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Development of Millet Based Foods Enriched with Peanuts and Pulses

K. Santosh Kumar[1*], S. Dattamazumdar[2] and R. Renu[3]

[1]Food Processing Technology, University College of Technology, Osmania University, Hyderabad, Telangana, India
[2]Chief Operating Officer, Nutri-Plus Knowledge Program, ICRISAT, India
[3]Department of Food Technology, University College of Technology, Osmania University, Hyderabad, Telangana, India

**Corresponding author*

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A B S T R A C T

Millet is a highly nutritious food recommended for children, elders. Millet represents 85% is used as food. Its production is majorly contributed in Nigeria, It is also a staple food for Namibia and Uganda where it's consumption is higher mostly 20 to 25%. A pilot facility was established at ICRISAT for millets primary processing to promote entrepreneurship qualities in case of small scale business enterprises and to provide value addition to the millets through its primary processing. Different machines were established in the pilot facility include De-stoner, Aspirator and Grader, De-huller, Millet mill, Roaster, Peanut de-skinner/Splitter, Flour mill, Flour Sifter, Flour Blender, Peanut butter mill, Planetary Mixer and Cup sealing machine etc. The major objective is to develop Peanut-Millet spreads and millet meal using primary processing machinery this pilot facility i.e. removal of stone, dehulling, roasting and milling was done using pilot facility and Shelf life studies were carried out for the two products under accelerated conditions at 37ºC and 92% of Relative humidity. These products found to be nutritionally rich and giving good shelf life for 3 Months by following good manufacturing and hygiene conditions.

Introduction

Millets are nutritionally rich and occupy an important place in the diet of people in many regions of the world. Although millets are nutritionally superior to cereals their utilization as a food is still mostly confined to the traditional consumers and population of lower economic strata.

Millets are considered as crop of food security because of their sustainability in adverse agro-climatic conditions (Ushakumari *et al.*, 2004). These crops have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security (Mal *et al.*, 2010).

Millets overview

Millet is a generic term used for small sized grains that form heterogeneous group and referred along with maize and sorghum as 'coarse cereals'. Millets are of minor

importance in the west but a staple food in the diets of African and Asiatic people. Their agricultural importance arises from their hardiness, tolerance to extreme weather and could be grown with low inputs in low rainfall areas. *Bajra*or pearl millet (*Pennisetum americanum*), *ragi* or finger millet (*Eleusine coracana*), *navane* or foxtail millet (*Setaria italica*), *samai*or little millet (*Panicum miliare*), *haraka* or kodo millet (*Paspalum scrobiculatum*), *panivaragu* or proso millet (*Panicum miliaceum*), banti or barnyard millet (*Echinochloa frumentacea*) are the important millets cultivated largely in the Asian and African countries. Fonio (*Digitaria exilis*) and Tef (*Eragrostictef*) are specific to Nigeria and Ethiopia respectively. Most of the millets are grown in different regions of the world from east to west. The world total production of millet grain was 762712 metric tonnes and India top ranking with a production of 334500 tonnes in 2010 (FAO, 2012).

Millets are considered as crop of food security because of their sustainability in adverse agro-climatic conditions (Ushakumari *et al.,* 2004). These crops have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security (Mal *et al.,* 2010). Along with nutrition millets offer health benefits in daily diet and help in the management of disorders like diabetes mellitus, obesity, hyperlipidemia, etc. (Veena, 2003). Millets offer unique advantage for health being rich in micronutrients, particularly minerals and B vitamins as well as nutraceuticals. Though millets are not the important part of daily diet of American and European people, now these countries have recognized the importance of millets as ingredient in multigrain and gluten-free cereal products. However, in many Asian and African countries millet is the staple food of the people in millet producing areas and used to prepare various traditional foods and beverages like *idli*, *dosa*, *papad*, *chakli*, *porridges*, breads, infant and snack foods (Chandrasekara and Shahidi, 2011). Whilst a number of traditional foods are made in the domestic household, the lack of large-scale industrial utilization discourages the farmers raising millet crops (Subramanian and Viswanathan, 2003). Therefore, many countries Including India, China, USA etc. have now started research projects to study and develop process technology for nutritional improvement and harvest health benefits and promote their utilization as food on large scale.

Primary processing of millets is a vital step for obtaining grain-rice and for further processing of grains for consumption. While processing millets without husk (naked grains) namely sorghum, pearl and finger millet is easy, processing of millets with husk namely little, proso, kodo, barnyard, foxtail and brown top millets is difficult. These have inedible husk which needs to be removed through processing. The major challenges in processing small millets are:

The small size of the grains

Variations in the raw materials due to variation in varieties, cultivation practices and

Micro climate across production regions and across the years and variations across the crops

Low shelf life of the processed rice and grits due to pest infestation and rancidity

The machines currently used for processing of small millets on a small to medium scale include, i) Graders / Shakers, ii) Destoners, iii) Air classifier / Aspirator and iv) Hullers. Currently three types of dehulling technologies are employed namely, 1. Emery mill working on abrasion principle, 2.Rubber roller mill working on abrasion principle and

3. Centrifugal type working on impact principle. Most of these processing machines are improvised version of paddy processing machineries. Small millet processing machines are designed and manufactured by the equipment manufacturers mainly based on their experiential knowledge (trial and error method), as limited scientific research inputs have gone into the same through systematic technology transfer. On the other hand, few resourceful processors in the market have learned small millet processing based on large number of iterations, thereby gaining operational knowledge which is *'tacit'* in nature. Limited formal research on standardizing the processing equipment as a process line has been done. There has been no effective working mechanism or learning platform for effective interaction and flow of knowledge between research institutions, equipment manufacturers and end users or to document the learning within their respective sectors. The few hulling technologies developed are not put to test in processing unit using large volumes of throughput to know their performance. The hulling efficiency (calculated as share of millet rice kernel to total grain processed) and quality of output has been less than acceptable. The presence of unhulled grains in the millet rice is an important issue faced by the consumers. On the processor side, the high cost of processing to achieve acceptable quality rice increases the price of small millet rice substantially and thereby hampers the volume of sales. Processing is the critical link in the small millet supply chain between production and consumption and therefore difficulties and inefficiencies in processing act as an important limitation for growth of markets for small millet food products. Therefore, there is need for fine-tuning the existing small millet processing machineries to improve the quantity and quality of output and to improve ease of use.

Introduction to primary processing

After primary processing i.e after removing stones, other foreign materials from the grains provide value to achieve good quality for product development. The work carried out related to primary processing are discussed as follows

Decortication/ Dehulling

Millets were earlier decorticated at household level by hand pounding. Now a day these are milled in rice milling machinery with slight modification of the process. Centrifugal sheller can be used to dehull/decorticate the small millets. The fractions of husk in pearl millet and small millet varied from 1.5 to 29.3% (Hadimani and Malleshi, 1993).

Soaking of pearl millet grain in 300 ml (w/v) 0.2 N HCL for 15 hr and washing twice with water helps in removing the hull. Then grains are scarified in laboratory scarifier (Osawa make) for 1–3 min can remove 8.10–15.84% hull (Pawar and Parlikar, 1990).

Milling

Most of the millets produced in India are used as staple food and less in ready-to-use and convenient food products due to non-availability of proper milling technology. The major constraints for widespread utilization of millet are its coarse fibrous seed coat, coloured pigments, astringent flavour and poor keeping quality of the processed products (Desikachar, 1975).

Pearling, debranning and chemical treatments of millets overcome some of these constraints; improve nutritional quality and consumer acceptability (Akingbala, 1991). In milling, the milling efficiency and shelling index are the important parameters that influence the head yield and further processing.

Processing of cereals and millets plays significant role during its utilization as food. Minor millets can be consumed by processing them into rice, flour, sprouting, roasted, popped, salted ready-to-eat grains, porridges and fermented products. As millet grains are hard seed coat grains, their processing starts with the task of removal of husk.

This pilot facility is utilized for the production of products like Peanut-Millet spreads and Millet meal. The primary one is a blend of millet flour and peanut paste, chick pea flour which in turn provide abundant calories and nutrients in foods. In case of PEANUT-MILLET SPREAD prior to

Processing the grains was subjected to malting to improve digestibility factor.

Various studies were proposed for malting is discussed as follows. Traditionally, the millet malt is utilized for infant feeding purpose. Finger millet possesses good malting characteristics and its malting is popular in Karnataka and part of Tamil Nadu. Malting helps to increase significantly the nutrient composition, fibre, crude fat, vitamins B, C and their availability, minerals (Sangita and Srivastav, 2000), improve the bioavailability of nutrients, sensory attributes of the grains.

After malting grains are subjected to primary processing and then product development. Shelf life analysis was carried out for the respective products.

Materials and Methods

List of machineries in pilot facility

De-stoner, Aspirator, Grader.
De-huller.
Millet mill.
Roaster.
Peanut De-Skinner.
Flour mill.
Flour sifter.
Flour blender.
Poly bag sealing machine.
Planetary mixer.
Cup sealing machine.

Peanut-millet spread

Two different products are been made using the pilot plant facility. These two products are rich in nutrition and energy. They are as follows

Peanut-millet spreads

Raw ingredients required

Sorghum, Peanuts, Chick pea, Sugar, oil, Emulsifier (Table 1).

Cleaning

Cleaned grains are collected which are free from Dust, stones, straws and other dust particles etc.

All the foreign particles are separated by using Destoner, Aspirator and Grader. The good quality grade grains are separated and collected using grader.

Weighing

During Weighing the whole grains weighing were done by making them into dry flour and then after sieving up to required size.

Roasting

In the production of PEANUT-MILLET SPREAD the followed ingredients need to be roasted before blending in order to remove the raw flavour. Sorghum grains and Chick pea grains, Peanuts are roasted before grinding and then go for further processing.

Grinding

Grinding is done in a flour mill or in a mixer. The roasted sorghum flour and roasted chick pea grains are fed into the flour mill for grinding. After grinding the flour is collected at the respective outlet.

Sieving

After making into flour the sorghum flour and chick pea flour is passed into the flour sifter for sieving where the fine particles and coarse particles were separated depending upon the respective mesh size.

Blending

Blending is the next step in PEANUT-MILLET SPREAD processing. The blending is done in a planetary mixer. Initially add Emulsifier to the warm oil then add oil into the planetary mixer. Then add peanut paste to it, mix it for some time then add sugar powder mix it for some time to avoid lump formation. Finally add all the dry flours into the mixer. Maintain the mixing time for 10 minutes. After achieving required consistency transfer the product into the sterile container.

Packing

The end product is packed in cups by using cup sealing machine.

Instant millet meal

Raw ingredients required

Jowar, Foxtail millet, Green gram, Curry Leaves, Cumin, and Spice/Salt (Table 2).

Cleaning

Cleaned grains are collected which are free from Dust, stones, straws and other dust particles etc. All the foreign particles are separated by using Destoner, Aspirator and Grader.

The good quality grade grains are separated and collected using grader.

Weighing

During Weighing the whole grains weighing were done by making them into dry flour and then after sieving up to required size.

Roasting

In the production of Millet meal all the whole grains were roasted and then go for milling.

Milling

Grinding is done in a flour mill or in a mixer. The roasted sorghum flour, Foxtail millet, Green gram were roasted and fed into the flour mill for grinding.

After grinding the Coarse particles are collected at the respective outlet.

Sieving

For the production of Millet meal while milling the uniform size coarse particles were separated using flour sifter by changing the respective metal frame fixed to the sifter.

Addition of ingredients

Apart from major ingredients the minor ingredients like cumin, salt, sugar, pepper, and red chilli were added and mixed uniformly with the help of a ladle.

Packing

The final mix is packed in a LDPE pouches and sealed.

Proximate analysis

Proximate Constituents include Water Activity, Moisture, Protein, Fat, Total Ash, Crude Fibre, Acid Value, Peroxide Value, and Alcohol Acidity.

Microbial analysis

Microbial Parameters analysed were include Total Bacterial Count, Yeast andMold, and Coliforms.

Results and Discussion

Sensory evaluation

Sensory evaluation of peanut-millet spread

The data on mean score value of sensory attributes are presented in table 3 and explained in terms of individual characters as follows.

Appearance

It was found that the mean values of Appearance of control, A, B and C where found as 7.2, 7.1, 7 and 7.3 respectively on Hedonic scale. The 'Control' has better mean score value as compared with others.

Colour

The data obtained from the sensory evaluation by a panel of 15 members shown the mean values of color of control, A, B and C where found as 7.4, 7.2, 7.0 and 7.6respectively on the Hedonic scale. The sample 'C' has better mean score value as compared with others.

Flavour

It was found that mean values of control, A, B and C where found as 7, 7.1, 7.2 and 7.3 respectively on Hedonic Scale. It was evident that 'C' sample have better flavour profile followed by control sample.

Texture

It was found that mean values of the texture control, A, B and C sample were found as 7.3, 7.2, 7 and 7.4 respectively on the hedonic scale. It was found that control sample and sample 'C' have better texture compared to other samples.

Taste

It was found that mean values of the taste control, A, B and C sample were found as 7.2, 7.1, 6.8 and 7.2 respectively on the hedonic scale. It was found that sample 'C' have better taste compared to other samples.

Overall acceptability

It was found that the mean values of overall acceptability control, A, B and C were found as 7.5, 7.2, 7 and 7.4 respectively on the Hedonic scale. However the sample 'C' has better value for over all acceptability as compared to other samples. Statistically the sample C was found to be more significantly acceptable as -compared to other samples under investigation.

Sensory evaluation of millet meal

The data on mean score value of sensory attributes are presented in table 4 and explained in terms of individual characters as follows.

Appearance

It was found that the mean values of Appearance of control, A, B and C where found as 7.4, 6.9, 7 and 7.3 respectively on Hedonic scale. The 'Control' has better mean score value as compared with others.

Table.1 Formulation of peanut-millet spread

Ingredients	Percent (%)			
	Control	Sample A	Sample B	**Sample C**
Sorghum flour	-	34.9	36.5	**38.5**
Chick Pea flour	-	8.9	8.9	**8.9**
Peanut Paste	100	30.7	34.1	**33.7**
Sugar	-	15	10	**15**
Oil	-	10	10	**10**
Milk Powder	-	-	-	**8.9**
Emusifier	-	0.5	0.5	**0.5**
Emulsifier	-	**0.5**	**o.5**	**0.5**

Table.2 Formulation of millet meal

Ingredients	Percent (%)			
	Control	Sample A	Sample B	**Sample C**
Sorghum	90.7	35	37.21	**39.21**
Foxtail millet	-	20	18.60	**18.60**
Green gram	-	35	27.91	**27.91**
Curry leaves	2	2	1.40	**1.40**
Cumin	3	3	2.79	**2.79**
Pepper	0.3	0.3	1.20	**1.21**
Red Chilli	2	2	2.32	**2.33**
Salt	2	2	6.04	**8.05**
Sugar		-	**2.04**	**2.05**

Table.3 Sensory evaluation of peanut-millet spread

Sample	Appearance	Colour	Flavor	Texture	Taste	Overall acceptability
Control	7.2	7.4	7	7.3	7.2	7.5
A	7.1	7.2	7.1	7.2	7.1	7.2
B	7	7	7.2	7	6.8	7
C	7.3	7.6	7.3	7.4	7.2	7.4

Table.4 Sensory evaluation of millet meal

Sample	Appearance	Colour	Flavor	Texture	Taste	Overall acceptability
Control	7.4	7.4	7	7.2	7.4	7.6
A	6.9	7.3	7.1	7.1	7	7
B	7	7.2	7.2	6.9	6.9	6.9
C	7.3	7.4	7.3	7	7.1	7.2

Table.5 Shelf life results of peanut-millet spreads and millet meal

Parameters	0th Day	15th Day	30th day	45th Day	0th Day	15th Day	30th day	45th Day
	PEANUT-MILLET SPREAD				Millet meal			
Moisture (%)	2.41	2.51	2.6	2.8	3.46	3.77	4.41	4.51
Fat (%)	26.02	25.14	26.77	26.06	10.1	10.2	10.4	10.4
Protein (%)	15.2	15.2	15.1	15.2	13.1	13.1	13.2	13.1
Ash (%)	1.4	1.2	1.2	1.4	10.2	10.5	10.2	10.1
Crude fiber (%)	2.9	2.8	2.8	2.8	0.9	0.9	0.9	0.9
Water Activity	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Peroxide value (Meq/kg)	10.1	10.2	10.1	10.3	33.9	34.7	33.7	33.8
Acid value	12.7	12.6	13	12.6	9.7	9.8	9.7	9.7
Alcoholic acidity (%)	0.1	0.09	0.1	0.1	0.1	0.09	0.1	0.1

Microbial Results

	PEANUT-MILLET SPREAD		Millet meal	
	0th Day	45th Day	0th Day	45th Day
TPC	<10cfu	<15 cfu	<10	<10
Yeast andMold	<5	<5	<5	<5
Coliforms	Negative	Negative	Negative	Negative

Process Flow Sheet

Cleaning
↓
Weighing the raw ingredients of required Quantity
↓
Roasting of Sorghum, Chick pea, Peanuts (80ºC)
↓
Grinding the Sorghum and Chick pea grains into fine flour (60 Mesh)
↓
Grinding peanuts in a peanut mill
↓
Sieving the flour using sifter
↓
Blending in a planetary mixer for 10 Mins
↓
Transfer into a container
↓
Sealing using cup sealing machine

Process Flow Sheet

Cleaning and Grading
↓
Weighing the raw ingredients of required Quantity
↓
Roasting (80ºC)
↓
Grinding/ Milling (30 Mesh)
↓
Sieving
↓
Addition of Ingredients
↓
Mixing
↓
Packing

Fig.1 Sensory evaluation of peanut-millet spread

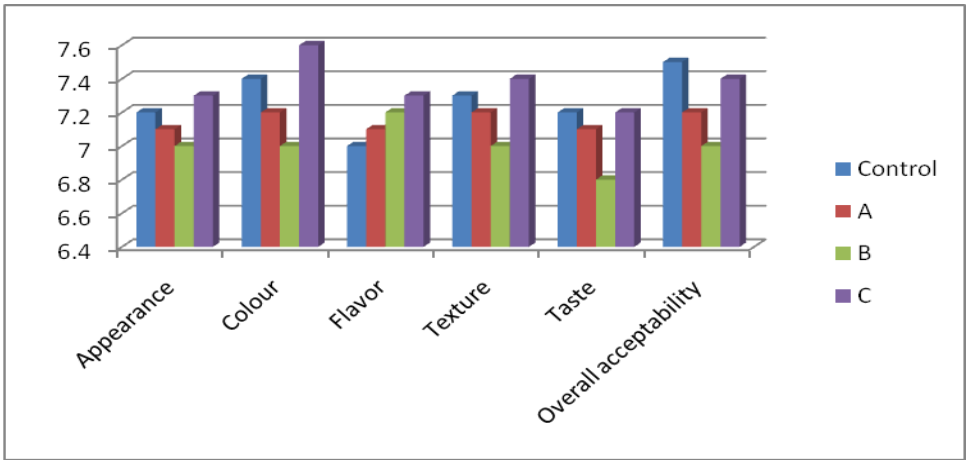


Fig.2 Sensory evaluation of millet meal

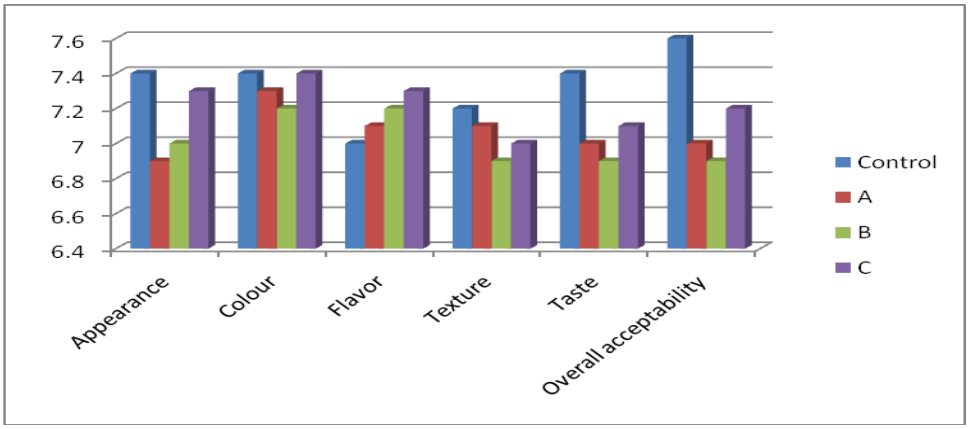


Fig.3 Graphical representation of proximate results of peanut-millet spread

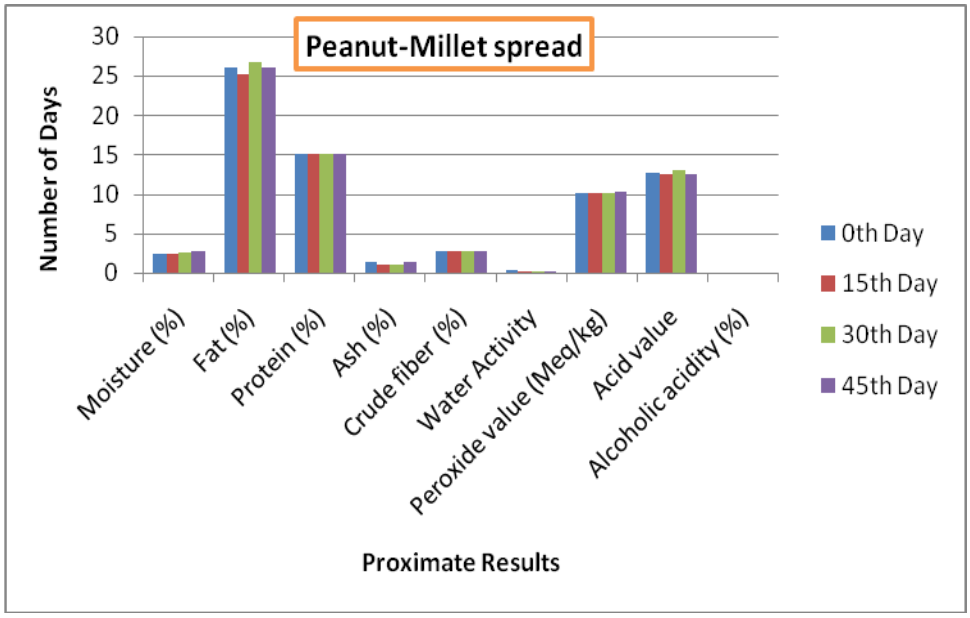
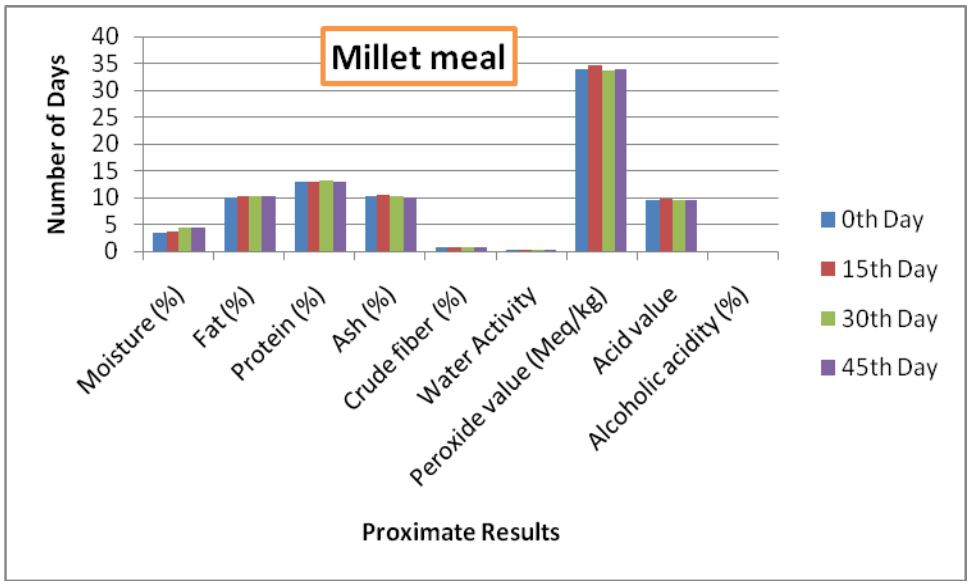


Fig.4 Graphical representation of proximate results of millet meal



Colour

The data obtained from the sensory evaluation by a panel of 15 members shown the mean values of color of control, A, B and C where found as 7.4, 7.3, 7.2 and 7.4 respectively on the Hedonic scale. The sample 'C' has better mean score value as compared with others.

Flavour

It was found that mean values of control, A, B and C where found as 7, 7.1, 7.2 and 7.3 respectively on Hedonic Scale.

It was evident that 'C' sample have better flavour profile followed by control sample.

Texture

It was found that mean values of the texture control, A, B and C sample were found as 7.2, 7.1, 6.9 and 7 respectively on the hedonic scale. It was found that control sample and sample 'C' have better texture compared to other samples.

Taste

It was found that mean values of the taste control, A, B and C sample were found as 7.4, 7, 6.9 and 7.1 respectively on the hedonic scale. It was found that sample 'C' have better taste compared to other samples (Fig. 1 and 2).

Overall acceptability

It was found that the mean values of overall acceptability control, A, B and C were found as 7.6, 7, 6.9 and 7.1 respectively on the Hedonic scale. However the sample 'C' has better value for over all acceptability as compared to other samples.

Statistically the sample C was found to be more significantly acceptable as -compared to other samples under investigation.

Shelf life studies

Both the samples were analysed for physic-chemical properties and microbial profile on O^{th} day and 45^{th} day. Proximate analyses were conducted on intervals of 0^{th}, 15^{th}, 30th, 45th days on accelerated conditions. The obtained results are discussed below. Microbial results were carried out at regular intervals of 15 days and data of 0^{th} day and 45^{th} day is considered primarily (Table 5).

Analysis

They were kept for storage up to 45 days at 37^0c and 72% RH. Samples were analyzed for Nutrient analysis, microbial on the day of preparation 0 day, 15th day, 30th day and 45^{th} day.

No significance difference was observed in protein and Fat content during storage study. There is a significant differences observed in Moisture content. The moisture content increased from 3.4% to 4.5 % in Millet meal and not much significant difference in case of Peanut-Millet Spread.

Crude fibre content showed no significant difference among both the samples. Both periods and samples showed no significance differences in total ash content (Fig. 3 and 4).

No bacterial or fungal count was recorded in case of Peanut-Millet Spread during the entire period of storage study.

Bacterial and Yeast growth was observed not more than 10 c.f.u in case of Millet meal.

No *E. coli* growth was recorded in the entire period of storage study.

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Production and evaluation of nutrient-dense complementary food from millet *(Pennisetum glaucum),* pigeon pea *(Cajanus cajan)* and seedless breadfruit *(Artocarpus altillis)* leaf powbaeyi-Nwaoha I.E. and Obetta F.C.

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