour (NF.3) (Fig.5).

Iron content of the selected nutri flakes varied from 2.00 mg/100 g to 5.58 mg/100 g. Finger millet based nutri flakes with tapioca flour (NF.1) observed the highest iron content of 5.58 mg/100 g, followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) with 5.12 mg/100 g iron content and barnyard millet based nutri flakes with jackfruit seed flour (NF.4) had 2.4 mg/100 g iron. The lowest iron content 2.00 mg/100 g was observed in barnyard millet based nutri flakes with tapioca flour (NF.3) (Fig.5).

Takhellambam *et al.* (2016) reported that calcium content in ragi flakes ranges from19.29 mg/100 g to 222 mg/100 g and for barnyard millet flakes, and iron content around 0.19 to 16. 92 mg/100 g. Krishnan *et al.* (2012) reported that, popping the millets, decreased calcium content to 10 mg/100 g of total calcium content. Singh and Srivastava (2006) reported the iron content of finger millet ranged from 3.61 mg/100 g to 5.42 mg/ 100 g. Finger millet is the richest source of calcium and iron. Longvah *et al.* (2017) reported that calcium and iron content of ragi ranged from 58 mg /100g to 364 mg/100g. By incorporating finger millet into the daily diet, calcium deficiency leading to bone and teeth disorders and iron deficiency leading to anaemia can be resolved.

Sodium content of the selected nutri flakes varied from 10.08 mg/100g to 13.66

mg/100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest sodium content of 13.66 mg/100g followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) with 13.4 mg/100g sodium content, followed by finger millet based nutri flakes with tapioca flour (NF.1) (13 mg/100 g). The lowest sodium content 10.08 mg/100g were observed in barnyard millet based nutri flakes with tapioca flour (NF.3) (Fig.6). In extracellular fluids, sodium is an essential cation responsible for maintaining acid-base balance and necessary for muscle irritability and cell permeability Pasha *et al*. (2017) reported that, mean sodium content of small millets ranged from 0.58 to 0.69 g / 100 g

Magnesium content of the selected nutri flakes varied from 31.1 mg/100 g to 87 mg/100 g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest magnesium content of 87 mg/100 g, followed by barnyard millet based nutri flakes with jackfruit seed flour (NF.4) with 82.5 mg/100 g magnesium content and finger millet based nutri flakes with tapioca flour (NF.1) with (59.1 mg/100 g). The lowest magnesium content of 31.1 mg/100g were observed in barnyard millet based nutri flakes with tapioca flour (NF.3) (Fig.6).

Potassium content of selected nutri flakes which varied from 153.5 mg/100 g to 396 mg/100 g. Barnyard millet based nutri flakes with jackfruit seed flour (NF.4) observed the highest potassium content of 396 mg/100 g. Followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) with 370 mg/100 g (Fig.7). Potassium is the principal mineral which regulating acid–base balance, osmotic pressure, cardiac muscle contraction. Pasha *et al.* (2017) observed that, mean potassium content of small millets ranged from 4.5 to 9.82 g /100 g. The mean magnesium content of small millets studied ranged from 2.46 to 3.14 g / 100 g. Ranasinghe *et al* (2019) observed 54 mg / 100 g of magnesium and 246 mg / 100 g of potassium content in jackfruit seed flour.

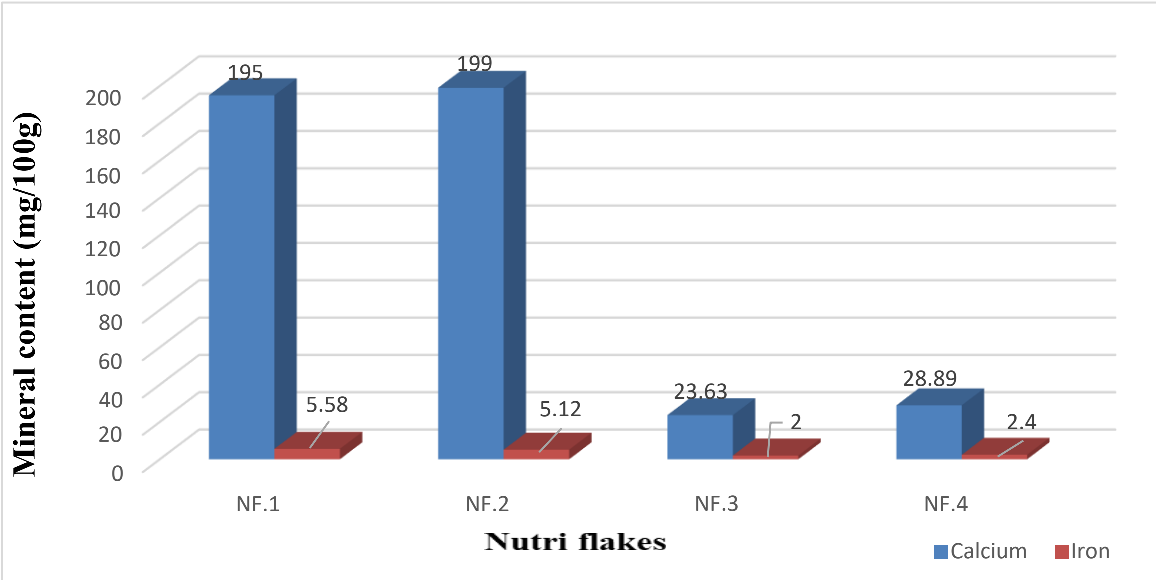

Fig. 5. Calcium and iron content (mg /100 g) of nutri flakes

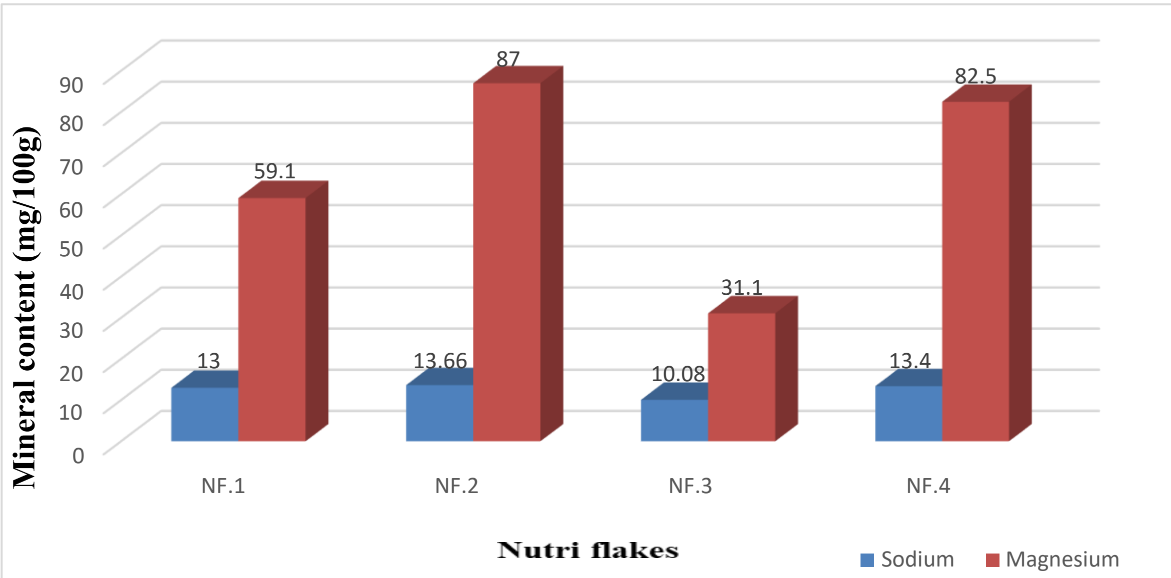

Fig. 6. Sodium and magnesium content (mg /100 g) of nutri flakes

NF. 1 - Nutri flakes. 1

NF. 2 - Nutri flakes. 2

NF. 3 - Nutri flakes. 3

NF. 4 - Nutri flakes.4

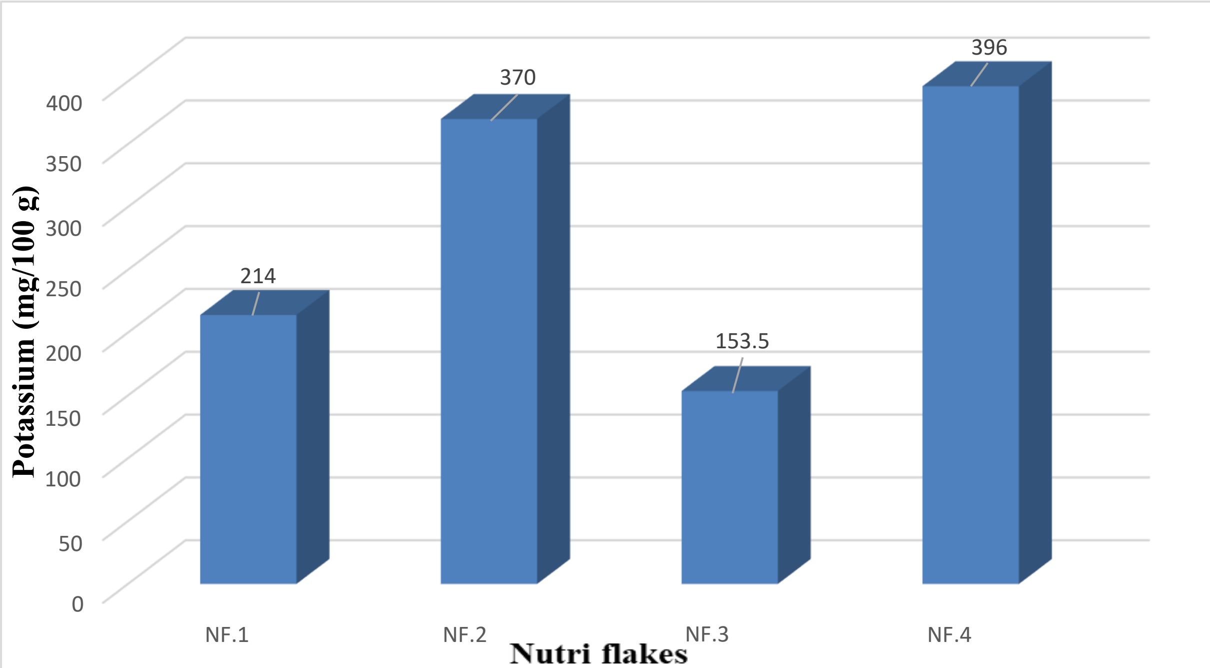

Fig. 7. Potassium content (mg /100 g) of nutri flakes

NF. 1 - Nutri flakes. 1

NF. 2 - Nutri flakes. 2

NF. 3 - Nutri flakes. 3

NF. 4 - Nutri flakes.

5.3. Changes in the quality attributes of nutri flakes during storage.

In the present study, finger millet and barnyard based nutri flakes incorporated with tapioca flour were organoleptically evaluated at initially and at the end of the storage. Initially, the highest mean scores for overall acceptability was observed as 7.92 and a slight decrease in score (7.78) was observed at the end of the storage for finger millet based nutri flakes. For barnyard millet based nutri flakes incorporated tapioca flour, the highest mean score for overall acceptability observed as 7.61 which decreased upto 6.75 at end of the storage.

Finger millet and barnyard millet based nutri flakes incorporated with jackfruit seed flour were organoleptically evaluated initially and after one month of storage. Initially, the mean score for overall acceptability was observed as 7.85 and a slight decrease was observed upto 7.67 at the end of the storage for finger millet based nutri flakes. For barnyard millet based nutri flakes incorporated with jackfruit seed flour, the mean scores for overall acceptability was observed as 7.62 which decreased to 7.1.

Devaraju *et al* (2006) millet pasta stored for 3 months and reported that, finger millet pasta was highly acceptable with a mean score of above 3.80 out of 5.00 after 3 months of storage. Lenkannavar (2010) developed instant mix by using rolled barnyard millet flakes and conducted sensory evaluation after storage. The result revealed that, initial mean total score of 35.63 was decreased to 33.50 after storage and instant mix was highly acceptable even after three months.

Devi *et al* (2014) carried out a study on the sensory qualities of kodo millet based pasta (60 per cent kodo millet and 40 per cent wheat flour) stored for a period of 3 months. They observed that mean score for overall acceptability was 7.62 initially which decreased to 7.40 at the end of the storage. Karpagavalli and Amutha (2015) formulated pasta by incorporating 5 to 10 per cent of cereal pulse blend and evaluated the organoleptic qualities initially and after 180 days. The prepared product was highly acceptable throughout the storage.

In the present study, finger millet and barnyard based nutri flakes were evaluated for bacteria, fungi and yeast. The bacterial load present in selected nutriflakes incorporated with tapioca flour was observed as 0.28×10^{5} cfu/g and 0.15×10^{-5} cfu/g initially, which were increased into 0.85×10^{-5} cfu/g and 0.65×10^{-5} cfu/g. The bacterial load present in selected nutriflakes incorporated with jackfruit seed flour was observed as 0.4×10^{-5} cfu/g and 0.26×10^{-5} cfu/g initially, which were increased into 1.15×10^{5} cfu/g and $.8 \times 10^{5}$ cfu/g. at the end of storage.

The fungal count were not detected initially in selected nutri flakes incorporated with tapioca flour and further it developed to 0.35×10^{-3} cfu/g (NF.1) and 0.18×10^{-3} cfu/g (NF.3). The fungal count present in selected nutri flakes incorporated with jackfruit seed flour observed as 0.08×10^{3} cfu/g (NF.2) and 0.13×10^{3} cfu/g (NF.4) which were increased to 0.43×10^{-3} cfu/g (NF.2) and 0.33×10^{-3} cfu/g (NF.4). Yeast population were not detected in any of selected nutri flakes at the entire the study. BIS, (2006) specified that, less than 10,0000 bacterial colony count per gram food product are considered under permissible limits.

Bera *et al*. (2001) stated that moisture content, relative humidity, temperature are the parameters which directly influence microbial growth. Shobha *et al* (2011) reported that, food with low moisture content and low water activity along with hygenic handling of the product reduce the the microbial contamination. Takhellambam *et al.* (2015) observed 1.33×10^{4} cfu/g fungal count in the developed little millet flakes. Gull *et al.* (2016) formulated millet based pasta and the microbial analysis of pasta showed that yeast and moulds were not observed for a period of four months.

Insect infestation was not observed in the entire period of storage in any nutri flakes, This may be due to the low moisture content of the nutri flakes. Ugare (2008) reported that barnyard millet flours can be stored for period of six months without insect infestation. Keskin and Oskya (2015) suggested that moisture content less than 9 per cent does not showed insect attack in foods. In present study moisture content were observed as less than 9 percent. Dried food products can be effectively stored without appreciable loss of sensory qualities and insect infestation.

5.4. Organoleptic qualities of the products developed with the nutri flakes.

Preservation of foods in ready-to eat form has achieved considerable success Breakfast cereals and bars are products that satisfy the palate of consumers seeking a balanced, tasty and healthy food, even allying a diet rich in fibre and carbohydrates with a low amount of calories and fat (Vasconcellos, 2006). Instant breakfast mix is a mixture of grain flakes and dried fruits, where can be also added nuts. It is traditionally consumed for breakfast together with milk, yogurt or hot water.

5.4.1. Organoleptic qualities of ready to eat instant breakfast mixes.

In the present study, all sensory attributes like appearance, colour, flavour, texture and taste were had the highest score for finger millet based nutri flakes instant breakfast mix incorporated with (IBM NF.1). The mean scores for overall acceptability varied from 6.82 (IBM- NF.4) to 7.46 (IBM-NF.1). The highest mean rank score for overall accceptability obtained were 3.27 for instant breakfast mix prepared with finger millet based nutri flakes (IBM-NF.1).

Song *et al.* (2006) reported that, the breakfast cereal along with the milk provided greater intakes of calcium (1.086.90 mg), riboflavin (2.8 mg), vitamin B6 (2.60 mg), B12 (5.90 mg) and niacin (707.90 mg). Kumari *et al.* (2019) developed Ready to Eat (RTE) breakfast cereal by the addition of standardised proportion of popped pearl millet. Sensory attributes of breakfast cereal were highly acceptable. Developed breakfast cereal had 22.8 per cent for energy, 12.80 per cent for protein, 13 per cent for fat, 34.5 per cent for calcium and 20.5 per cent for iron as per serving. Senhofa *et al* (2015) developed muselli with whole grain oat flakes 15 per cent dried apricots with good sensory qualities.

5.4.2. Organoleptic qualities of ready to eat nutri bars.

Energy bars, commonly referred to as food bars, consist mostly of cereals and other high-energy ingredients, which are nutritionally healthy and convenient snack foods. Because of the inclusion of carbohydrates, lipids, proteins and minerals, these bars have strong sensory and nutritional qualities.

Loveday *et al.* (2010) indicated that, nutribars are heterogeneous due to the presence of fruit and nut fragments in addition to cereal components and had the appearance of an aggregate of coarse particles. This rough appearance adds value and sensory characterises of the food bars. Zahra *et al.* (2014) also reported changes in textural properties and acceptability with respect to variations in the ingredients used.

In the present study all sensory qualities like appearance, colour, flavour, texture and taste were attributes had highest score of 8.25,8, 8.18, 7.81, 7.87 observed in nutri bar prepared with finger millet based nutri flakes (NB-NF.1). The mean scores for overall acceptability varied from 7.43 (NB-NF.4) to 8.12 (NB-NF.1).

Shahla (2012) developed different types of nutri bars, the highest mean score for different quality attributes like appearance, colour, flavor, texture, taste and over all acceptability was noticed in nutri bar prepared using wheat flakes and the mean scores were 8.81, 8.89, 8.61, 8.82, 8.85, 8.82 respectively. The developed nutri bar prepared by rice flakes and corn flakes in glucose syrup showed highest mean score of 8.92, 8.85, 8.75 and 8.66 for appearance, colour, texture and overall acceptability respectively and it was also reported that, nutri bars contain about 5.5-7 per cent protein, 45-5 per cent fat, 0.3-1.4 per cent dietary fiber, 49-79 per cent starch and 48-74 per cent zinc.

In the present study all the developed nutri bars obtained higher mean score of 8 and above for appearance. According to Sun-Waterhouse *et al*. (2010), an important appearance feature of snack bars to consumers is the surface colour of the base and the filling. Addition of brown sugar imparted brown colour to glucose syrup based nutribars.

The texture of the developed products were also obtained scores more than 7.5. The greater the amount of residue in the cereal bars, the greater the hardness of the bars. Similar findings were reported by Garcia *et al.* (2012). Verma *et al.* (2018) developed iron rich sorghum based cereal bars and indicated that, sorghum can be puffed, popped, shredded and flaked to produce ready-to-eat breakfast cereals. Padmasree *et al*. (2018) developed choco quinoa nutri bar and the highest values were found to be 8.07, 8.10 and 8.20 for colour, aroma and taste respectively.

Freitis and Moretti (2006) evaluated three formulations of banana flavoured cereal bars and all the formulations were found to be moderately acceptable. Chauhan *et al*. (2012) developed nutritionally and organoleptically acceptable multigrain bar using bajara, peanut, peas, flax seed, margarine, honey and jaggery which provided 7.96 per cent protein and 14.89 per cent fat and considerable amounts of vitamins and minerals. Giri *et al*. (2012) developed good quality, low cost, high calorie, fibre rich acceptable nutri bars with rolled oat, wheat flour and puffed rice. Purnima *et al*. (2012) formulated highly acceptable nutri bar with oats, wheat bran flakes, milk powder, jaggery, nuts and oil seeds and dehydrated fruits and vegetables as functional food.

Summary

6. SUMMARY

The present study entitled "Standardisation and quality evaluation of millet based nutri flakes" was proposed to standardise ready to eat millet based nutri flakes and to evaluate organoleptic, nutritional and storage qualities of the developed nutri flakes. The study also envisaged to assess the suitability of the nutri flakes for the preparation of different value added food products.

Two types of nutri flakes, one based on finger millet flour and the other one based on barnyard millet flour will be standardised in combination with tapioca flour and jack fruit seed flour. Defatted soy flour, cocoa powder, and rice bran were the other ingredients (10%) used in nutri flakes.

The major ingredients used were malted finger millet flour, barnyard millet flour and tapioca flour. Preparation of jackfruit seed flour was standardised for developing good aroma and appealing flavor. It was found that simple roasting to be effective in developing good aroma in the preparation of jackfruit seed flour with the highest mean scores for all organoleptic parameters.

Nutri flakes based on finger millet flour were standardised with different proportions of tapioca flour. Among different treatments, the treatment T_3 (60 % FMF + 30% TF+ 10% OI) secured the highest scores for all quality attributes like appearance (7.88), colour (8.02), flavour (7.85), texture (8.08), taste (7.84) and overall acceptability (7.92). The finger millet based nutri flakes incorporated with 30 per cent tapioca flour and 10 per cent of other ingredients had good sensory qualities. Among finger millet based nutri flakes prepared with jackfruit seed flour (JSF), the mean scores and mean rank scores for sensory parameters was the highest for treatment T_3 (60% + FMF + 30% JSF+ 10% OI) than the other treatments. Incorporation of 30 per cent jackfruit seed flour with 60 per cent of finger millet flour and 10 per cent of other ingredients was found to be successful.

Among nutri flakes prepared with barnyard millet flour in combination with tapioca flour (TF), T_5 (40% BMF + 50% TF+ 10% OI) secured a mean score of 7.61 for overall acceptability. Mean score of 8.17, 7.77, 7.24, 7.66 and 7.15 was obtained for appearance, colour, flavor, texture and taste, respectively. Nutri flakes prepared with barnyard millet flour in combination with 50 per cent tapioca flour and 10 per cent of other ingredients had good sensory qualities. Among barnyard millet based nutri flakes prepared with jackfruit seed flour (JSF), the treatment T_5 (40 % BMF + 50% JSF+ 10% OI) secured a mean score of 7.61 for overall acceptability. Incorporation of 50 per cent jackfruit seed flour with 40per cent of barn yard millet flour and 10 per cent of other ingredients was found to successful.

These organoleptically best treatments were selected and their nutritional and shelf life qualities were evaluated. In the present study the moisture content of the developed nutri flakes were in the range of 3.17 per cent to 8.49 percent. Moisture content was maximum in finger millet based nutri flakes with jackfruit seed flour (NF.2) (8.48%) followed by NF.1 (FMF+ TF) with 7 per cent and NF.4 (BMF+ JSF) with 5.35 per cent moisture content and the lowest value of moisture content of 3.16 per cent was observed in barnyard millet based nutri flakes with tapioca flour (NF.3). The fibre content of the developed nutri flakes were in the range of 2.85 per cent to 5.76 per cent. Total fibre content was maximum (5.76 %) for NF.4 (BMF + JSF) followed by NF.2 (FMF + JSF) with 4.09 per cent, NF.3 (BMF+TF) with 3.82 per cent and NF.1 (FMF+TF) with 2.85 per cent. The starch content of the developed nutri flakes were in the range of 24.62 g/100 g to 43.11 g/100 g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest starch content of 43.11 g/100 g followed by NF.4 (BMF + JSF) with 38.04 g/100 g, NF.1 (FMF + TF) with 34.49 g/100 g and NF.3 (BMF+ TF) with 24.62 g/100 g of starch content.

Total carbohydrate content of the selected nutri flakes varied from 36.54 g/100g to 50.46 g/100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest carbohydrate content of 50.46 g/100 g, followed by NF.4 (BMF+JSF) with 47.12 g/100 g, NF.1 (FMF + TF) with 44.31 g/100 g and NF.3 with 36.54 g/100 g carbohydrate content. Protein content of the selected nutri flakes varied from 13.67 g/100 g to 6.87 g/100 g. Nutri flakes prepared with barnyard millet based nutri flakes with jackfruit seed flour (NF.4) observed the highest protein content of 13.67 g/100 g, followed by finger millet based nutri flakes with jackfruit seed flour (NF.2) with 12.84 g/100 g, NF.1 (FMF+TF) with 7.73 g/ 100 g and NF.3 (BMF+

TF) with 6.88 g /100g of protein content. Fat content of selected nutri flakes varied from 1.99 g/100 g to 1.26g/100 g. Nutri flakes incorporated with barnyard millet flour and jackfruit seed flour (NF.4) had the highest fat content of 1.99 g/100g, followed by NF.3 (BMF + TF) with 1.72 g/100 g, NF.2 (FMF+JSF) with 1.39 g / 100 g and NF.1 (FMF+ TF) with 1.26 g / 100 g of fat content. Energy present in selected nutri flakes varied from 189.16 kcal/100 g to 265.78 kcal/ 100 g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest energy value of 265.78 kcal/100g, followed by NF.4 (BMF+ JSF) with 261.14 kcal/100 g, NF.1 (FMF+ TF) with 219 kcal/ 100 g and NF.3 (BMF+ TF) with 189.16 kcal /100 g of caloric value.

Calcium content of the selected nutri flakes varied from 23.63 mg/100g to 199 mg/100g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest calcium content of 199 mg /100 g, followed by NF.1 (FMF+TF) with 195 mg/100g, NF.4 (BMF+ JSF) with 28.89 mg/ 100 g and NF.3 (BMF + TF) with 23.63 mg / 100 g of calcium content. Iron content of selected nutri flakes varied from 2.00 mg/100g to 5.58 mg /100 g. Finger millet based nutri flakes with tapioca flour (NF.1) observed the highest iron content of 5.58 mg/100g followed by NF.2 (FMF+ JSF) with 5.12 mg/100g, NF. 4 (BMF+ JSF) with 2.4 mg/100g and NF.3 (BMF+TF) with 2 mg / 100 g of iron content.

Sodium content of the selected nutri flakes varied from 10.08 mg/100g to 13.66 mg /100 g. Finger millet based nutri flakes with jackfruit seed flour (NF.2) observed the highest sodium content of 13.66 mg/100g followed by NF.4 (BMF+JSF) with 13.4 mg/100 g, NF.1 (FMF+TF) with 13 mg / 100 g and N.3 (BMF+TF) with 10.08 mg /100 g of sodium content. Magnesium content of the selected nutri flakes varied from 4.83 mg/100 g to 14.82 mg/100 g. Magnesium content was highest in finger millet based nutri flakes with jackfruit seed flour (NF.2) with 87.00 mg/100g, followed by NF.4 (BMF+JSF) with 82.5 mg/100 g, NF.1 (FMF+TF) with 59.1 mg /100 g and NF.3 (BMF+TF) with 31.1 mg /100 g of magnesium content. Potassium content of the selected nutri flakes varied from 153.5 mg/100 g to 396 mg/100 g. Barnyard millet based nutri flakes with jackfruit seed flour (NF.4) observed the highest potassium content of 396 mg/100g followed by NF.2 (FMF + TF) with 370 mg/100g, NF.1 (FMF

+TF) with 214 mg /100 g and NF.3 (BMF+TF) with 153.5 mg /100 g of potassium content.

The selected millet based nutri flakes were packed in laminated aluminium pouches and kept for storage period under ambient conditions. organoleptic and keeping qualities of stored nutri flakes were analysed initially and also end month of the storage. Finger millet and barnyard based nutri flakes incorporated with tapioca flour were organoleptically evaluated initially and at the end of the storage. Initially, the highest mean scores for overall acceptability was observed as 7.92 and a slight decrease in score (7.78) was observed at the end of the storage for finger millet based nutri flakes. For barnyard millet based nutri flakes incorporated tapioca flour, the highest mean score for overall acceptability observed as 7.61 and it were decreased to 6.75 at end of the storage.

Finger millet and barnyard millet based nutri flakes incorporated with jackfruit seed flour were organoleptically evaluated initially and after one month of storage. Initially, the mean score for overall acceptability was observed as 7.85 and a slight decrease was observed (7.67) at the end of the storage. For barnyard millet based nutri flakes incorporated with jackfruit seed flour (NF.4), the mean scores for overall acceptability was 7.62 which decreased to 7.1. The prepared product was highly acceptable throughout the storage.

In the present study, finger millet and barnyard based nutri flakes were evaluated for bacteria, fungi and yeast. The bacterial load present in the selected nutri flakes incorporated with tapioca flour was observed as 0.28 $\times 10^{-5}$ cfu/g (NF.1) and 0.15 $\times 10^{-5}$ cfu/g (NF.3) initially, which increased to 0.85 $\times 10^{-5}$ cfu/g (NF.1) and 0.65 $\times 10^{-5}$ cfu/g (NF.3). The bacterial load was observed as 0.4 and 0.26 $\times 10^{-5}$ cfu/g initially, which were increased into 1.15 and .8 $\times 10^{-5}$ cfu/g at the end of the storage in NF.1 and NF.3 respectively.

The fungal count were not detected initially in selected nutri flakes incorporated with tapioca flour and further it developed to 0.35$\times 10^{-3}$ cfu/g (NF.1) and 0.18 $\times 10^{-3}$ cfu/g (NF.3). The fungal count present in the selected nutri flakes incorporated with jackfruit seed flour observed as 0.08 $\times 10^{-3}$ cfu/g (NF.2) and

$0.13{\times}10^{-3}$ cfu/g (NF.4) which increased to 0.43×10^{-3} cfu/g (NF.2) and 0.33×10^{-3} cfu/g (NF.4). Yeast population was not detected in any of selected nutri flakes at the entire the study. Insect infestation was not observed in the entire period of storage in any nutri flakes, this may be due to the low moisture content of selected nutri flakes.

In the present study, the selected nutri flakes were used for the preparation of different value added products such as ready to eat (RTE) instant breakfast mixes (IBM) and ready to eat (RTE) nutri bars (NB). All sensory attributes like appearance, colour, flavour, texture and taste were had the highest score for finger millet based nutri flakes instant breakfast mix incorporated with (IBM NF.1). The mean scores for overall acceptability varied from 6.82 (IBM - NF.4) to 7.46 (IBM - NF.1). The highest mean rank score for overall acceptability obtained was 3.27 for instant breakfast mix prepared with finger millet based nutri flakes (IBM-NF.1). Nutri bar prepared with finger millet based nutri flakes (NB-NF.1) had high mean score of 8.25,8, 8.18, 7.81, 7.87 for appearance, colour flavor, texture and taste, respectively. The mean scores for overall acceptability varied from 7.43 (NB- NF.4) to 8.12 (NB-NF.1).

From the present study, it is clear that millet based nutri flakes can be developed by finger millet and barnyard millet flour with high nutritional quality and acceptability. Incorporation of 30 per cent tapioca flour and 50 per cent jackfruit seed flour was done successfully without affecting organoleptical and nutritional qualities of millet based nutri flakes. The prepared nutri flakes were nutritionally good with high amount of carbohydrate, protein, calcium, iron, potassium and fibre. The product was microbiologically safe and shelf stable in laminated aluminium pouches. The finger millet and barnyard millet flour were effectively utilised for value added products such as ready- to- eat instant breakfast mixes and nutri bars which have good sensory qualities.

The developed nutri flakes, instant breakfast mixes and nutri bars can be used as functional foods for people who lead demanding and hectic lifestyles and also prefer for nutritious convenient foods. It can be included in the daily diet and is also suitable for combating micro nutrient deficiencies. This will trigger positive inspiration among millet growers and for millet based entrepreneurship development too.

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Appendices

APPENDIX - I

Score card for the organoleptic evaluation of nutri flakes

Name :

Date :

Signature :

Treatments	Appearance	Colour	Flavour	Texture	Taste	OAA

Nine point hedonic scale

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

APPENDIX - II

Score card for the organoleptic evaluation of RTE instant breakfast mixes

Name :

Date :

Signature :

	Treatments			
	IBM.NF-1	**IBM.NF-2**	**IBM.NF-3**	**IBM.NF-4**
Appearance				
Colour				
Flavor				
Texture				
Taste				
Overall acceptability				

Nine point hedonic scale

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

APPENDIX - III

Score card for the organoleptic evaluation of nutri bars

Name :

Date :

Signature :

	Treatments			
	NB.NF-1	**NB.NF-2**	**NB.NF-3**	**NB.NF-4**
Appearance				
Colour				
Flavor				
Texture				
Taste				
Overall acceptability				

Nine point hedonic scale

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

STANDARDISATION AND QUALITY EVALUATION OF MILLET BASED NUTRI FLAKES

By

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ABSTRACT OF THE THESIS

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Abstract

Convenient foods are commercially prepared processed foods, which are designed for the ease of preparation and consumption. Utilisation of millets is restricted due to non availability of processed foods in ready to eat form. Millets can be effectively utilised for developing value added products which can improve the overall diet quality.

The present study entitled 'Standardisation and quality evaluation of millet based nutri flakes' was carried out to develop nutri flakes using millets and to evaluate the organoleptic, nutritional and shelf life qualities. The suitability of the nutri flakes for the preparation of different food products was also assessed. Two types of nutri flakes, one based on finger millet flour and another one based on barnyard millet flour in combination with tapioca flour and jack fruit seed flour were standardised.

Nutri flakes based on finger millet flour (FM) were standardised with different proportions of tapioca flour (TF) along with other ingredients (OI). Among different treatments, T_3 (60 % FM + 30% TF+ 10% OI) secured the highest mean score of 7.92 for overall acceptability. Among finger millet based nutri flakes incorporated with jackfruit seed flour (JSF), the mean scores and mean rank scores for sensory parameters were the highest for treatment T_3 (60% + FM + 30% JSF+ 10% OI) and secured a mean score of 7.85 for overall acceptability. Nutritious millet flakes using a composite flour of 60% finger millet flour and 30% tapioca flour along with other ingredients was successfully standardised with good sensory qualities. Incorporation of 30% JSF instead of tapioca flour was also found to be suitable for millet based nutri flakes.

Barnyard millet flour (BM) based nutri flakes incorporated with tapioca flour was prepared by incorporating tapioca flour in different proportions. The treatment T_5 (40 % BM + 50% TF+ 10% OI) secured the highest mean score of 7.61 for overall acceptability. Among barnyard millet based nutri flakes incorporated with jackfruit seed flour (JSF), the highest mean score of 7.61 for overall acceptability was obtained for the treatment T_5 (40 % BM + 50% JSF+ 10% OI) Barnyard millet nutri flakes incorporated

with 50 per cent tapioca flour and 40% of barnyard millet flour obtained good sensory qualities. Instead of tapioca flour, 50% jack fruit flour also was found to be suitable for nutri flakes.

The selected nutri flakes were subjected to quality evaluation. The carbohydrate content of nutri flakes were in the range of 36.54 g / 100 g (BM + JSF) to 50.46 g /100 g (FM + JSF). Protein content was in the range of 6.87 g / 100 g (BM + JSF) to 13. g / 100 g (BM + JSF). Jackfruit seed flour incorporated nutri flakes were found to be high in protein content. The fat content of nutri flakes were in the range of 1.26 g / 100 g (FM + TF) to 1.99 g / 100 g (BM + JSF). Finger millet based nutri flakes with jackfruit seed flour had highest calcium content of 199 mg / 100 g Iron content of nutri flakes varied from 2 mg /100 g (NF.3) to 5.58 mg / 100 g (NF.1).

The selected nutri flakes were packed in laminated aluminium pouches and shelf life was studied under ambient conditions. Though the mean scores of all organoleptic parameters slightly decreased throughout the storage, all nutri flakes maintained an acceptable level at the end of storage period. The total microbial count observed were within permissible limits at the end of storage. Yeast population and insect infestation were not observed throughout the storage period.

In the present study, nutri flakes were used for the preparation of different value added products such as ready to eat (RTE) instant breakfast mix (IBM) and ready to eat (RTE) nutri bar (NB). The mean scores for overall acceptability for instant breakfast mix varied from 6.82 (IBM- 40 % BM + 50 % JSF) to 7.46 (IBM-60 % FM + 30% TF). The mean scores for overall acceptability varied from 7.43 (NB-40 % BM + 50 % JSF) to 8.12 (NB 60 % FM + 30% TF) for different nutri bars.

Acceptable and nutritious nutri flakes and were developed successfully and these products can be successfully utilized for value added products like instant breakfast mixes and nutribars. These millet based products can be included in the daily diet as a strategy to combat micro nutrient deficiencies.