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Standardization and formulation of sorghum based cookies and their nutritional composition

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Abstract
The objective of this research was to determine the feasibility of commercialization of sorghum cookies through pilot plant. The dehulled and grounded sorghum flour with different particle distribution in the final flour were used for preparation of cookies made for replacement of wheat flour with sorghum flour.The cookies made with 44.3% dehulled and pulverized sorghum flour yielded best quality cookies in terms of sensory properties. The sensory score was highest i.e. 6.9 when cookies prepared from 44.3% Sorghum flour to replace complete wheat flour for sensory attributes like color, flavor and texture and overall acceptability indicating the acceptability by the panelist member. In case of chemical composition of cookies, cookies prepared by 44.3% percent sorghum flour have high content of crude fiber than commercial cookies. The Shelf studies revealed that cookies can be stored for 6 months without affecting its keeping qualities.

Keywords: sorghum flour; cookies; wheat flour

Introduction
Sorghum [*Sorghum bicolor* (L.)] is an important cereal crop in the developing countries of Africa and Asia (FAO, 2013) [2]. In India, sorghum ranks third in production, after maize. It is grown predominantly by subsistence farmers for household food security Taylor 2003) [21]. Sorghum and millets are the most resilient cereal grain crops and require little input during growth, but, as *with* other crops, yield better with good husbandry (ICRISAT/FAO, 1996) [3]. With increasing world population and decreasing water supplies, they represent important crops for future human use. In India sorghum and millets are vital food crops for millions of people in the country with the annual production of 6.0 million tones and 11.5 million tons respectively (Annual report 2016-17, Ministry of Agriculture, Cooperation and Farmer Welfare, GOI). They are an underutilized resource in most developed countries, with sorghum being primarily used as animal feed and millet little cultivated (ICRISAT/FAO, 1996) [3].
Sorghum is usually prepared in different ways as food for human consumption. Most commonly it is ground or cracked, prepared into dough and baked as flat-unleavened bread. Also, sorghum is frequently cooked like rice or is mixed with other dried cereals and legumes. On the other hand, Sorghum is used in starch production, bread and biscuits and glucose production (ICRISAT, 1991) [4]. Sorghum and millet have considerable further potential to be used as a human food and beverage source. In developing countries the commercial processing of these locally grown grains into value-added food and beverage products is an important driver for economic development (Taylor, 2004) [22]. The use of sorghum and millets not only provides farmers with a market for their products but also saves foreign exchange, which would otherwise be required to import cereals.

Materials and Methods
Materials
Sorghum flour, Maida flour, Sugar, Butter, Custard powder and Baking powder were procured from the local market of patancheru, Secunderabad.

Blending of flours
For the preparation of the cookies, raw materials prepared in laboratory were stored in glass/plastic containers at room temperature (25°C), or under refrigeration (4°C) depending on the storage requirements of the material. The formulations for the cookies are presented in Table 8. Preliminary trials were made to optimize maximum level of sorghum flour in the final formulations. The following blended formulations were made and analysed for the sensory analysis.

Table 1: Formulation of cookies

Ingredients	Percent (%)			
	Control	Sample A	Sample B	Sample C
Sorghum flour	-	50	44.3	55
Maida flour	44	-	-	-
Sugar	23	18.2	22.1	15
Butter	23	19	22.1	16
Custard powder	3.1	2.3	2.3	2.3
Baking powder	0.9	0.9	0.9	0.9
Water	9	9.6	8.3	10.8

Preparation of sorghum cookies

The ingredients were mixed completely in a planetary mixer and the dough was laminated in the same machine at a 0.4 cm height. The dough was cut in circles of 5 cm of diameter and placed on an aluminum mold. The cookies were baked in a household oven, at an approximate temperature of 180°C for 25 min. Once baked, the cookies were allowed to cool for 30 min. Process from blending of flours to baking is described in flow chart in Figure 2 below. The cookies were analyzed for their physic-chemical, shelf life and sensory attributes.

Proximate analysis of cookies

The proximate composition like moisture, protein, crude fat, crude fiber, total Ash, acid value, peroxide value and alcoholic acidity of the sorghum cookies samples were determined based on the available standard procedures (AOAC 2000) [1].

Microbial analysis

The microbial analysis like bacterial limit test, fungal limit test, determination of Yeast and determination of Coliforms of the sorghum cookies samples were determined based on the available standard procedures (AOAC 2000) [1].

Sensory analysis

The sensory assessments were conducted in a Nutri Plus laboratory. The panel of 25 members consisted of staff of ICRISAT. The panelists were naive to project objectives. The samples with different levels of sorghum in the final cookies were coded with three digit-numbers and served with the order of presentation counter-balanced. Panelists were provided with a glass of water and, instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the products for acceptability based on its appearance, flavour, texture, taste, color and overall acceptability using nine-point hedonic scale (1 = dislike extremely to 9 = like extremely; Meilgaard *et al*., 1999) [7].

Shelf life studies

Shelf life studies were conducted by keeping the optimized food samples in stability chamber at temperature 38°C, relative humidity 90% and in regular interval samples were analyzed for the Alcoholic acidity, Peroxide value and Acid values.

Results and Discussion

Proximate composition of cookies

The proximate constituents such as moisture, protein, fat, carbohydrate, total ash and crude fibre of wheat flour cookies (control) and sorghum flour cookies were reported in Table 2.

Table 2: Chemical composition of control and sample-B cookies.

Nutrients	Control	Sample-B
Moisture (%) on (db)	3.8	4.6
Protein (%) on (db)	15.18	4.5
Carbohydrates (%) on (db)	59.12	75.2
Fat (%) on (db)	20.19	18.2
Crude Fiber (%) on (db)	0.16	0.8
Total ash (%) on (db)	0.8	1.3

*Each value is average of three determinations

From theTable1, it revealed that the proximate composition of control and sorghum cookies. The Moisture content of control (3.8%) was slightly higher than sample-B (4.6%) respectively. The protein in wheat (control) was highest (15.18%) as followed by sample-B(4.5%) respectively. The carbohydrate content were higher in sample-B (75.2%) and lowest in control (59.12%) respectively.

The fat content was highest in sample-B (18.2%) followed by control (20.19%) respectively. The highest crude fibre content (0.16%) was observed in control sample and the lowest (0.8%) was observed in sample-B.

The ash content in the samples was observed highest in sample-B (1.3%) and lowest in control (0.8%) respectively.

Sensory evaluation of cookies prepared from sorghum flour

Sensory evaluation of cookies prepared from wheat flour and sorghum flour were carried out on the basis of 9-point hedonic scale. The mean score of organoleptic characteristics of cookies prepared from wheat flour and sorghum flour were summarized in the Table 3.

Table 3: Sensory evaluation of cookies prepared from sorghum flour.

Sample	Appearance	Colour	Flavor	Texture	Taste	Overall acceptability
Control	7.2	6.5	6.8	7.1	7.4	6.6
A	7.1	6.5	6.6	6.6	6.8	6.7
B	6.7	7	7	7.1	7.5	6.9
C	6.8	6.8	6.4	6.4	6.4	6.7

*Each value is average of three determinations

Appearance

It was found that the mean values of Appearance of control, A, B and C where found as 7.2, 7.1, 6.7 and 6.8 respectively on Hedonic scale. The 'Control' has better mean score value as compared with others.

Color

The data obtained from the sensory evaluation by a panel of 25 members shown the mean values of color of control, A, B and C where found as 6.5, 6.5, 7.0 and 6.8 respectively on the Hedonic scale. The sample 'B' has better mean score value as compared with others.

Flavor

It was found that mean values of control, A, B and C where found as 6.8, 6.6, 7 and 6.3 respectively on Hedonic Scale. It was evident that 'B' sample have better flavor profile followed by control sample.

Texture

It was found that mean values of the texture control, A, B and C sample were found as 7.1, 6.6, 7.1 and 6.3 respectively on the hedonic scale. It was found that control sample and sample 'B' 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, 6.8, 7.5 and 6.36 respectively on the hedonic scale. It was found that sample 'B' 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 6.6, 6.7, 6.9 and 6.7 respectively on the Hedonic scale. However the sample 'B' has better value for over all acceptability as compared to other samples.

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

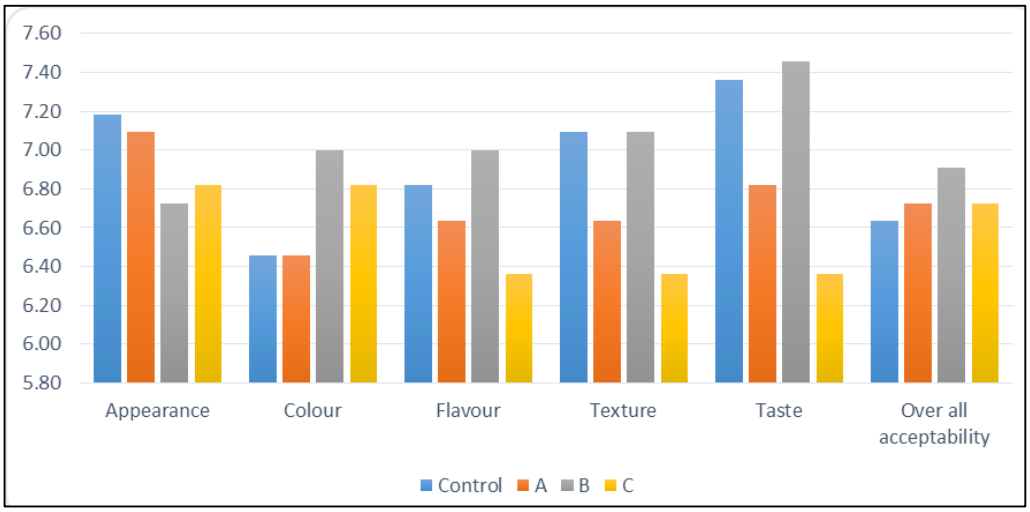

Fig 1: Graphical representation of sensory evaluation of cookies

Table 4: Shelf life stability of sorghum flour cookies

Parameters	0th Day	15th Day	30th day	45th Day
	Sorghum Cookies			
Moisture (%)	1.6	4.5	5.5	6.8
Fat (%)	18.2	18.2	18.2	18.1
Protein (%)	4.8	4.7	4.7	4.7
Ash (%)	1.4	1.4	1.4	1.4
Crude fiber (%)	0.8	0.8	0.8	0.8
Water Activity	0.3	0.4	0.4	0.4
Peroxide value (Meq/kg)	13.7	13.9	13.9	14.0
Acid value	8.1	8.2	8.4	8.5
Alcoholic acidity (%)	0.0	0.1	0.1	0.1

*Each value is average of three determinations

Shelf life stability of sorghum flour cookies

Shelf life studies of cookies prepared from wheat flour and sorghum flour were carried out every 15 days during storage up to 45 days. The results recorded during the present investigation were presented in Table 4.

The sorghum cookies were stored in poly propylene pouches at room temperature and stored for 45 days. There was a slight increase in moisture content of sorghum cookies during storage and it increased from 1.6% to 6.8% at the end of 45 days (Table 4). The increase in moisture content might be due to the hygroscopic nature of biscuits, storage environment (temperature, relative humidity) and the nature of packaging material used. Similar report of increase in moisture content of cereal bran incorporated biscuits at the end of 90 days of storage was reported by Nagi *et al*. (2012). Peroxide value, the indicator of rate of auto oxidation, was increased significantly during storage from 13.7 to 14.0meq O2/kg fat at the end of 45 days. In packed products, the rate of auto-oxidation is mainly governed by the oxygen retention in the pack, which in turn is related to the headspace and oxygen permeability of the packaging material (Khan *et al*. 2008) [5].

The content of FFA in cookies measured by acid value and it was found to be increased with the increase in storage period. There was a slight increase in acid value of sorghum cookies during storage and it increased from 8.1% to 8.5% at the end of 45 days.

Water activity is the measurement of free moisture and is usually expressed as "aw" or percentage Equilibrium Relative Humidity (% ERH) (Worobo and Padilla-Zakour, 1999) [9-13]. Freshly baked sorghum cookies usually have water activity about 0.3 (Wade, 1988) [14-18]. The following table shows the changes in a values of sorghum cookies during storage and it increased from 0.3% to 0.4%. This finding indicates that the aw of biscuits has been within the critical aw limit of 0.43 for biscuits and crackers (Labuza and Contreras-Medellen, 1981) [6]. The water activity (aw) value is lower than 0.70 it prevents microbiological damage, but to prevent deteriorative chemical and biochemical reactions, it is necessary that the dryness be reduced to a water activity value lower than 0.3. (Roudaut *et al*. 1998, 2000) [19, 20]. There is no change in ash and crude fiber of cookies in storage period at the end of 45 days. Table 4 shows the crude fat content of sorghum cookies during the storage. There was a slight decrease in crude fat and protein from 18.2%-18.1% and 4.8%-4.7% of sorghum cookies during storage. The variance analysis of fat content showed that there was no significant difference ($p > 0.05$) in the fat content during storage.

Microbiological analysis of the prepared sorghum cookies

The prepared sorghum cookies was further analyzed for microbial qualities during storage up to 45 days (Plate 1). The sample T_2 was organoleptically selected and subjected to

microbial studies for total plate count, yeast and mold count, coliform count and fungi. The results recorded during the present investigation were presented in Table 5.

Table 5: Microbiological evaluation of the prepared sorghum cookies

Storage period (day)	Microbial quality			
	Total Plate Count	Yeast and mold Count	Coli form count	Fungi
0	ND	ND	ND	ND
15	ND	ND	ND	ND
30	ND	ND	ND	ND
45	1	1	ND	2

*Each value was the mean of three determinations

To study the storage stability of the prepared sorghum cookies, the sample was analyzed through standard plate count technique to detect bacterial contamination. There was no growth when the sample was fresh, as the storage period increased the number of bacterial counts and yeast and mold also increased. The bacterial count, yeast and mold count were found1 cfu/g and the fungi count were 2cfu/g after time period of 45 days. No coliform count were detected in the sample.

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