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Studies on nutritional quality of barnyard millet cookies

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Abstract
The present research work was carried out to explore the possibility of utilization of underutilized but highly nutrient rich barnyard millet in cookies. Preliminary experiments were carried out to find out optimum level of barnyard millet flour with maida and wheat flour for the preparation of quality cookies. The quality cookies were prepared from 50% maida and 50% wheat flour (MWF_{50}), 30% maida and 70% barnyard millet (MBF_{70}) and 20% wheat flour and 80% barnyard millet flour (WBF_{80}). The selected treatments were packed in LDPE and stored at ambient (30 ± 4 ^{0}C) for 90 days to study their storage feasibility. Chemical composition of the fresh cookies prepared from 50% maida and 50% wheat flour (MWF_{50}) that showed moisture content was 4.0 %, protein 11.55%, crude fat 26.30%, crude fiber 1.10%, carbohydrates 71.65%, calcium 35.50 mg/100 g, phosphorous 238 mg/100g and iron 3.80 mg/ 100 g. Chemical composition of the fresh cookies prepared from 30% maida and 70% barnyard millet flour (MBF_{70}) that showed moisture content was 3.10 %, protein 7.64%, crude fat 26.81%, crude fiber 6.95%, carbohydrates 68.02%, calcium 20.90 mg/100 g, phosphorous 232 mg/100g and iron 4.31 mg/ 100 g. Chemical composition of the fresh cookies (WBF_{80}) prepared from 20% wheat flour and 80% barnyard millet flour that showed moisture content was 3.0 %, protein 7.38%, crude fat 27.10%, crude fiber 8.22%, carbohydrates 66.28%, calcium 30.60 mg/100 g, phosphorous 295 mg/100g and iron 4.98 mg/ 100 g. The sensory evaluation of cookies was carried out regularly at an interval of one month for 3 month during storage. The results on overall acceptability score of cookies are influenced by storage. The results indicated that score for overall acceptability decreased for control from 7.35 to 7.10, for MWF_{50} from 7.50 to 7.15, for MBF_{70} from 8.45 to 8.00 and for WBF_{80} from 8.63 to 8.15 in LDPE was observed for 90 days of storage. Storage study of cookies showed that the cookies prepared by incorporation of maida, wheat and barnyard millet flour can be stored up to 3 month in LDPE with minimum losses in sensory, nutritional and textural characteristics. There was no significant difference in protein, crude fiber, calcium and iron content with advancement of storage period during 3 month. The cookies were found to be acceptable up to 3 month storage at ambient temperature. The total cost of production of cookies prepared from maida and wheat flour (MWF_{50}) for 1 kg was Rs. 110. The total cost of production of cookies prepared from maida and barnyard millet flour (MBF_{70}) for 1 kg was Rs. 164. The total cost of production of cookies prepared from wheat and barnyard millet flour (WBF_{80}) for 1 kg was Rs. 172.

Keywords: Barnyard millet, cookies, nutritional value, organoleptic properties

Introduction
The demand for processed foods is ever increasing due to the technological, industrial and economic advances of the developing societies of the world including India. The bakery industry has been steadily growing in the country, being the largest among the processed food industries. The two major bakery industries namely bread and biscuits account for almost 82 per cent of the total bakery products. The annual production of bakery products is estimated to be more than 3.0 million tonnes (www.biscuitfederation.org). India is recognized to be the second largest producer of biscuits next only to the United States of America with annual production of which was 7.40 lakh metric tonnes in 1997-98 which has escalated to 17.14 lakh metric tonnes in 2005-2009 (Agrawal, 1990) [3]. Among the bakery products biscuits command wide popularity in rural as well as urban areas among people of all age groups (Agrawal, 1990) [3]. The production of biscuits in the country, both in the organized and unorganized sectors, is estimated to be around 11 million tones.

The cookie formula consists of refined flour, hydrogenated fat, sugar and other additives. It is well documented that most of the ingredients used in commercial cookies lack important nutrients. The refined flour lacks in dietary fiber and micronutrients which are important health promoting components.

The hydrogenated fat comprises of trans-fats which have proven to be harmful to human health. Recognizing the negative health effects of transfats many countries have banned the trans-fats in foods and have recommended zero tolerance to trans-fats in foods for infants and other vulnerable groups. Nutrition labeling to indicate the trans-fats content is made mandatory in many countries.

There is a growing awareness among the consumers regarding the constituents that affect health both positively and negatively. The number of such health conscious consumers is fast increasing and so is the health food industry. New foods with new health claims are flooding the market to meet the diverse demands of consumers. However, still there is ample scope to enhance the nutritional value of cookies both quantitatively and qualitatively using nutritious food ingredients. In this regard, there are several food ingredients with exceptional nutritional qualities because of their nutraceutical and /or nutritional components, such as millets, oil seeds, condiments and other novel ingredients. Value addition to existing foods with such ingredients is a simple and feasible way of enhancing nutritional values of foods and in turn the health benefits.

Millets have been in food use since time immemorial and an array of traditional foods are prepared across rural India. However, food use of millets is fast decreasing due to several reasons. There is therefore a need to revive these important groups of health promoting foods to enhance nutritional quality of diets of consumers. Among the millets barnyard millet (*Echinochloa frumantacea*) is an important underutilized grain, also called as *ooda, oodalu, sanwa, sawan, sanwank* and Japanese barnyard millet. The average yield of barnyard millet is around 18-20 q/ha (Anon., 2009). It is a fair source of protein with high digestible value and it is an excellent source of dietary fiber with good amount of soluble and insoluble fractions (Veena *et al.,* 2005) [33]. The carbohydrate content is low and slowly digestible. Besides, it is rich in minerals and phytochemicals. It has been proved to be suitable for people suffering from metabolic disorders such as *diabetes mellitus* (Ugare, 2008) [31]. Additionally, it can blend with most of traditional and novel foods without imparting any flavours of its own. Hence, in the present study barnyard millet was chosen to enhance the nutrient composition of cookies in terms of dietary fiber and other nutrients

Materials and Methods

Materials:

Ingredients: The major ingredients for the preparation of products were barnyard millet procured from Zonal Agriculture Research Station, Kolhapur. The wheat (*var*. Phule Samadhan) seeds were procured from ARS, Niphad. The maida was procured from local market.

Packaging material: The packaging material *viz*., LDPE (above 51 micron) bags were procured from local market and used for packaging of cookies and for storage study.

Treatment details: The barnyard millet cookies were prepared by using different levels of barnyard millet flour with wheat flour and maida as shown below:

Table 1: Treatment details for preparation of barnyard millet cookies

Treatments	Product A		Product B		Product C	
	Maida (%)	Wheat flour (%)	Maida (%)	Barnyard millet flour (%)	Wheat flour (%)	Barnyard millet flour (%)
T_0 (Control)	100	0	100	0	100	0
T_1	90	10	90	10	90	10
T_2	80	20	80	20	80	20
T_3	70	30	70	30	70	30
T_4	60	40	60	40	60	40
T_5	50	50	50	50	50	50
T_6	40	60	40	60	40	60
T_7	30	70	30	70	30	70
T_8	20	80	20	80	20	80
T_9	10	90	10	90	10	90
T_{10}	0	100	0	100	0	100
SE ±	0.056	0.055	0.055	0.057	0.056	0.057
CD at 5 %	0.167	0.164	0.164	0.170	0.167	0.170

Method

Procedure for preparation of barnyard millet flour

The barnyard millet grains were cleaned to remove extraneous matter and taken in small bowel and then attached to the electric decorticator to remove brans. The dried debraned barnyard millet grains were grinded in to flour and passed through sieve of 80 mesh to get uniform flour.

Preparation of barnyard millet flour cookies

The cookies were prepared using standard levels of ingredients as per the traditional creaming process.

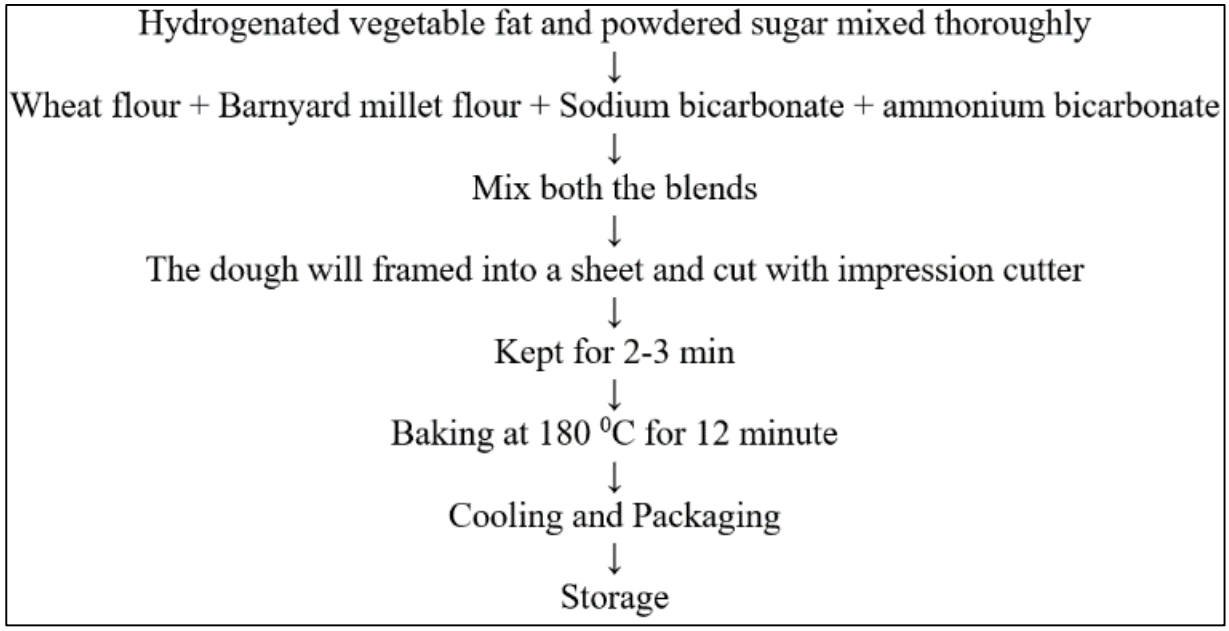

Fig 1: Flow chart for preparation of barnyard millet cookies

Physical characteristics of raw material

The raw materials wheat and barnyard millet grains were analyzed for different physical characteristics like thousand kernel weight, bulk density and colour.

Chemical properties of raw materials and cookies

Chemical constituents like moisture, fat, protein, carbohydrate, crude fiber and minerals like calcium, phosphorous and iron content of raw material and cookies were determined as per the standard procedure.

Physico-chemical analysis of raw material and cookies

The method described in A.O.A.C. (2000) for determining moisture was used. The protein content of cookies was estimated by determining total nitrogen content using standard Micro-Kjeldhal method and fat content of the cookies estimated by the soxhlet method A.A.C.C (2000). The crude fiber content in the products was estimated by A.A.A.C. (2000). The carbohydrate content in the selected cookies were obtained by subtracting from 100, the sum of values of moisture, protein and fat content per 100 g of the sample (Raghuramulu, *et al.*, 1993) [20]. Calcium, phosphorous and iron were analyzed using atomic absorption spectrometry (AAS). These methods give a good precision and accuracy (Ojeka and Ayodele 1995) [18].

Packaging and storage of barnyard millet cookies

The selected treatments of barnyard millet cookies were packed in low density polyethylene and stored at ambient (30 ± 4^0C) for 3 months. The samples were drawn at an interval of 1 month and evaluated for chemical and sensory quality.

Sensory evaluation of cookies

Sensory evaluation of barnyard millet cookies was carried on 9 point hedonic scale. The average scores of the ten judges for different quality characteristics *viz.* colour and appearance, flavour, texture, taste and overall acceptability were recorded.

Statistical analysis

All experiments were carried out by using Completely Randomized Design (CRD). The results obtained in the present investigation were analyzed for the statistical significance according to the procedure given by Rangaswamy (2010) [21].

Results and Discussion

Physical characteristics of raw materials

The results obtained for physical characteristics of wheat and barnyard millet grains are presented below:

Table 2: Physical characteristics of raw materials

Parameter	Wheat	Barnyard millet
Colour	Pale yellow	Dull whitish
1000 Grain Weight (g)	222	9
Bulk density (g/ml)	0.78	0.85
True density (g/ml)	1.41	2.89
Porosity (%)	31.58	70.59
Angle of repose	27^0	25^0

The variations in density of barnyard millet may be due to random harvesting of barnyard millet at different maturity stages. This factor is important because it determines the capacity of storage, packaging and transport systems (James, 2005) [4, 13]. The per cent porosity of sample was found to be moderate (i.e. 70.59%) and was in the same order as reported for quinoa (Vilche *et al*., 2003) [34] and coriander (Coskuner and Karababa, 2007) [10]. Porosity depends on size, shape and boldness of seeds. It must be noted that porosity of the mass of seeds determines the resistance to air flow during aeration and drying procedures. Angle of repose represents the smoothness of seed surface and has marked effect on transportation of seeds. During present investigation, 25^0 were observed value for angle of repose of barnyard millet. Angle of repose is also an indicator of free flowing nature of seeds and is important for designing of processing equipments (Barbosa, *et al.,* 2006) [7]. With respect to various physical properties, the similar results have been reported by Vanesa, *et al.,* (2008) [32].

Chemical characters of raw materials

The results obtained for chemical characteristics of maida, wheat flour and barnyard millet flour are presented here:

Table 3: Chemical characters of raw materials

Chemical constituent	Maida	Wheat flour	Barnyard millet flour
Moisture (%)	13.3	12.2	11.9
Protein (%)	11	12.1	6.2
Crude fiber (%)	0.9	1.7	2.2
Fat (%)	0.3	1.9	9.8
Carbohydrates (%)	73.9	69.4	65.5
Calcium (mg/100g)	23	48	20.0
phosphorous (mg/100g)	121	355	280
Iron (mg/100g)	2.7	4.9	5.0

*****Each value is the average of three determinations

Chemical characters of various raw materials are comparable with findings reported by other scientist Tosco, (2004) [30]. These values are also comparable with Gopalan, *et al.,* (2006) [11]. Chemical composition especially mineral contents of wheat revealed that wheat is rich source of minerals. Similar conclusions have been drawn by Bushway, *et al.,* (1981) [8], Mayela, *et al.,* (2007) [15] and Salazar, *et al.,* (2011) [24].

Sensory evaluations of fresh barnyard millet cookies

The organoleptic evaluation of cookies prepared by different combination of barnyard millet flour, maida and wheat flour were carried out. Barnyard millet cookies were prepared and presented to panel of ten judge for assessing the quality and acceptability of product. Organoleptic evaluation of cookies was carried out using a 9 point hedonic scale of sensory characteristics such as colour, flavour texture, taste and overall acceptability. The score obtained for sensory evaluation for maida, wheat and barnyard millet flour cookies are shown in Table 4, 5 and 6. Maida and wheat flour cookies (50 maida: 50 wheat flour), maida and barnyard millet cookies (30 maida: 70 barnyard millet flour) and wheat and barnyard millet flour cookies (20 maida: 80 barnyard millet flour) were found the best for preparation of maida, wheat barnyard millet cookies of good quality and stored at ambient temperature (30 ± 4 °C) for 3 month.

Organoleptic quality parameters of a product assume pivotal role in anticipating the consumer response to the product (Rey 2006) [23]. Colour and appearance uniformity are vital components of visual quality of fresh as well as processed foods and play a major role in consumer choice (Alistair 2005) [4]. Flavour being a combination of taste, smell and mouth feel, has multifaceted impact on sensory quality of a product (Amerine, *et al.,* 1980) [5].

Overall acceptability of product is a function of various factors including colour and appearance, flavour, texture and taste. Amongst all samples containing maida 30 per cent and barnyard millet 70 per cent combination was found to be more acceptable. Statistical analysis showed that sample MBF_{70} is best sample in all sensory attributes. Singh *et al.,* (2000) [28] reported overall acceptability of product like cookies is a function of various factors including colour and appearance, flavour, texture and taste in the soy fortified biscuits storage. Gupta and Singh (2005) [12] reported overall acceptability of biscuits containing colour and appearance, flavour, texture and taste which gives overall acceptance by considering above all attributes.

Selection of Best Combination for Preparation of Barnyard Millet Fortified Cookies.

On the basis of organoleptic properties (colour and appearance, flavour, texture, taste and overall acceptability) the best combination from wheat and maida was 50:50, from maida and barnyard millet flour was 30:70 and from wheat and barnyard millet flour was 20:80. For the storage study these three combinations with control (100% maida) were selected and the cookies prepared from them used for further storage study. During storage study their nutritional composition, organoleptic properties and microbial quality were analysed using standard procedures.

Table 4: Sensory evaluation of fresh maida and wheat flour cookies*

Sample code	Sensory attributes*					
	Colour and appearance	Flavour	Texture	Taste	Overall acceptability	Rank
MWF_0	8.3	8.0	7.8	7.1	7.80	6
MWF_{10}	8.0	7.5	7.6	8.1	7.81	5
MWF_{20}	7.6	7.6	7.3	8.0	7.82	4
MWF_{30}	8.0	7.6	8.0	8.3	7.90	3
MWF_{40}	8.0	7.8	8.0	8.3	8.02	2
MWF_{50}	8.8	9.0	8.5	9.0	8.82	1
MWF_{60}	6.8	6.5	7.3	7.3	6.90	7
MWF_{70}	6.5	6.5	7.0	7.3	6.80	8
MWF_{80}	6.5	6.3	7.0	7.3	6.77	9
MWF_{90}	6.3	6.3	7.0	7.3	6.72	10
MWF_{100}	6.5	6.5	6.5	6.5	6.50	11
Mean	7.39	7.45	7.24	7.68	7.42	-
S.E.±	0.057	0.057	0.055	0.055	0.039	-
C.D at 5%	0.169	0.169	0.161	0.161	0.114	-

*Maximum score out of 9. All results are mean value of ten determinations.

where as,

MWF_0 = (100 maida: 0 wheat flour), MWF_{10} = (90 maida: 10 wheat flour),
MWF_{20} = (80 maida: 20 wheat flour), MWF_{30} = (70 maida: 30 wheat flour),
MWF_{40} = (60 maida: 40 wheat flour), MWF_{50} = (50 maida: 50 wheat flour),
MWF_{60} = (40 maida: 60 wheat flour), MWF_{70} = (30 maida: 70 wheat flour),
MWF_{80} = (20 maida: 80 wheat flour), MWF_{90} = (10 maida: 90 wheat flour),
MWF_{100} = (0 maida: 100 wheat flour).

Table 5: Sensory evaluation of fresh maida and barnyard millet cookies*

Sample code	Sensory attributes*					
	Colour and appearance	Flavour	Texture	Taste	Overall acceptability	Rank
MBF_0	8.0	8.0	8.0	8.0	8.00	11
MBF_{10}	8.3	8.2	8.2	8.6	8.32	10
MBF_{20}	8.3	8.2	8.3	8.6	8.35	9
MBF_{30}	8.5	8.3	8.2	8.6	8.40	8
MBF_{40}	8.2	8.6	8.5	8.6	8.47	7
MBF_{50}	8.2	8.6	8.6	8.6	8.50	6
MBF_{60}	8.8	8.8	8.8	8.8	8.80	2
MBF_{70}	9.0	9.0	9.0	9.0	9.00	1
MBF_{80}	8.8	8.6	8.8	8.6	8.70	3
MBF_{90}	8.6	8.6	8.6	8.6	8.60	4
MBF_{100}	8.5	8.5	8.6	8.6	8.50	5
Mean	8.47	8.51	8.49	8.60	8.51	-
S.E.±	0.052	0.052	0.052	0.052	0.073	-
C.D at 5%	0.153	0.153	0.153	0.153	0.216	-

*Maximum score out of 9. All results are mean value of ten determinations.
where as,
MBF_0 = (100 maida: 0 barnyard millet flour), MBF_{10} = (90 maida: 10 barnyard millet flour),
MBF_{20} = (80 maida: 20 barnyard millet flour), MBF_{30} = (70 maida: 30 barnyard millet flour),
MBF_{40} = (60 maida: 40 barnyard millet flour), MBF_{50} = (50 maida: 50 barnyard millet flour),
MBF_{60} = (40 maida: 60 barnyard millet flour), MBF_{70} = (30 maida: 70 barnyard millet flour),
MBF_{80} = (20 maida: 80 barnyard millet flour), MBF_{90} = (10 maida: 90 barnyard millet flour),
MBF_{100} = (0 maida: 100 barnyard millet flour).

Table 6: Sensory evaluation of fresh wheat and barnyard millet cookies*

Sample code	Sensory attributes*					
	Colour and appearance	Flavour	Texture	Taste	Overall acceptability	Rank
WBF_0	6.5	6.5	6.5	6.5	6.50	11
WBF_{10}	6.7	6.7	6.5	6.5	6.60	10
WBF_{20}	7.0	6.5	6.5	6.5	6.67	9
WBF_{30}	7.0	6.7	6.7	6.8	6.82	8
WBF_{40}	7.0	6.7	6.8	6.8	6.87	7
WBF_{50}	7.1	7.0	7.0	7.0	7.02	6
WBF_{60}	7.2	7.2	7.2	7.2	7.20	5
WBF_{70}	8.1	8.3	8.1	8.3	8.20	4
WBF_{80}	9.0	9.0	9.0	9.0	9.00	1
WBF_{90}	9.0	8.8	8.8	9.0	8.90	2
WBF_{100}	8.8	8.7	8.7	8.8	8.70	3
Mean	7.58	7.48	7.46	7.49	7.50	-
S.E.±	0.052	0.055	0.055	0.052	0.042	-
C.D at 5%	0.153	0.162	0.162	0.153	0.125	-

*Maximum score out of 9. All results are mean value of ten determinations.
where as,
WBF_0 = (100 wheat: 0 barnyard millet flour), WBF_{10} = (90 wheat: 10 barnyard millet flour),
WBF_{20} = (80 wheat: 20 barnyard millet flour), WBF_{30} = (70 wheat: 30 barnyard millet flour),
WBF_{40} = (60 wheat: 40 barnyard millet flour), WBF_{50} = (50 wheat: 50 barnyard millet flour),
WBF_{60} = (40 wheat: 60 barnyard millet flour), WBF_{70} = (30 wheat: 70 barnyard millet flour),
WBF_{80} = (20 wheat: 80 barnyard millet flour), WBF_{90} = (10 wheat: 90 barnyard millet flour),
WBF_{100} = (0 wheat: 100 barnyard millet flour).

Nutritional value changes in barnyard millet cookies during storage

The average values of fresh cookies for control (100% maida) was moisture 4.10 per cent, protein 11 per cent, fat 25.90 per cent, crude fiber 0.30 per cent, carbohydrate content 73.90 per cent, calcium 23.00 mg/100g, phosphorous 121.00 mg/100g and iron content was 6.32 mg/100g. For MWF_{50} (50% maida and 50% wheat flour) was moisture 4.00 per cent, protein 11.55 per cent, fat 26.90 per cent, crude fiber 1.10 per cent, carbohydrate content 71.65 per cent, calcium 35.50 mg/100g, phosphorous 238.00 mg/100g and iron content was 3.80 mg/100g. For MBF_{70} (30% maida and 70% barnyard millet flour) was moisture 3.10 per cent, protein 7.64 per cent, fat 26.81 per cent, crude fiber 6.95 per cent, carbohydrate content 68.02 per cent, calcium 20.90 mg/100g, phosphorous 232.30 mg/100g and iron content was 4.31 mg/100g. For WBF_{80} (20% wheat and 80% barnyard millet flour) was moisture 3.00 per cent, protein 7.38 per cent, fat 27.10 per cent, crude fiber 8.22 per cent, carbohydrate content 66.28 per cent, calcium 30.60 mg/100g, phosphorous 295.00 mg/100g and iron content was 4.98 mg/100g. The average values of 90 days cookies for control (100% maida) was moisture 4.12 per cent, protein 11.39 per cent, fat 26.77 per cent, crude fiber 0.20 per cent, carbohydrate content 73.80 per cent, calcium 22.90 mg/100g, phosphorous 120.80 mg/100g and iron content was 2.60 mg/100g. For MWF_{50} (50% maida and 50% wheat flour) was moisture 4.12 per cent, protein 11.39 per cent, fat 26.16 per cent, crude fiber 0.97 per cent, carbohydrate content 71.55 per cent, calcium 35.41 mg/100g, phosphorous 237.84 mg/100g and iron content was 3.71 mg/100g. For MBF_{70} (30% maida and 70% barnyard millet flour) was moisture 3.19 per cent, protein 7.48 per cent, fat

26.58 per cent, crude fiber 6.82 per cent, carbohydrate content 67.89 per cent, calcium 20.80 mg/100g, phosphorous 232.16 mg/100g and iron content was 4.22 mg/100g. For WBF_{80} (20% wheat and 80% barnyard millet flour) was moisture 3.10 per cent, protein 7.24 per cent, fat 26.96 per cent, crude fiber 8.09 per cent, carbohydrate content 65.97 per cent, calcium 30.51 mg/100g, phosphorous 294.86 mg/100g and iron content was 4.88 mg/100g (Table 7). Protein, fat, crude fiber, carbohydrate, calcium, phosphorous and iron decreased in ambient temperature during storage period of 3 month. The decrease in moisture, protein, fat, carbohydrate, crude fiber, phosphorous, calcium and iron was more rapid in the samples stored in low density polyethylene (LDPE) during the storage period.

Table 7: Nutritional changes in barnyard millet cookies during storage at ambient temperature

Parameters	**Initial (0 days)**				**Final (90 days)**			
Chemical constituent	Control	MWF_{50}	MBF_{70}	WBF_{80}	Control	MWF_{50}	MBF_{70}	WBF_{80}
Moisture (%)	4.10	4.00	3.10	3.00	4.22	4.12	3.19	3.10
Protein (%)	11	11.55	7.64	7.38	10.85	11.39	7.48	7.24
Fat (%)	25.90	26.90	26.81	27.10	26.77	26.16	26.58	26.96
Crude fiber (%)	0.30	1.10	6.95	8.22	0.20	0.97	6.82	8.09
Carbohydrate (%)	73.90	71.65	68.02	66.28	73.80	71.55	67.89	65.97
Calcium (mg/100g)	23.00	35.50	20.90	30.60	22.90	35.41	20.80	30.51
Phosphorous (mg/100g)	121.00	238.00	232.30	295.00	120.86	237.84	232.16	294.86
Iron (mg/100g)	2.70	3.80	4.31	4.98	2.60	3.71	4.22	4.88
Overall acceptability (Score out of 9)	7.35	7.50	8.45	8.63	7.10	7.15	8.00	8.15

*Each value represents the average of three determinations.

Where, Control= 100% maida, MWF_{50}= 50% maida and 50% wheat, MBF_{70}= 30% maida and 70% barnyard millet and WBF_{80}= 20% wheat and 80% barnyard millet.

Mirsaeedghazi, *et al*., (2008) reported that increase of protein in dough causes greater consistency of dough. The interaction including physical and chemical forces among protein molecules play key role on the rheological properties (Shiau and Yeh, 2001) [27]. The increase in protein content is acceptable for better rheological characteristics.

In cookies production, addition of fat imparts tenderness making it more palatable; assist in texture improvements. External added fat during preparation of cookies have plasticizing effects reported by Mulvancey and Cohen (1997) [17].

Sharoon, *et al*., (2014) [27] reported considerable increment the moisture content in all cookies with increasing storage duration. This increase was primarily due to packaging material (polythene bags). Sujitha and Thirumani (2014) [29] also reported increase in moisture content from 3.6-5.6% of flaxseed cookies during the storage period of 60 days. This increase was primarily due to packaging material (polythene bags). The packaging was not airtight and lack of temperature control resulted in an increase in moisture contents of cookies. Moreover, cookies absorbed moisture from surrounding atmosphere due to hygroscopic behavior of wheat flour. An increase in moisture contents of cookie samples during storage has also been reported by Leelavathi and Rao (1993) [14], Rao, *et al*., (1995) [22] Pasha, *et al*., (2002) [19], Butt, *et al*., (2004) [9] and Shariff, *et al*., (2005) [25] either due to atmosphere or packaging materials.

Conclusion

These results indicates that MWF_{50} cookies (50 per cent maida and 50 per cent wheat flour), MBF_{70} cookies (30 per cent maida and 70 per cent barnyard millet flour) and WBF_{80} cookies (20 per cent wheat and 80 per cent barnyard millet flour) with constant levels of other ingredients stored at ambient temperature had better acceptability till 90th day. It is evident from all the physicochemical properties that MWF_{50} cookies (50 per cent maida and 50 per cent wheat flour), MBF_{70} cookies (30 per cent maida and 70 per cent barnyard millet flour) and WBF_{80} cookies (20 per cent wheat and 80 per cent barnyard millet flour) are the best for preparation of barnyard millet cookies of good quality.

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