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Development and Quality Evaluation of Popcorn Nutri Bar

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Abstract

Popcorn is a type of corn (*Zea mays var. everta*) that expands from the kernel and puffs up when heated with light crunchy texture. Attempt was made to develop popcorn bar using 50 per cent pop corn powder incorporation along with other ingredients (nutri bar). The developed bar was evaluated for nutritional, sensory, microbial and storage quality as per standard procedures. The keeping quality of the bar was tested by storing in low density polyethylene (LDPE) covers and polyethylene teraphthalate (PET) jars for a period of seven weeks. Among the four types of nutri bars tested *i.e.,* pista, orange, chocolate and without flavor (control), the control bar scored between very good to excellent (4.1) in sensory quality on a five point hedonic scale followed by chocolate flavored bar (3.8). The nutritional composition of the developed popcorn nutri bar revealed that it contained crude fibre (6.73 g), protein (13.36 g), energy (405.55 kcal) and minerals such as calcium (147.66 mg) magnesium (100 mg), phosphorus (166.66 mg) and iron (8.89 mg). Increase in peroxide value as well as free fatty acids was observed in both PET jars as well as LDPE covers. However, the popcorn nutri bar stored in PET jars was acceptable up to six weeks at room temperature. The consumer acceptability scores revealed that about 84 - 92 per cent of the children rated the pop corn nutri bar as "very good".

Keywords: Popcorn, Nutri bar, Popping process, Sensory quality and Crude fiber

Popcorn is a type of corn (*Zea mays var. everta*) that expands from the kernel and puffs up when heated with light crunchy texture. Popcorns are usually consumed as a snack food with or without salt (regular) and sweetened (caramel/chocolate corn) or butter like topping. Pop corn consumption has greatly increased in recent years because of the advent of microwavable pop corn and the proliferation of flavored ready to eat products. Popping is simple and economical processing technique which is traditional and may be adopted easily with the improvement in nutritional quality of grain. It is a high temperature short time (HTST) treatment which sterilizes product, gelatinizes its starch and develops a pleasant aroma to form ready-to-eat food (RTE) at a very low processing cost. Popping process not only retains the actual nutritional profile of grains but also markedly enhances its protein digestibility, bio availability of iron and dietary fiber content due to the development of resistant starch. Popping also reduces some of the anti nutrients *viz.,* phytates, tannins and poly phenols. The bulkiness of the fibers of popped grain mixes and popped products aid in slower digestion rate which makes the consumers to feel on fewer calories and therefore may help to prevent from eating excess calories. Its high fiber content is further helpful to the individuals having the problem of constipation (Cade *et al.,* 2007).

Popped grains are good in terms of energy, carbohydrate, fat, fiber, protein and iron. Pop corns are prepared out of whole grains, which are rich in many components including dietary fiber, starch and fat. Apart from this, popcorn do contain other antioxidant nutrients, minerals, vitamins, lignin and phenolic components, all of which have been linked to reduced risk of different types of cancer. Most of these protective components are found in the germ and bran which are reduced in almost all the grains due to refining process. However, popping is one such technique of grain processing where in the germ and bran portions are retained and it is the most simplest and economical method of processing which imparts a pleasant aroma and flavor that can be enjoyed at all times. Apart from above advantages, popping of grains enhances the acceptability of cereals as well as millets. Popcorn is used primarily for human consumption as

a favorite nutritious snack food and is becoming more and more popular over time. Most of the popcorn is popped in home at domestic levels and the remaining is sold through retail outlets, fast food shops and also by confectionery industry. Popcorn and its products are cereal based snack foods and always been an important part of life and these products represent an important segment of the food industry worldwide especially in developing countries (Shobha *et al.,* 2016).

Bar or nutri bar is a popular food with blend of ingredients to provide nutrition to different age groups in an amount that is effective in enhancing their nutrition. The nutritious bars provide the energy required for consumer along with nutritional benefits they want in one convenient easy to stow package. Nutritionally packed bars are gaining importance now-a-days due to the consumers concerns about obesity and their corresponding desire for healthier foods. (Jan *et al.,* 2012).

Now-a-days snack food market is continually changing and adapting to the new consumer needs. Commercial food manufacturers produce an array of ready-to-eat (RTE) as well as convenient foods which are high in oil and flavored with salt or salty flavorings. The simpler snacks can be produced from popcorn in a natural way with higher nutritional benefits. It is high time that measures be taken up for value addition to pop corn grain by simple and economical technique of popping and value addition that could create tasty and nutritious food which would further enriches the popped grains. The ground popcorn as flour of various sized grits can be utilized in the preparation of many traditional as well as fancied dishes, including health mixes, sweet and savory products including burfi and bars (Shobha *et al.,* 2016).

In the recent past, due to busy life style and the increasing demands from consumers for meals and snacks that are quick source of good nutrition have prompted the food scientists to develop nutritionally packed bars which combine convenience as well as nutrition. Hence these snacks such as nutri bars have become an excellent vehicle for the inclusion of functional ingredients of natural foods in the consumer's diet (Sharma *et al.,* 2014). In developing countries like India where half of the population still comes under the category of malnutrition, improving maize utilization with increased human consumption in the form of pop corn value added products will go long way in ensuring nutritional security. In this regard, the development of nutri bar using popcorn as the main ingredient presents itself as an emerging force for the niche market. Hence the main objective of the study was to develop nutri bar using pop corn and to study the biochemical, sensory and nutritional quality changes during storage.

Material and Methods

The pop corn grains were procured from AICRP maize centre, V. C. Farm and other ingredients such as groundnut, garden cress seeds and skim milk powder were purchased from local market in a single lot and refrigerated until further use.

Development of Pop Corn Nutri Bar

Popcorn nutri bar was standardized with different proportions of popcorn powder such as 50, 60, 70 and 80 per cent. The acceptable ratio was tried with four different flavor variations. (pista, orange, chocolate and no flavor as control) The best acceptable bar was stored in two different packages such as low density polyethylene (LDPE) covers and polyethylene teraphthalate (PET) jars for a period of seven weeks at room temperature (28 ± 5^0C). The method of preparation of bar is depicted in figure 1.

Sensory evaluation

In order to select the best acceptable level of pop corn powder incorporation, sensory evaluation was carried out by a panel of 21 semi trained judges using 5-point hedonic scale (Ranganna, 1986) for appearance, color, texture, flavor, taste, and overall acceptability.

Analysis of nutritional composition

Developed popcorn nutri bar was analyzed for moisture, protein and fat contents (AOAC, 2005). Carbohydrate content was determined by difference

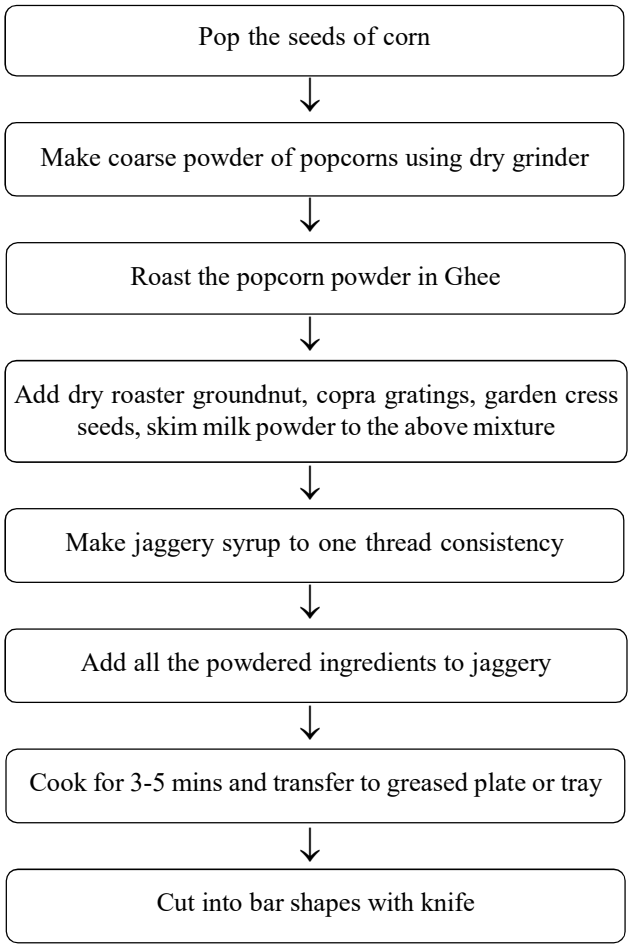


Fig. 1: Flow chart for the preparation of popcorn nutribar

(Livesey, 1995). For mineral estimation, the samples were prepared by dissolving the ash obtained after ashing the samples in a muffle furnace in dilute hydrochloric acid (1:1 v/v). Calcium and phosphorus contents were estimated according to standard procedure of AOAC (1995), iron by Wong's method (Wong, 1928) while magnesium and potassium were estimated by the methods of versanate titration and Ranganna (1986), respectively.

Storage Studies

Pop corn nutri bars packed in LDPE covers and PET jars were drawn periodically for sensory, biochemical and nutritional changes (AACC, 2000). Packed samples were subjected to seven weeks of storage studies. Microbial quality of the stored samples was carried out by the method of Collins and Lyne (1970) wherein all the isolations were carried out following serial dilution technique. Plates were incubated at 32±1°C for 96 hrs and every week colony counts were recorded for bacteria, fungi and moulds.

Consumer Acceptance

In order to know the general acceptance of popcorn nutri bar by the consumers, pop corn nutri bar was served to rural and urban children especially school children of Mandya District in Karnataka and asked to rate the products as "good" "very good" and "not good".

Statistical analysis

The data was analyzed statistically for the mean, standard deviation and Anova to test the significance among different levels of flavor incorporation and effect of storage on shelf-life of the products at 5 per cent significance level.

Results and Discussion

Sensory Evaluation of Pop Corn Nutri Bar

Sensory evaluation of pop corn nutri bar on a five point hedonic scale indicated (Table 1) that the incorporation of 50 per cent pop corn powder to the nutri bar was acceptable out of four variations tested (50 per cent, 60 per cent, 70 per cent and 80 per cent.). Among the four flavor variations tested, *i.e.*, orange, pista, chocolate and control (Table 2). The control bar with no added flavor was scored between "very good to excellent" (4.7) in overall acceptability, where as taste (4.1) and flavour (4.2) scored between "good to very good". Similar kind of study conducted by Latika *et al.,* (2016) indicated that defatted soy cereal bar (DSCA) prepared by substituting different proportions of defatted soy flour with basic meal indicated that T_2 (80:20) was highly acceptable compared to all other treatments.

Nutritional Composition of Pop Corn Nutri Bar

The perusal of Table 3 indicated that pop corn nutri bar prepared with incorporation of 50 per cent popcorn powder without added flavor was found to contain fairly good amount of protein (13.36 %) which may be due to addition of garden cress seed, groundnut

TABLE 1

Sensory evaluation of pop corn bar with different ratios of pop corn powder incorporation

Sensory characteristics	Ingredient variations				Statistical analysis		
	A	B	C	D	F-value	SEm±	CD@5%
Appearance	4.0	3.0	3.0	3.7	5.09	0.32	0.64
Colour	4.2	3.0	3.0	3.6	5.94	0.33	0.68
Texture	3.3	3.2	3.3	3.3	0.12	0.39	0.78
Flavour	3.6	3.2	3.1	3.3	3.46	0.31	0.62
Taste	4.1	3.7	3.1	4.0	4.07	0.32	0.64
OAA	4.1	3.5	3.1	3.8	3.67	0.32	0.64

*OAA- Overall acceptability
Note: Score pattern: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent
A - 50 % popcorn powder B - 60 % popcorn powder
C - 70 % popcorn powder D - 80 %- popcorn powder

TABLE 2

Sensory evaluation of pop corn nutri bar with different flavors

Sensory characteristics	Ingredient variations				Statistical analysis		
	A	B	C	D	F-value	SEm±	CD@5%
Appearance	3.1	2.4	4.2	4.5	25.52	0.27	0.55
Colour	2.6	2.6	4.4	4.6	45.37	0.23	0.47
Texture	3.0	2.7	4.5	4.6	23.52	0.29	0.59
Flavour	2.2	2.4	4.2	4.2	30.42	0.26	0.53
Taste	2.0	2.3	4.0	4.1	33.78	0.27	0.55
OAA	2.5	2.5	4.1	4.7	37.90	0.26	0.52

*OAA- Overall acceptability
Note: Score pattern: 1- poor, 2- fair, 3- good, 4- very good, 5- excellent
A - 50 % popcorn powder + Orange flavor B - 50% popcorn powder + Pista flavor
C - 50% popcorn powder + Chocolate flavor D - 50 % popcorn powder + No added flavor

and poppy seeds. Our results are in agreement with the results of Verma and Patel (2013) developed RTE mix from puffed finger millet grains by simple grinding and mixing with other additional ingredients. The RTE mix contains higher amount of protein, fibre, calcium and zinc compared to puffed finger millet powder. The calcium (147 mg/100g), magnesium (100 mg/100g) and iron (8.89 mg/100g) contents were fairly good in pop corn nutri bar, it was obviously because of addition of garden cress seeds and poppy seeds which are known to contain 17.20 mg and 10.13 mg of iron per 100 g respectively.

Sensory Changes During Storage

The storage of any product determines its wholesomeness during the definite period of time (Shobha *et al.,* 2011). The storage study includes sensory, biochemical and nutritional changes. The perusal of figure 2 indicates the changes in sensory quality during storage. The overall acceptability scores decreased from 4.5 to 3.6 and 4.2 to 2.8 in LDPE covers and PET jars respectively. Whereas, taste, texture, color and appearance were significantly decreased in LDPE covers as well as PET jars over

TABLE 3

Nutritional composition of popcorn nutri bar (per 100g)

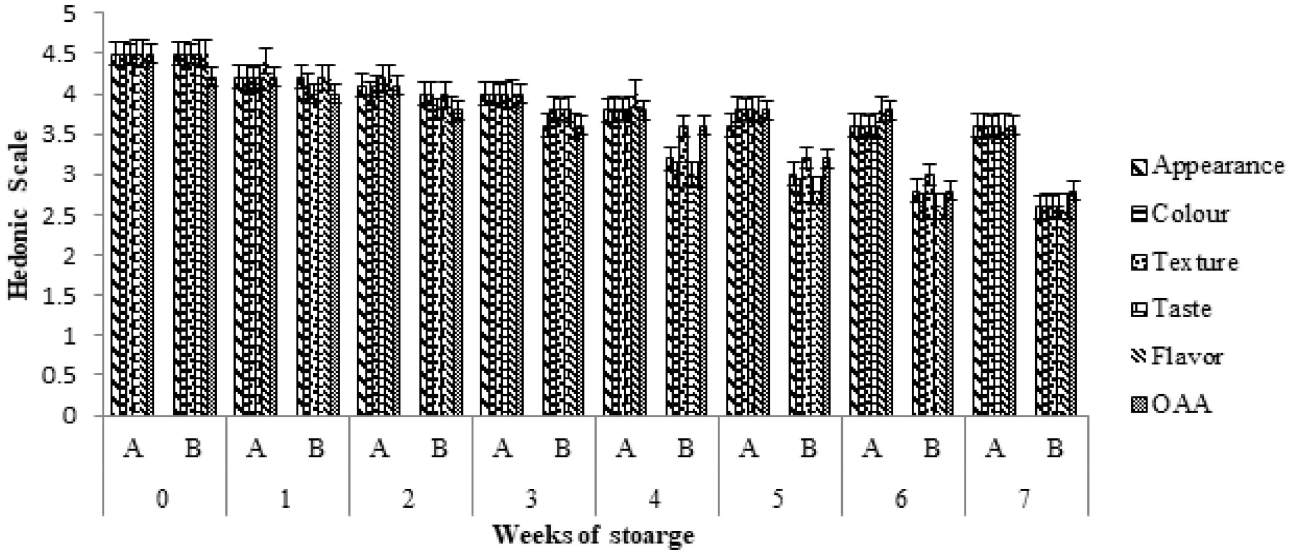
Nutrients	Per 100g
Moisture (g)	10.52 ± 0.07
Carbohydrates (g)	53.13 ± 0.015
Protein (g)	13.36 ± 0.01
Fat (g)	15.51 ± 0.06
Crude Fibre (g)	4.73 ± 0.015
Ash(g)	2.75 ± 0.01
Calcium (mg)	147.66 ± 2.51
Phosphorous (mg)	166.66 ± 2.51
Iron (mg)	8.89 ± 0.09
Magnesium (mg)	100.00 ± 2.0
Energy (Kcal)	405.55 ± 1.37

Note: Values are mean of three replications ± SD

seven weeks of storage. Between weeks and between packaging materials significant differences ($P<0.05$) were observed. At the end of storage period, the bar was slightly hard in texture which was indicated by sensory parameters (Table 2). Our results are supported by Ananthan *et al.* (2012) where in hard texture of nutri bar was due to the migration of moisture as well as formulation of most ordered secondary structure and lower surface hydrophobocity of protein particles. The decreased color of the nutri bar during storage (Fig. 2) was due to maillard reaction between reducing sugar and reactive lysine residue play a part in the hardening and colour changes in nutri bar. However, the nutri bar stored in PET jars was found to be acceptable in sensory quality with an overall acceptability score of 3.8 (between good to very good) by end of six weeks storage.

Chemical Changes During Storage

A close look at Fig. 3 depicts the biochemical changes during storage. The moisture content increased significantly from 7.22 per cent to 10.36 per cent and 7.3 per cent to 10.52 per cent, in PET jars and LDPE covers respectively (Fig 3). While peroxide value increased from 3.09 to 4.42 m eq/kg of fat in PET jars similarly in LDPE covers, it was increased from 3.15 to 4.55 m eq/ kg of fat (fig 4). Similar kind of study was conducted by Panjin *et al.,* (2006) reported that metalized polyester/ polyethylene; labeled metalized PET/ PE containers were most suitable for the storage of dragee product. Earlier they had observed peroxide value in the dragee product increased from 0.5 to 9 mmo l / kg during the five months of storage. The packaging materials such as metalized polyester / polyethylene; labeled metalized PET/ PE containers



Note: A- PET Jars, B- LDPE Covers

Fig. 2 : Sensory Evaluation scores of popcorn nutri bar during storage

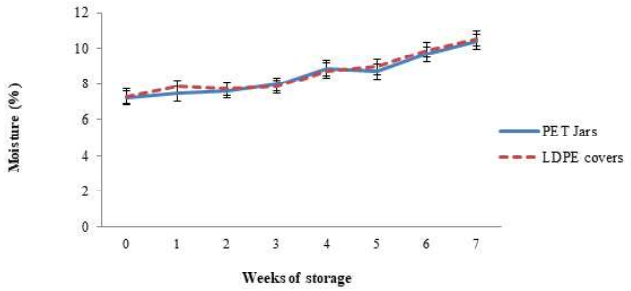


Fig. 3 : Changes in moisture content during storage of popcorn nutri bar

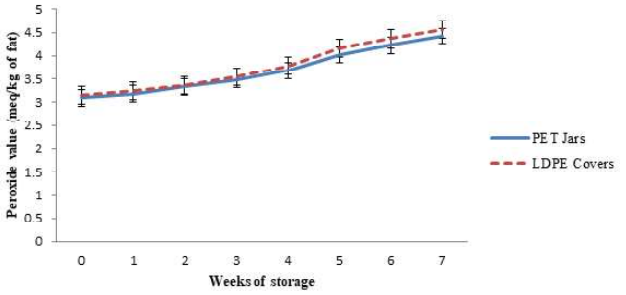


Fig. 4 : Changes in peroxide value during storage of popcorn nutri bar

had lowest oxygen permeability (8.0mLm^{-2} / dan " p1 bar) which had strong influence in the prevention of hydrolytic and oxidative changes in the final product. Earlier study indicated that, the crunchy bars packed in polypropylethin metal film and polyester polyethylene bags stored for 90 days under ambient condition indicated exponential increased peroxide value. Similar pattern of changes were noticed in free fatty acid (fig. 5) content of popcorn nutri bar, which significantly increased from 0.78 per cent to 2.42 per cent and 0.79 per cent to 2.97 per cent. Similar study conducted by Monika and Mridula (2015) on the effect of storage period on the nutritious bar indicated a significant increase in free fatty acid content and which was within the acceptable limit for three months of storage. Therefore, the present results of the showed that pop corn nutri bar packed in LDPE covers had significant ($P<0.05$) increase in moisture, peroxide value and free fatty acid by the end of four weeks, where as in PET jars the significant changes were noticed from sixth week. The changes in peroxide values normally results in off flavor. The development of off flavor in the nutri bar was due to the decomposition of peroxides and formation of volatile aldehydes, ketones, esters etc.,

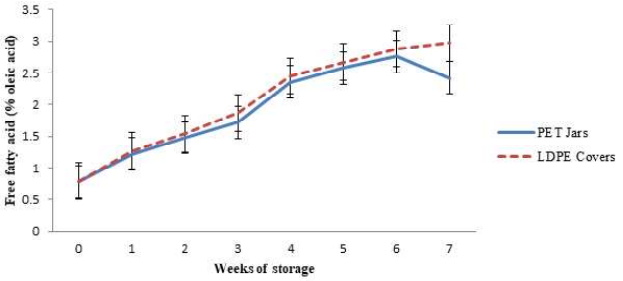


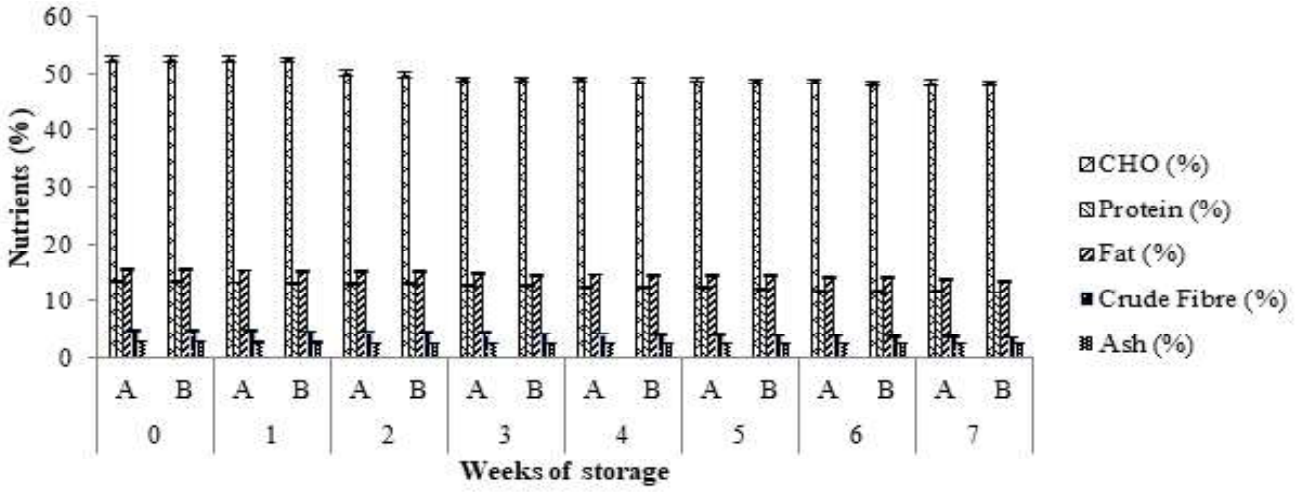
Fig. 5 : Changes in free fatty acid value during storage of pop corn nutri bar

which are having low flavor threshold values. Therefore, the rate of lipid per oxidation was monitored by following changes in peroxide value, free fatty acids (Ananthan *et al.,* 2013). The values of peroxide value and free fatty acid in the study were within the range for noticeable rancidity, wherein for an oil product, the FFA level should not exceed 1.5 per cent and peroxide value 20-40 meq /kg fat for noticeable rancidity (Shobha *et al.,* 2012).

Nutritional Changes During Storage

The perusal of Fig. 6 indicated the changes in nutritional composition of pop corn nutri bar during storage. There was no significant ($P>0.05$) change with respect to carbohydrate and ash contents in both the types of packages. However, the changes in fat content (15.51 to 13.74 % in PET jars, 15.63 to 13.50 % in LDPE covers) and no significant variation was observed with respect to crude fibre and ash contents of nutri bar. The protein percentage increased from 13.36 per cent - 14.11 per cent in PET jars, whereas in LDPE cover ranged from 13.44 per cent to 14.06 per cent as it was due to the oxygen permeability rate of the packaging material and the intensity of light that reaches the food through the packaging system and the heat penetration rate through the packages greatly influences the stability of nutrients, as these macronutrients are highly sensitive to oxygen, light and heat (Manoj Kumar, 2014). However the nutritional composition of popcorn nutri bar was quite stable up to four and six weeks in LDPE covers and PET jars respectively.

The consumer acceptability (Table 4) revealed that 90 per cent of the children including rural and urban



Note : A- PET Jars, B- LDPE Cover

Fig. 6 : Changes in nutritional composition of popcorn nutri bar during storage

TABLE 4

Consumer acceptability of Popcorn nutri bar (N=150)

Consumer ratings	Govt primary School, V.C Farm		Cresent primary School Mandya		Anganvadi KendraV.C Farm		Total	
	No	%	No	%	No	%	No	%
Very good	46	92	42	84	48	96	136	90.66
Good	4	8	6	12	2	4	12	8.00
Not good	0	0	2	4	0	0	2	1.33
Total	50	100	50	100	50	100	150	100

background rated the pop corn nutri bar as "very good". Similar line of work conducted by Sudharani *et al.,* (2013) on consumer acceptability study of ash gourd and amla based instant soup and juice mixes showed that juice mix was highly accepted and appreciated by 68 per cent of UG and 56 per cent of PG students.

Thus, the study indicated that pop corn based nutri bar prepared by incorporating 50 per cent powdered pop corn without added flavor supplemented with specific quantity of jaggery, groundnut, garden cress seeds, poppy seeds and copra gratings was scored between very good to excellent in sensory quality. The developed bar can be stored in PET jars without affecting the sensory, biochemical and microbial quality for seven months and it was accepted by consumers.

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