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Evaluation of physical, nutritional and sensory characteristics of cookies developed with bio-fortified pearl millet

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This study examines the effect of pearl millet varieties bio-fortified *AHB* 1200 Fe and *MRB* (Aurangabad Hybrid *Bajra* and Maharashtra *Rabi Bajra*, respectively) as a replacement of whole wheat flour at various levels on quality of cookies. For improving nutritional composition germination treatment was given to both varieties. Before making cookies germination effect was analyses on two varieties of pear millet for proximate, mineral and on anti-nutritional. This raw material analysis revealed that protein was increased and ash, fat, fibre is decreased but availability of minerals was increased due to decreasing level of anti-nutritional upto 40-45 per cent. Enriched cookies were produced by the ratio of whole wheat to pearl millet was 100:00, 80:20, 70:30, 60:40 and 50:50. Cookies were prepared by four types of pearl millet flour (Two varieties and one treatment with wheat flour using these five ratios. From each type of flour one sample was selected on the basis of sensory analysis. And these selected four types of cookies were evaluated for chemically and physical characteristics. Physical characteristics of cookies shows that the diameter and spread ratio is increased slightly as compare to control but did not very markedly. Germination is lightly affected on physical properties but varieties were not markedly affecting. The overall results indicated that the positive response of pearl millet flour substitution to whole wheat flour upto 30 and 40 per cent in preparation of cookies germinated and without germinated, respectively.

Key Words : Anti-nutritional, Cookies, Germination, Mineral, Pearl millet

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INTRODUCTION

Cookies are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven (Anozia *et al.,* 2014). "Cookie", originates from a dutch word koekje, which means "little cake", the sound of cracker being eaten most likely lead to the use of that name (Zydenbos *et al.,* 2004). The major ingredients used in cookies are flour, fat, sugar, salt and water. These are mixed together with other minor ingredients (baking powder, skimmed milk, emulsifier and sodium meta-bisulphite) to form dough containing a gluten network (Akinwande *et al.,* 2008). Among ready to eat snacks, biscuits/cookies posses several attractive features, including a wider consumption base, relatively long shelf-life, greater convenience and good eating quality (Hooda and Jood, 2005).

Also due to poverty and low income status, most

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communities in developing countries largely consume cereal and inadequate nutritional foods leads to this malnutrition and/or deficiency. Inadequate consumption of macronutrients like carbohydrate, protein and fat leads to under nutrition with a consequent feeling of hunger. Unlike macronutrients mentioned above micronutrients required in trace amount but they play vital role in various physiological functions and their deficiencies do not leads to hunger effects. Thus, these micronutrients deficiencies are also called hidden hunger. Iron and zinc are two of the most critical micronutrients deficient in developing countries, particularly in rural area or in the low- and middle-income countries (UNICEF, 2015). Micronutrient deficiencies commonly affect about two billion people mostly in developing countries (FAO, 1995). At this condition especially during the situations of climate changes, water scarcity, increasing world population and rising food prices scientist and nutritionist have challenge to produce, processing and utilizing other potential food sources to fight against these malnutrition and deficiency diseases.

Pearl millet (*Pennisetum glaucum*) is most widely grown type of millet and account for approximately 50 per cent of the world millet production (Charyulu *et al.*, 2016). Pearl millet is significantly rich in resistant starch, soluble and insoluble dietary fibres, minerals, proteins and antioxidants. It contains many essential minerals like magnesium, phosphorus, iron, zinc etc. It contains essential amino acids and vitamins also which contribute to its therapeutic properties (Dayakar *et al.*, 2017). Apart from these nutritional benefits of pearl millet its ability of tolerance to difficult growing conditions such as drought, low soil fertility and high temperature; it can be grown in areas where other cereal crops, such as maize, wheat would not survive (Devi *et al.*, 2011). When considering all these benefits of pearl millet make it good source of functional food with minimum cost. Aim of these study to promote the utilization of pearl millet by improving bioaccessibility.

METHODOLOGY

Material:

Two variety of pearl millet namely AHB 1200 Fe and MRB were procured from National Agricultural Research Project, Aurangabad. Wheat and other minor ingredients like fat, Sugar, Baking powder, Ammonium bicarbonate, Salt, Vanilla flavour etc. were purchased from local market of Aurangabad.

Chemicals, processing and analytical equipments:

The different chemical, equipment and instruments required for this study were made available from the Department of Agricultural Engineering, Soil, Food Science and Technology and other Department of Maharashtra Institute of Technology, Aurangabad.

Methods:

Physical parameters of grains:

Thousand kernel weight, density, bulk density, porosity and angle of repose were determined using standard method described by AOAC (2005).

Milling of grains:

For preparation of untreated pearl millet flour and wheat flour after cleaning of grains they were subjected to milling in laboratory grinding mill. For preparation of treated/germinated pearl millet flour, cleaned grains were subjected to germination for three days and drying was carried out in hot air oven at 50^0C. Whole pearl millet and wheat flour was used for preparation of cookies.

Composite flour:

Whole wheat flour was replaced with 0, 20, 30, 40 and 50 per cent by whole pearl millet flour. This proportion repeated with germinated and without germinated flour of both variety of pearl millet. In this way four types of cookies were prepared by using two varieties.

Preparation of cookies:

For preparation of cookies AOAC (2005) was followed using given ingredients. Blended flour 1000g, fat 650g, sugar 550g, sodium bicarbonate 7g, ammonium bicarbonate 10g, vanilla flavour 5 ml, water upto 100 ml as per required.

Determination of proximate composition and mineral content:

Both raw material (pearl millet and wheat) and prepared cookies were analyzed using following method. Moisture, ash, crude fibre, crude protein and fat content analyzed by using standard procedure of A.O.A.C. (2005). Mineral analysis was carried out for iron and zinc was determined by di-acid digestion and analysis on ICP-OES (Tandan, 2017). Calcium is determined by EDTA

titration method (Tandan, 2017).

Determination of anti- nutritional factor:

Phytic acid was determined by the method of Haug and Lantzsch (1983) and polyphenol by method of Singh and Jambunathan (1981).

Evaluation of cookies for physical characteristics:

Physical parameters of cookies *i.e.* weight, diameter, thickness were measured with vernier calipers and spread ratio was calculated by the method described by (Ayo *et al.,* 2007).

Sensory evaluation of cookies:

Sensory evaluation of cookies carried out by a panel of ten semi trained panel members on a 9- point hedonic scale for different parameters such as color, aroma, taste, texture and over all acceptability as described in Ranganna (2000).

Statistical analysis:

The data was analyzed by using the method described by Kaushik *et al*. (2014). Means (n=3), standard error (SE), Critical difference (CD) were calculated using Microsoft Excel 2007. Data was subjected to a single way analysis of variance (ANOVA).

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Studies on physical properties of pearl millet and wheat:

Physical properties of grains were determined prior to milling and data is presented following (Table 1), such as thousand kernel weight, bulk density, true density, porosity, angle of repose etc.

Studies on functional properties of pearl millet varieties and wheat flour:

Data in Table 2 shows the functional properties of raw and germinated two varieties of pearl millet and wheat flour. From this result we can say that water and oil absorption capacity of germinated millet flour is increased than raw flour. Bulk density was also increased slightly after germination.

Proximate composition of raw:

Proximate composition of raw flour (untreated and germinated two varieties of pearl millet) used in preparation of cookies were analyzed which is given below (Table 3). From these result we can revealed that the influence of germination on the chemical composition of pearl millet due to the various enzymes involving them.

Table 3 shows the moisture content was increased germinated flour may be due to remaining some moisture in grain after germination but below the moisture limit

Table 1: Physical properties of pearl millet varieties and wheat

Sr. No.	Physical properties	MRB 204	AHB 1200 Fe	Wheat
1.	Thousand Kernel weight	9.16	9.20	40.5
2.	Bulk Density (g/cm^3)	0.769	0.757	0.864
3.	True Density (g/cm^3)	1.470	1.538	1.568
4.	Porosity (%)	48.51	50.0	44.9
5.	Angle of repose	25^0 64′	26^0 74′	24^0 44′

Table 2: Functional properties of pearl millet and wheat flour

Samples	WAC (%)	OAC (%)	Bulk density (g/cm^3)
MRB (RF)	237	140	0.641
AHB (RF)	234	130	0.625
MRB (GF)	265	160	0.625
AHB (GF)	261	170	0.609
WWF	248	130	0.762

where, RF- Raw flour, GF- Germinated flour, WAC- Water absorption capacity, OAC- Oil absorption capacity, WWF- Whole wheat flour

(13%) for pearl millet recommended by FAO (1995). The protein content in both varieties ranged from 11.54 per cent (*MRB*) to 12.01 per cent (*AHB*). These values of protein were in close agreement with Fasasi *et al.* (2004). Germination leads to increase in protein may be due to protein synthesis (Fasasi *et al.*, 2004), which is ranged between 12.01 per cent (*AHB*) to 13.45 per cent (*MRB*). Ash and fibre content reduced after germination, reduction in ash content may be due to the leaching of total soluble solids or soluble inorganic salts during soaking prier to germination (Wang *et al.*, 1997). The fat content of germinated millet flour was reduced it is beneficial for increasing shelf-life. Data in Table 3 also revealed the carbohydrate content of raw millet flour was higher than the germinated flour, loss in carbohydrate due to increased activity of the α-amylase. The α-amylase breaks down complex carbohydrate to simpler and more absorbable sugars which are utilized by the growing seedlings during early stage of germination (Lasekan, 1996).

Proximate composition of whole wheat flour used in preparation of cookies were analyzed which is also given in below (Table 3).

Mineral composition of raw:

Besides providing protein, pearl millets are also considered as a good source of minerals. In order to enhance the nutritive value of cookies, pearl millet is incorporated with whole wheat flour. The mineral analysis of the raw material is presented in following Table 4.

From this Table 4 result we can say that mineral content of AHB varieties of pearl millet is higher than MRB varieties of pearl millet and wheat. Data also revealed that loss in mineral content after germination but availability is increased due to reduction in anti-nutritional factor.

Effect of germination on anti-nutritional content in pearl millet:

The utilization of pearl millets is limited due to the presence of various anti-nutrients. Pearl millet is often rich in fibre - associated anti-nutrients namely polyphenol, phytic acid, oxalate and tannins which have a negative influence on the bioavailability of minerals, also causing poor digestibility of proteins and carbohydrates (Taylor 2004). Malting is one of the effective and common house hold method for reduction of these anti-nutritional factor

Table 3: Proximate composition of pearl millet varieties and wheat

Constituent (%)	Pearl millet *MRB*- 204		Pearl millet *AHB*- 1200		Wheat
	RF	GF	RF	GF	
Moisture	7.03	8.72	7.25	8.6	7.70
Ash	2.2	1.06	2.5	1.80	1.2
Protein	11.54	13.45	12.01	14.05	11.60
Fat	4.86	3.69	5.11	4.82	1.62
Fibre	1.10	0.91	1.03	0.96	1.73
Carbohydrate	73.27	72.17	72.10	69.77	76.15

Table 4: Mineral content in raw material

Constituent (mg/100g)	PM MRB		PM AHB		Wheat
	RF	GF	RF	GF	
Iron	7.0	6.90	8.2	7.80	3.1
Zinc	3.0	2.80	3.96	3.72	2.92
Calcium	41	28	42	31	20

Table 5 : Anti- nutritional content in pearl millet

Samples	Antinutrients (mg/100g)			
	MRB		AHB 1200	
	PP	PA	PP	PA
Control	520	815	437	563
Germinated (72h)	437	470	251	317

*Each value is the mean of three determinations where, PP = Polyphenol, PA=Phytic acid

and improve their nutritional quality, mainly due to hydrolysis of anti-nutrients and protease inhibitors (Afify *et al.*, 2011). During germination an anti-nutrient hydrolyzing enzyme activity has been observed which helps to reduction of this anti-nutrient (Sandberg and Andlid, 2002). The decrease in the level of phytic acid during soaking may be attributed to leaching out into soaking water under the concentration gradient (Abdallah *et al.,* 1984). Other researchers have reported a decrease in the level of phytic acid during germination (Borade *et al*., 1984) due to phytase activity in the germinating grains (Rao and Deosthale, 1982).

Table 5 shows the effect of germination on anti-nutritional factors comparing to raw flour sample. From these result revealed that 40-45 per cent polyphenol and phytic acid reduced after 3 days germination.

Preparation of cookies:

The process evolve composite flour with varying inclusion of 0, 20, 30, 40 and 50 of the raw and germinated pearl millet flour of two varieties mixing with other dry ingredients *i.e*. sodium bicarbonate, ammonium bicarbonate and salt was labelled as T_0, T_1, T_2, T_3, and T_4, respectively. Other side butter and sugar were mixed to form a cream. Flavour is added in cream and mixes well, and then add mixture of dry ingredients, mix thoroughly to form dough. The dough was kneaded and sheeted to a uniform thickness of 0.52 cm and cut into circular shapes

Table 6 : Sensory evaluation of cookies by different formulation of

Sample code	Appearance	Colour	Taste	Texture	Flavour	Overall acceptability
T_0	8.2	8.5	8.0	8.5	8.60	8.5
T_1	7.7	7.9	8.2	8.2	8.1	8.1
T_2	7.5	7.9	8.0	8.2	8.2	8.3
T_3	7.8	7.5	8.4	8.2	8.2	8.2
T_4	7.7	7.5	8.4	8.3	8.5	8.3

*Each value is the mean of six determinations, where, T_0- Whole wheat flour (100%), T_1 – Whole wheat flour and MRB raw flour (60:40), T_2–WWF whole wheat flour and AHB raw flour (60:40), T_3– Whole wheat flour and MRB germinated flour (70:30) and T_4 – Whole wheat flour and AHB germinated flour (70:30).

Table 7: Nutritional composition of selected cookies sample

Sample code	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
T_0	1.45	1.03	8.5	22.24	1.03	66.75
T_1	1.32	1.10	13.21	23.73	1.63	59.01
T_2	1.26	1.13	13.52	23.85	1.74	58.50
T_3	1.42	1.07	14.70	24.17	1.18	57.46
T_4	1.50	1.09	15.20	24.49	1.13	56.59
S.E.±	0.020	0.047	0.057	0.008	0.032	0.008
C.D. (P=0.05)	0.064	0.149	0.130	0.017	0.073	0.019

*Each value is the mean of three determinations. where, T_0- Whole wheat flour (100%), T_1 – Whole wheat flour and MRB raw flour (60:40), T_2–WWF whole wheat flour and AHB raw flour (60:40), T_3– Whole wheat flour and MRB germinated flour (70:30) and T_4 – Whole wheat flour and AHB germinated flour (70:30)

Table 8: Mineral composition of selected cookies samples

Sample code	Iron	Zinc	Calcium
T_0	2.02	1.17	15.02
T_1	5.96	1.90	32.16
T_2	6.70	2.56	17.05
T_3	5.27	1.76	33.04
T_4	6.50	2.30	21.12

*Each value is the mean of three determinations where, T_0- Whole wheat flour (100%), T_1 – Whole wheat flour and MRB raw flour (60:40), T_2–WWF whole wheat flour and AHB raw flour (60:40), T_3– Whole wheat flour and MRB germinated flour (70:30), T_4 – Whole wheat flour and AHB germinated flour (70:30).

of 5 cm diameter. Baking was carried out at 180^{0}C for 18 min. In this way 4 types of cookies sample were prepared by using two varieties and their raw and germinated flour. Prepared cookies were cooled and pack in polythene bag and stored in airtight container.

Sensory evaluation of cookies :

From these prepared cookies one sample was selected from each four types of cookies sample on the basis of sensory evaluation with control sample. These selected samples sensory were given collectively in fallowing Table 6 and Fig. 1.

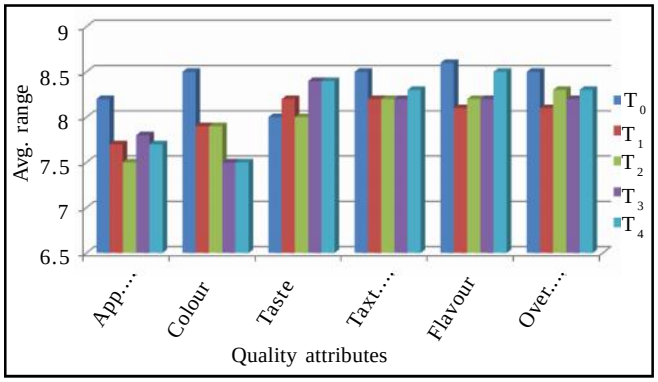

Fig 1: Sensory quality of cookies

Nutritional composition of selected cookies samples:

To study the proximate composition is very important to study the nutritional content of the final product. Nutritional component such as moisture, ash, crude protein, fat, crude fibre and carbohydrate were analyzed for selected cookies sample prepared from different proportion of wheat and two varieties of pearl millet with or without treatment. The result of nutritional analysis of selected cookies are summarized and discussed under following Table 7.

Data in Table 7 and Fig. 2 also revealed that the chemical composition of cookies which is made from germinated two varieties of pearl millet. From this data we can conclude that protein and fibre content in AHB 1200 varieties is good as compare to control sample and MRB varieties of pearl millet.

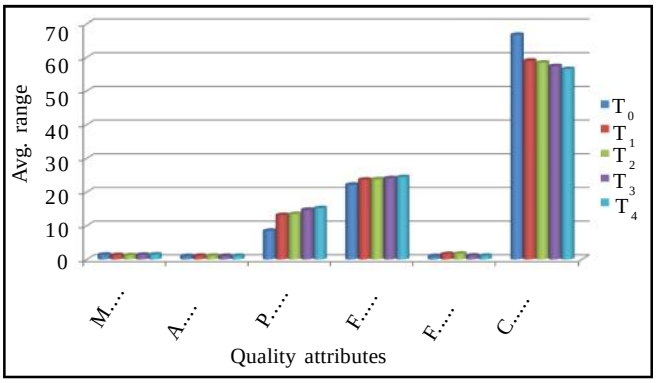

Fig 2: Nutritional composition of cookies

Mineral composition of selected cookies samples:

The pearl millet contains good amount of minerals like iron, zinc and calcium. It is important to know the retention of these minerals in the final product. The mineral composition of different sample is shown in following Table 8.

Physical properties of selected cookies samples:

Results of incorporation of pearl millet flour in whole wheat flour on physical properties of selected samples such as weight, diameter, thickness and spread ratio of cookies is presented in Table 9. Due to changes in textural properties of germinated flour product quality was also

Table 9: Physical parameters of selected cookies samples

Sample code	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio
T_0	14.67	53.33	11.30	4.71
T_1	14.14	54.66	11.33	4.82
T_2	14.12	53.36	11.00	4.85
T_3	14.09	54.66	10.60	5.15
T_4	14.02	55.00	10.60	5.18
S.E.±	0.015	0.007	0.084	0.025
C.D. (P=0.05)	0.034	0.016	0.190	0.056

*Each value is the mean of three determinations where, T_0- Whole wheat flour (100%), T_1 – Whole wheat flour and MRB raw flour (60:40), T_2–WWF whole wheat flour and AHB raw flour (60:40), T_3– Whole wheat flour and MRB germinated flour (70:30), T_4 – Whole wheat flour and AHB germinated flour (70:30).

changed. From these data in Table 9 revealed that spread ratio was increased as incorporation of pearl millet.

Conclusion:

It can be conclude that cookies made from treated pearl millet flour from AHB varieties *i.e.* T_4 having proportion whole wheat flour to germinated pearl millet flour 70:30 found to be higher quality. Germination is effective method for reduction of anti-nutritional factor and increasing nutritional quality profile. Three days germination of pearl millet reduces the anti-nutritional upto 40 to 45 per cent. Variety of AHB 1200 is suitable for preparation of cookies in terms of nutritional and sensory quality profile. Prepared product having good overall acceptability and improves the nutritional value of food product. It helps in reducing mineral deficiencies among all age group of people.

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