International Journal of Food Science and Nutrition
ISSN: 2455-4898
Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 3; Issue 2; March 2018; Page No. 120-128

Development of sorghum biscuits incorporated with spices

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Abstract
The present research study was performed to investigate the proximate analysis, microbial analysis, sensory evaluation and shelf life of the developed spiced sorghum biscuits of composite flours prepared by using refined wheat flour (*Triticum aestivum*) and sorghum flour (*Sorghum bicolor*). Five blends were prepared by homogenously mixing sorghum flour and wheat flours in the percentage proportions: 0:100, 30:70, 50:50, 70:30, 60:40 (SF: WF) and later used to make cookies. Proximate analysis, microbial analysis and sensory evaluation of cookies made from the above combinations were determined. The results of the proximate composition showed that the S4 is the acceptable product for the consumption respectively. The developed spiced sorghum biscuits were packed in metallised polyester pouches and the shelf life of the developed pouches was observed to be 60 days. Sensory evaluation of the packed product was conducted at an interval of 15 days respectively. Statistical results revealed that the addition of sorghum, wheat flour and a combination of these whole flours have highly significant effect ($p<0.01$) on the sensory characteristics of cookies.

Keywords: composite flours, microbial analysis, proximate composition, cookies, sensory evaluation, shelf life

1. Introduction

In many countries, biscuits are considered as ready-to-eat, convenient and cheap food product that is likely consumed by every age group people (Hussein *et al*., 2006; Iwegbue, 2012) [10, 11]. Biscuits are rich in fat and carbohydrates; hence they can be referred to as energy giving food as well as good source of protein and minerals (Kure *et al*., 1998) [14]. In general, the ingredients/ raw materials used in the manufacture of biscuits are: wheat flour, margarine (shortening), sweeteners (sugar), leavening agents, eggs, milk, salt and flavours (Hui, 1992; Ghattas *et al*., 2008) [9].

Whole grains serve as a preferred carbohydrate source in a modern Indian diet to achieve a balance of macronutrients, micronutrients, fibers, and phytochemicals for optimal health promotion. The five most common ancient grains that have the potential to be used more in Indian cooking are: amaranth, barley, pearl millet, finger millet, and sorghum. These grains have higher fiber and protein content and can be used to make the commonly eaten food products. Use of these grains may also allow individuals to make healthier dietary changes that align with cultural tradition (Kalra *et al*., 2004) [12].

India is the largest producer of many kinds of coarse cereals/millets which includes pearl millet, sorghum, oat, finger millet, foxtail millet etc. Among these, pearl millet and sorghum are unique millets which are rich in dietry fiber, micronutrients and phytochemicals. Research shows that sorghum and pearl millet grains are nutritionally comparable or even superior to major cereals such as wheat and rice owing to higher levels of protein with more balanced amino acid profile, dietary energy, vitamins, several minerals (especially micronutrients such as iron and zinc), insoluble dietary fiber leading to lower glycemic index. In addition to their nutritive value, several potential health benefits such as preventing cancer and cardiovascular diseases, reducing tumor incidence, lowering blood pressure, risk of heart disease, cholesterol and rate of fat absorption, delaying gastric emptying, and supplying gastrointestinal bulk have been reported for millet (Truswell, 2002; Gupta *et al*., 2012) [28]. Technologies for various processing treatments, such as milling, malting, blanching, acid treatment, dry heating, and fermentation, which reduce antinutritional factors and increase the digestibility and shelf life of various alternative food products such as unleavened flat bread (roti/chapati), porridges, noodles, bakery products, and extruded and weaning food products, have been developed and tested at the laboratory scale. Therefore, with value-added strategies and appropriate processing technologies, the millet grains can find a place in the preparation of several value-added and health food-products, which may then result in high demand from large urban populations and nontraditional millet users (Mal and others, 2010) [15].

Sorghum is consumed in various forms around the world like baked bread, porridge, tortillas, couscous, gruel, steam-cooked products, alcoholic and non-alcoholic beverages etc. The potential food and industrial applications of sorghum have been reported (Brannan *et al*., 2001; Obizoba, 1988) [4, 19]. It has the potential to be processed into starch, flour, grits and flakes and used to produce a wide range of industrial products. It can also be malted and processed into malted foods, beverages and beer. On account of its nutritional significance, easy adaptability to a wide range of growing conditions, lesser water requirements, sorghum has the potential to be incorporated in the diets of human populations around the world, more specifically to those intolerant to wheat. In India, most of the sorghum produced is consumed in the form of 'roti' which is unleavened, flat bread. It has been estimated

that nearly 70% of the total sorghum produced in India is consumed in the form of roti (Murty and Subramanian, 1981) [17]. It forms the staple diet and source of nutrition for the farming communities and agricultural laborers in India.

Traditional flatbreads from sorghum and millets as described by Murty and Kumar (1995) [18] might be regarded as leavened if they are fermented like injera (Ethiopia) or puffed like chapatti/roti (India). Another well-established use of sorghum in leavened baked goods is in wheat–sorghum composite breads (Munck, 1995) [16]. While numerous studies have dealt with the above-mentioned products, only a limited number have addressed the issue of wheat-free loaf breads from sorghum, resembling wheat pan breads. Unlike composite breads, wheat-free sorghum breads are suitable for coeliacs (Schober *et al*., 2005) [223] and might possibly replace wheat breads in developing countries, reducing expensive wheat imports (Satin, 1988) [22]. Much of the older research on sorghum bread has been reviewed by Taylor and Dewar (2001) [27].

The objectives of this research study were:

- To incorporate sorghum flour in biscuits making.
- To evaluate the quality of biscuits made from composite flours (wheat and sorghum).
- To conduct the sensory evaluation of the product and finalize the most acceptable product by the panelists.
- To study the shelf life of such biscuits under the room temperature
- To evaluate the chemical and microbiological quality of the developed product.

2. Experimental Methodology

The present investigation entitled "Development of Sorghum Biscuits Incorporated with Spices" was carried out in the Department of Technology (Food Technology), University College of Technology, Osmania University, Hyderabad, Telangana State.

The ingredients used in this product development were procured from local market of Hyderabad.

Raw Materials / Ingredients

1. Sorghum Flour (Heritage Supermarket)
2. Refined Wheat Flour (Heritage Supermarket)
3. Fat (Marvo)
4. Icing Sugar
5. Skimmed Milk Flour
6. Salt (Optional)
7. Packaging materials (Metallised Polyester Pouches)
8. Ginger (*ZingiberofficinaleRosc.*)
9. Garlic (*Allium sativum L*)
10. Ajwain (*Trachyspermumammi (L.)*)
11. Jeera (*Cuminumcyminum*)

2.1 Formulation of the sorghum based biscuits

For the development of the sorghum based biscuits the ingredients were procured from the local market of Hyderabad. Different proportions of wheat flour and sorghum flour were taken keeping the icing sugar, salt and fat constant to standardize the biscuit formulation respectively as shown in Table 1.

Also to the obtained acceptable product different natural flavours (ginger, garlic, ajwain, jeera) were added to improve the flavour and acceptability of the product (Table 2).

Table 1: Formulation of the sorghum biscuits.

Samples	Sorghum Flour (%)	Wheat Flour (%)	Sugar (%)	Fat (%)	Skimmed Milk Powder (%)	Salt (%) (optional)
Control	----	100	24	44	30	2
S1	30	70	24	44	30	2
S2	50	50	24	44	30	2
S3	70	30	24	44	30	2
S4	60	40	24	44	30	2

S1: sample 1 of the sorghum based biscuit with plain / blank flavour; S2: sample 2 of the sorghum based biscuit with plain / blank flavour; S3: sample 3 of the sorghum based biscuit with plain / blank flavour; S4: sample 4 of the sorghum based biscuit with plain / blank flavour

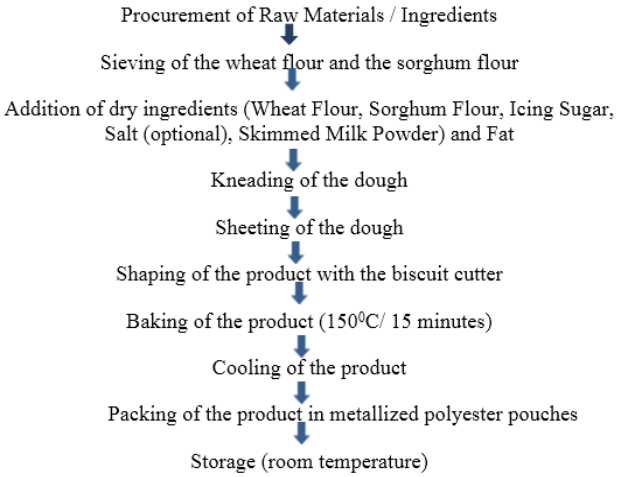
Table 2: Formulation of the sorghum biscuits incorporated with spices

Sample	Trails	Ginger (%)	Garlic (%)	Ajwain (%)	Jeera (%)
S4	T1	6	8	6	7
	T2	4	6	4	5
	T3	8	10	8	9

S4: Sample of the acceptable Sorghum based Biscuit (Composite Flour: 60:40); T1: First trail of the S4 sample with different proportions of ginger, garlic, ajwaine, Jeera flavours; T2:Second trail of the S4 sample with different proportions of ginger, garlic, ajwaine, Jeera flavours; T3: Third trail of the S4 sample with different proportions of ginger, garlic, ajwaine, Jeera flavours.

Fig 1: Spiced Sorghum Biscuits, Spiced Sorghum Biscuits Packed in the metallised polyester pouches.

Flow diagram for the production of sorghum based biscuits



2.2 Proximate Analysis

2.2.1 Moisture

Moisture in the samples was calculated by employing the standard methods of analysis (AOAC, 2000).

Moisture (%) = Loss in weight / Weight (g) of sample × 100

2.2.2 Crude Protein

Crude Protein was estimated using micro-kjeldahl method with KELPLUS nitrogen estimation system.

2.2.3 Crude Fiber

Crude fiber was estimated by the standard method of analysis (AOAC, 2000).

2.2.4 Fat

Crude fat was estimated by standard method (AOAC, 2000) using soxhlet extraction apparatus.

2.2.5 Ash

Ash in the sample was estimated by employing the standard method of analysis (AOAC, 2000).

2.2.6 Total carbohydrates

The total carbohydrate was calculated by difference method.
Total carbohydrate (%) = 100 – (Crude protein % + Crude fiber % + Crude fat % + Total ash %).

2.2.7 Free fatty acids

25.0 g of biscuit sample is treated with 100 ml. of hexane for the extraction of fat. The fat solution is filtered through a paper containing anhydrous Sulphite. The filtrate is collected in 100 ml. volumetric flask. 10 ml. of the filtrate are evaporated on steam bath. It is then dried in an oven at 100°C for 3 hours, cooled in desiccator and weighed (W) (This is to determine the fat content). To 10 ml. of the filtrate, 10 ml. of neutralized ethanol is added. The mixture is titrated with 0.01N NaOH solution using phenolphthalein as indicator. The free fatty acid is calculated as oleic acid percentage (FAO, 1986).

2.2.8 Peroxide value

Peroxide value of stored products at 0, 15, 30, 45, 60, 75 and 90 days was determined by the method of AOAC (2000).

2.2.9 Iron Content

2 g sample was mixed with 25 ml pepsin HCl (0.5 % pepsin in 0.1N HCl) in a conical flask. The pH of the mixture was adjusted to 1.35 with HCl and incubated at 37°C for 90 min in a water bath-cum-shaker. After incubation, pH of the contents was adjusted to 7.5 with NaOH and again incubated at 37°C in a water bath-cum-shaker for 90 min. Contents of the flasks were centrifuged at 9000 rpm for 30 min and the supernatant was filtered through Whatman No. 42 filter paper. The filtrate was oven dried, digested in the di acid mixture and preceded for the determination of iron by atomic absorption spectrophotometric method.

2.2.10 Phosphorous content

Make the sample homogeneous. Keep the homogeneous sample in a completely filled, air-tight, closed container and store it in such a way that deterioration and change in composition are prevented. Analyse the sample as soon as possible, but in any case within 24 h.

2.2.11 Total Sugars

10 ml freshly prepared anthrone reagent was pipetted in test tube and chilled in ice cold water. One ml sugar extract was taken and layered on the acidic anthrone reagent. After cooling for further five minutes, the contents were thoroughly mixed while still immersed in ice cold water. The contents in the tube were heated vigorously in a boiling water bath for 10 minutes and then, immediately cooled in cold water. The absorbance was then read at 625 nm in UV-VIS Spectrophotometer against a suitable blank. The amount of sugars was then determined by referring to a standard curve previously prepared with glucose.

2.2.12 Reducing Sugars

Reducing sugars were estimated by using Somogyi's modified method; 1ml test extract was taken in blood sugar tube graduated at 25 ml. One ml mixed copper reagent was added, and then, heated for 24 minutes in a boiling water bath, after cooling, added one ml of arseno-molybdate reagent, mixed thoroughly, and the contents were diluted to 25 ml. A stable blue colour appeared quickly, which was read at 520 nm against suitable blank. The amount of reducing sugars was then determined by referring to the glucose standard curve.

2.3 Microbial Analysis

2.3.1 Total plate count

Total plate count can be made using plate count agar. This microbiological growth medium is not a selective medium, standard plate count agar. Typically this agar consists of peptone, yeast extract glucose and agar. Two methods of growing is usually practiced- the pour plate or the spread plate. The pour plate mixes the sample and the agar at 45°C and pours it onto a petri dish. The spread plate method uses a solidified agar plate and uses a spreader to spread the bacteria onto the plate.

2.3.2 Yeast and Mould

Weigh 50 g test portion into 450 mL sterile diluent [e.g., 0.1% peptone water (BAM method) or peptone salt solution (ISO method)]. This is a 1:10 dilution. Macerate mixture.If alternative test portion size is specified in testing procedure, prepare 10% (w/v) suspension.If necessary, prepare 10-fold serial dilutions appropriate for anticipated population of test portion. To determine the population, calculate as follows:
(1) Count the number of positive wells on the plate;
(2) Determine the total population per plate.
Ref.: J. AOAC Int. 86, 299–300(2003).

2.4 Sensory evaluation of the developed sorghum biscuits and sorghum biscuits incorporated with spices

Most acceptable and storable value added products viz. sorghum biscuits and sorghum biscuitsincorporated with spices were stored for two months in metallised polyester pouches at room temperature. Products were evaluated for sensory parameters like taste, appearance, aroma, texture, colour and overall acceptability at different intervals of 0, 15, 30, 45 and 60 days using nine-point Hedonic Scale by a panel of ten judges.

2.5 Shelf life studies of the developed sorghum biscuits and sorghum biscuits incorporated with spices

Among the developed products sorghum biscuits and sorghum biscuits incorporated with spices were selected for storage up to 2 months depending on their storability. The stored products were organoleptically evaluated for proximate values at 15 days interval.

3. Results and Discussion

In this Present research study efforts were made to develop the sorghum based biscuits and sorghum biscuits incorporated with spices with the addition of the natural ingredients like ginger, garlic, ajwain, jeera to get good flavour to the developed products. The proximate analysis, microbial analysis, sensory evaluation and the shelf life of the developed products were estimated respectively. According to the obtained results in this research study sample S4 is more acceptable than the other samples and also in the case of sorghum biscuits incorporated with spices sample T1 was observed to be more acceptable than other two prepared samples.

3.1 Proximate analysis of the developed sorghum based biscuits

3.1.1 Proximate analysis, Microbial analysis of the developed plain sorghum biscuits

In this present research study it was observed that in the samples (control, S1, S2, S3, S4) of the developed plain sorghum biscuits there were fluctuations in the proximate parameters and microbial results respectively there was neither steady increase on steady decrease as shown in the Table 3, 4, 5 respectively. From the graphical representation of the obtained results the acceptable sample can be obtained (Fig 3.1, 3.2).

Table 3: Proximate analysis of developed plain sorghum biscuits

Sample	Moisture (%)	Ash (%)	Crude Fiber (%)	Carbohydrate (%)	Fat (%)	Protein (%)	Peroxide value (meq/kg)	Free Fatty Acid (%)	Phosphorous (mg/100g)	Iron (mg/kg)
Control	2.43	1.65	0.41	63.45	21.42	5.82	1.82	0.15	118.38	6.93
S1	2.89	1.17	0.42	65.05	22.82	7.53	1.69	0.17	142.06	1.22
S2	2.36	1.79	0.41	66.83	21.90	7.12	1.88	0.19	148.11	1.70
S3	2.47	1.82	0.45	65.99	22.61	7.11	1.79	0.19	191.26	1.62
S4	3.10	1.69	0.49	68.28	19.81	7.12	1.89	0.17	127.30	1.44

Control: 100% Wheat Flour, S1: 30% Sorghum Flour, 70% Wheat Flour, S2: 50% Sorghum Flour, 50% Wheat Flour, S3: 70% Sorghum Flour, 30% Wheat Flour, S4: 60 % Sorghum Flour, 40% Wheat Flour

Table 4: Microbial analysis of the developed plain sorghum biscuits

Sample	Total Plate Count(CFU/g)	Yeast &Mould(CFU/g)
Control	25	<10
S1	24	<10
S2	22	<10
S3	20	<10
S4	18	<10

Control: 100% Wheat Flour; S1: 30% Sorghum Flour, 70% Wheat Flour; S2: 50% Sorghum Flour, 50% Wheat Flour; S3: 70% Sorghum Flour, 30% Wheat Flour; S4: 60 % Sorghum Flour, 40% Wheat Flour

3.1.2 Sensory Evaluation of the developed plain sorghum based biscuits

Sensory evaluation of the developed plain sorghum biscuits was conducted with the help of the 9 point hedonic scale. From the Table 6 it can be observed that the Sample S4 has more acceptability than the other two samples respectively.

Table 5: Sensory evaluation of the developed plain sorghum biscuits

Sample (%)	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
Control (100 WF)	8.18±0.22	8.09±0.16	8.00±0.12	8.08±0.10	8.08±0.10	8.02±0.11
S1 (30 SF: 70 WF)	7.89±0.29	7.89±0.31	7.68±0.34	7.89±0.30	7.54±0.36	7.71±0.32

S2 (50 SF: 50 WF)	7.40±0.26	7.20±0.24	7.00±0.25	7.30±0.21	7.15±0.25	7.21±0.18
S3 (70 SF: 30 WF)	6.90±0.18	6.90±0.18	6.80±0.20	6.95±0.21	6.85±0.18	6.88±0.18
S4 (60 SF: 40 WF)	7.90±0.29	7.90±0.31	7.70±0.36	7.90±0.32	7.60±0.38	7.82±0.32

WF: Wheat Flour; SF: Sorghum Flour

3.2 Proximate Analysis of the Developed Sorghum Biscuit Incorporated with Spices (Ginger)

From the obtained results of the sensory evaluation of the developed plain sorghum biscuits, it was observed that the sample S4 contain the acceptability for the consumption. In order to improve the flavour of the plain sorghum biscuits, the naturally available spices are procured and incorporated in the plain sorghum biscuits to standardize and obtain the sorghum biscuits incorporated with spices (ginger, garlic, ajwain, jeera). The samples of sorghum biscuits incorporated with spices were termed as: T1, T2, and T3. Among these samples it was observed that the sample T1 is acceptable respectively. Not only the proximate analysis the microbial analysis and sensory evaluation were also done respectively.

Table 6: Proximate Analysis of the Sorghum Biscuit incorporated with spices (Ginger)

Sample (%)	Moisture (%)	Fat (%)	Ash (%)	Crude Fiber (%)	Carbohydrate (%)	Fat (%)	Protein (%)	Peroxide Value (meq/kg)	Free Fatty Acid (%)	Phosphorous (mg/100g)	Iron (mg/kg)
T1 (6%)	2.89	1.61	0.40	60.83	23.05	23.05	6.3	1.88	0.12	141.96	15.13
T2 (4%)	2.62	1.48	0.36	60.45	22.76	22.76	5.8	1.44	0.8	141.64	15.0
T3 (8%)	2.72	1.56	0.39	60.66	22.89	22.89	6.1	1.76	0.6	141.89	15.11

Table 7: Microbial Analysis of developed sorghum biscuit incorporated with spices (Ginger)

Sample	Total Plate Count(CFU/g)	Yeast &Mould (CFU/g)
T1	880	<10
T2	890	<10
T3	910	<10

Table 8: Sensory Evaluation of the Sorghum Biscuit incorporated with spices (Ginger)

Sample	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
T1	7.85±0.20	7.90±0.20	7.75±0.18	7.70±0.15	7.75±0.15	7.79±0.12
T2	7.30±0.26	7.30±0.26	7.20±0.24	7.10±0.27	7.05±0.26	7.19±0.25
T3	7.05±0.27	7.10±0.27	7.00±0.29	7.00±0.29	6.85±0.25	7.04±0.27

3.3 Proximate analysis of developed sorghum biscuit incorporated with spices (Garlic)

From the obtained results of the sensory evaluation of the developed plain sorghum biscuits, it was observed that the sample S4 contain the acceptability for the consumption. In order to improve the flavour of the plain sorghum biscuits, the naturally available spices are procured and incorporated in the plain sorghum biscuits to standardize and obtain the Sorghum Biscuit Incorporated with Spicess (ginger, garlic, ajwain, jeera). The samples of sorghum biscuits incorporated with spices were termed as: T1, T2, and T3. Among these samples it was observed that the sample T1 is acceptable respectively. Not only the proximate analysis the microbial analysis and sensory evaluation were also done respectively.

Table 9: Proximate Analysis of the developed sorghum biscuits incorporated with spices (Garlic)

Sample	Moisture (%)	Ash (%)	Crude Fiber (%)	Carbohydrates (%)	Fat (%)	Protein (%)	Peroxide Value (meq/kg)	FreeFatty Acid (%)	Phosphorous (mg/100g)	Iron (mg/kg)
T1	2.39	1.57	0.39	61.21	22.64	5.26	1.71	0.13	160.19	18.69
T2	2.41	1.54	0.36	60.89	22.46	5.12	1.56	0.12	158.62	17.16
T3	2.46	1.52	0.30	60.64	22.26	5.08	1.42	0.11	154.22	17.02

Table 10: Microbial Analysis of developed sorghum biscuit incorporated with spices (Garlic)

Sample	Total Plate Count (CFU/g)	Yeast &Mould (CFU/g)
T1	320	<10
T2	336	<10
T3	342	<10

Table 11: Sensory Evaluation of the Sorghum Biscuit incorporated with spices (Garlic)

Sample	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
T1	7.80±0.18	7.80±0.18	7.70±0.13	7.80±0.13	7.65±0.15	7.75±0.12
T2	7.10±0.34	7.00±0.33	7.00±0.33	7.00±0.33	6.95±0.32	7.01±0.33
T3	7.00±0.25	7.00±0.25	6.80±0.29	6.80±0.29	6.75±0.27	6.87±0.26

3.4 Proximate analysis of developed sorghum biscuit incorporated with spices (Ajwain)

From the obtained results of the sensory evaluation of the developed plain sorghum biscuits, it was observed that the sample S4 contain the acceptability for the consumption. In order to improve the flavour of the plain sorghum biscuits, the naturally available spices are procured and incorporated in the plain sorghum biscuits to standardize and obtain the Sorghum Biscuit Incorporated with Spicess (ginger, garlic, ajwain, jeera). The samples of Sorghum Biscuit Incorporated with Spicess were termed as: T1, T2, and T3. Among these samples it was observed that the sample T1 is acceptable respectively. Not only the proximate analysis the microbial analysis and sensory evaluation were also done respectively.

Table 12: Proximate Analysis of the developed sorghum biscuits incorporated with spices (Ajwain)

Sample	Moisture (%)	Ash (%)	Crude Fiber (%)	Carbohydrates (%)	Fat (%)	Protein (%)	Peroxide Value (meq/kg)	Free Fatty Acid (%)	Phosphorous (mg/100g)	Iron (mg/kg)
T1	3.37	1.82	0.43	60.18	22.14	5.66	1.96	0.19	152.97	16.03
T2	3.21	1.70	0.32	58.98	21.76	5.44	1.82	0.16	148.99	15.02
T3	3.12	1.58	0.11	57.24	20.66	5.02	1.60	0.10	132.69	14.89

Table 13: Microbial Analysis of developed sorghum biscuit incorporated with spices (Ajwain)

Sample	Total Plate Count(CFU/g)	Yeast &Mould(CFU/g)
T1	480	<10
T2	490	<10
T3	510	<10

Table 14: Sensory Evaluation of the Sorghum Biscuit incorporated with spices (Ajwain)

Sample	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
T1	7.60±0.37	7.40±0.34	7.30±0.30	7.10±0.34	7.20±0.32	7.32±0.30
T2	7.50±0.16	7.50±0.16	7.40±0.16	7.10±0.18	6.90±0.23	7.28±0.14
T3	7.40±0.16	7.20±0.20	7.10±0.18	7.00±0.21	6.70±0.21	7.08±0.15

3.5 Proximate Analysis of Developed Sorghum Biscuit incorporated with spices (Jeera)

From the obtained results of the sensory evaluation of the developed plain sorghum biscuits, it was observed that the sample S4 contain the acceptability for the consumption. In order to improve the flavour of the plain sorghum biscuits, the naturally available spices are procured and incorporated in the plain sorghum biscuits to standardize and obtain the Sorghum Biscuit Incorporated with Spicess (ginger, garlic, ajwain, jeera). The samples of sorghum biscuits incorporated with spices were termed as: T1, T2, and T3. Among these samples it was observed that the sample T1 is acceptable respectively. Not only the proximate analysis the microbial analysis and sensory evaluation were also done respectively.

Table 15: Proximate Analysis of the developed sorghum biscuits incorporated with spices (Jeera)

Sample	Moisture (%)	Ash (%)	Crude Fiber (%)	Carbohydrates (%)	Fat (%)	Protein (%)	Peroxide Value (meq/kg)	Free Fatty Acid (%)	Phosphorous (mg/100g)	Iron (mg/kg)
T1	2.39	1.57	0.39	61.21	22.64	5.26	1.71	0.13	160.19	18.69
T2	2.42	1.58	0.36	61.26	22.46	5.12	1.68	0.10	158.6	18.02
T3	2.48	1.60	0.32	61.18	22.58	5.24	1.64	0.11	156.98	17.89

Table 16: Microbial Analysis of developed sorghum biscuit incorporated with spices (Jeera)

Sample	Total Plate Count (CFU/g)	Yeast &Mould (CFU/g)
T1	320	<10
T2	310	<10
T3	296	<10

Table 17: Sensory Evaluation of the Sorghum Biscuit incorporated with spices (Jeera)

Sample	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
T1	7.78±0.29	7.75±0.29	7.88±0.15	7.90±0.16	7.47±0.16	7.75±0.22
T2	7.45±0.20	7.40±0.20	7.50±0.15	7.52±0.23	7.10±0.23	7.39±0.17
T3	7.35±0.20	7.38±0.13	7.40±0.13	7.40±0.26	7.10±0.23	7.32±0.19

3.6 Shelf Life Studies of Plain Sorghum Biscuit and Sorghum Biscuits incorporated with spices in metallised polyester pouch

Among the developed products, Plain Sorghum Biscuit and Sorghum biscuit incorporated with spices for storage up to 2 months depending on their storability. The stored products were organoleptically evaluated.

3.6.1 Sensory evaluation

Stored products were studied for their sensory characteristics

at an interval of 15 days during the storage period i.e. for 60 days by a panel of 10 judges using nine-point Hedonic Scale. The results of sensory evaluation are presented in Table 18. Mean scores of organoleptic characteristics of stored biscuits prepared from plain composite flours and those incorporated with spices are depicted in Table 18.

3.6.1.1 Colour
The acceptability scores of colour of plain sorghum biscuit declined from 7.90 (0 day) to 7.51 (60th day). In Sorghum Biscuit Incorporated with Spices the mean scores of colour declined from 7.80 (0 day) to 7.33 (60th day). However, no significant change was observed in organoleptic characteristics upto 60 days of storage in colour of three biscuits.

3.6.1.2 Appearance
Mean scores of appearance of developed plain sorghum biscuit declined non-significantly (P<0.05) from 7.90 (0 day) to 7.75 (60th day). Likewise, Sorghum Biscuit Incorporated with Spices also showed non-significant decrease in mean scores of appearance from 7.90 (0 day) to 7.50 (60th day).

3.6.1.3 Aroma
The acceptability of aroma of plain sorghum biscuit and Sorghum Biscuit Incorporated with Spices decreased nonsignificant (P<0.05) from zero to sixty day. The mean scores of aroma of plain sorghum and Sorghum Biscuit Incorporated with Spices were rated as 'liked moderately' during storage time by the judges.

3.6.1.4 Texture
Non-significant change in the mean scores of texture was observed in composite flours based biscuits. In spite, of decrease in mean scores of texture the composite flours based biscuit were found in the category of 'liked moderately' throughout the storage period.

3.6.1.5 Taste
Mean scores of taste of Plain sorghum biscuit decreased from 7.65 (0 day) to 7.05 (60th day) and of Sorghum Biscuit Incorporated with Spices from 7.40 (zero day) to 6.87 (60th day). However, the decrease in mean score of taste of biscuit was non-significant.

3.6.1.6 Overall acceptability
The mean scores of overall acceptability of plain sorghum biscuit declined from 7.85 (zero day) to 7.26 (60th say) and in Sorghum Biscuit Incorporated with Spices it was reduced from 7.78 (zero day) to 7.08 (60th day).

Table 18: Effect of storage period on mean scores of organoleptic characteristics of biscuit based on composite flours

Sensory Attributes	0 Days	15 Days	30 Days	45 Days	60 Days	Mean	CD (P<0.05)
Plain Sorghum Biscuit							
Colour	7.90±0.18	7.90±0.16	7.82±0.22	7.70±0.15	7.51±0.16	7.76	NS
Appearance	7.90±0.18	7.90±0.26	7.80±0.26	7.68±0.20	7.51±0.16	7.75	NS
Aroma	7.90±0.18	7.80±0.13	7.68±0.15	7.46±0.27	7.30±0.15	7.62	NS
Texture	7.90±0.18	7.80±0.16	7.70±0.22	7.50±0.20	7.22±0.12	7.62	NS
Taste	7.65±0.15	7.47±0.23	7.29±0.20	7.18±0.15	7.05±0.12	7.29	NS
Overall Acceptance	7.85±0.16	7.77±0.13	7.65±0.16	7.46±0.17	7.26±0.18	7.59	NS
Sorghum Biscuit Incorporated with Spices							
Colour	7.80±0.23	7.70±0.11	7.55±0.11	7.45±0.13	7.33±0.13	7.56	NS
Appearance	7.90±0.31	7.90±0.09	7.81±0.16	7.67±0.13	7.50±0.19	7.75	NS
Aroma	7.70±0.36	7.61±0.10	7.38±0.11	7.20±0.11	6.84±0.11	7.34	NS
Texture	7.80±0.32	7.65±0.09	7.50±0.10	7.23±0.11	6.90±0.19	7.41	NS
Taste	7.40±0.37	7.33±0.07	7.15±0.08	7.02±0.09	6.87±0.10	7.15	NS
Overall Acceptance	7.78±0.30	7.63±0.20	7.47±0.16	7.31±0.13	7.08±0.11	7.45	NS

3.7 Effect of storage period on the peroxide value
Peroxide value content of biscuits increased significantly (P ≤0.05) during storage. Peroxide value of Plain sorghum biscuit and Sorghum Biscuit Incorporated with Spices peroxide value from 0 to 60th day of storage ranged from 1.84 to 4.57 and 1.73 to 4.37 meq peroxide/1000g. Biscuit prepared from Plain Sorghum flour and wheat flour combination had maximum content of peroxide value as compared to Sorghum Biscuit Incorporated with Spices.

Table 19: Effect of storage period on peroxide value (meq peroxide/1000g) content of stored biscuit based on composite flours

Sample	0 – Day	15 – Days	30 – Days	45 – Days	60 – Days	CD(P<0.05)
Plain Sorghum Biscuit	1.84±0.03	2.04±0.03	2.94±0.19	3.34±0.03	4.57±0.03	0.02
Sorghum Biscuit Incorporated with Spices	1.73±0.03	1.94±0.07	2.79±0.03	3.21±0.03	4.37±0.03	0.03
CD (P<0.05)	0.01	0.01	0.04	0.02	0.01	

4 Discussions
4.1 Organoleptic acceptability of plain and Sorghum Biscuit Incorporated with Spices
The plain and Sorghum Biscuit Incorporated with Spices were developed and subjected to the proximate, microbial analysis and sensory evaluation. Sensory evaluation was done by using nine point hedonic scale by a panel of judges.
The mean scores for overall acceptability of control biscuit fell in the category of 'liked very much'. The mean scores for overall acceptability of plain sorghum and spiced sorghum

based biscuit were 7.21 and 7.82, respectively. The Sorghum Biscuit Incorporated with Spices prepared with supplementation of ginger, garlic, ajwain, jeera showed scores of overall acceptability i.e. 7.25 and 7.78 for plain and Sorghum Biscuit Incorporated with Spices, respectively as compared to unsupplemented biscuit and rated as 'liked moderately'. Results of organoleptic acceptability of biscuits are in close agreement to that reported by Singh *et al*. (2006) [25] as biscuits prepared from blanched and malted pearl millet flour were also 'liked moderately'. Anu *et al*. (2003) [1] reported that sweet biscuit prepared from 100 per cent blanched flour were 'liked moderately' whereas type-I (40:50:10; blanched pearl millet flour: refined flour: green gram flour) and type-II (60:30:10) were 'liked very much' by the judges. Sangwan and Dahiya (2013) [21] reported that biscuit prepared from composite flour in different ratios were in the category of 'liked moderately' on the basis of organoleptic evaluation. Pearl millet cookies had higher overall quality score as compared to control cookies as reported by Suma *et al*. (2014) [26]. Tulsi (10g) and moringa (5g) leaves' powder supplemented biscuit were acceptable by the judges as reported by Ariful *et al*., (2014) [3].

4.2 Nutrient composition of most acceptable value-added products

Proximate composition

The proximate composition of biscuit, plain sorghum biscuit had significantly higher moisture and crude protein while crude fibre (3.86 and 3.89%) and ash (2.02 and 1.08%) content were higher in Sorghum Biscuit Incorporated with Spices. Control biscuit contained significantly higher amount of total carbohydrate. Similarly, Devi *et al*. (2000) [5] prepared biscuits from green gram dhal and observed that salty biscuits contained highest crude fibre and ash contents. Similar results were reported by earlier workers in respect that incorporation of leaves'powder for development of biscuits increased the crude fiber and ash content (Wani and Sood, 2014; Sihag, 2007; Hafez, 2012) [29, 24, 8]. Anu *et al*. (2006) [2] reported that moisture, protein, fat, ash and crude fibre content is higher in cake prepared from blanched pearl millet, refined wheat flour and green gram flour as compared to control. The pearl millet cookies had higher protein, ash content as compared to control (Suma *et al*., 2014) [26].

4.3 Shelf life study of organoleptically most accepted storable value-added products

Sensory characteristics

Overall acceptability scores of control, plain sorghum and Sorghum Biscuit Incorporated with Spices declined non-significantly during storage from 8.04, 7.82 and 7.78 at zero days to 7.59, 7.13 and 7.08 at 60th days of storage.

Peroxide Value

Peroxide value content of biscuits increased significantly ($P \leq 0.05$) during storage. Peroxide value of control ranged from 1.70 to 4.32 meq peroxide/1000g. In Plain and Sorghum Biscuit Incorporated with Spices peroxide value from 0 to 60th day of storage ranged from 1.84 to 4.57 and 1.73 to 4.37 meq peroxide/1000g.

Similar results were also observed by Hafez (2012) [8] who reported that control cake exhibited highest peroxide value whereas, cake supplemented with sweet marjoram showed lowest peroxide value throughout storage period. The anti-oxidative effect may have contribution to the oxidative stability of cakes with addition of natural antioxidant. Supplementations of marjoram provide antioxidant benefits to cakes during room temperature storage.

4.4 Conclusions and future works

- The present study provides information pertaining to proximate composition, sensory attributes and microbial quality of spiced sorghum based biscuits prepared using composite flours. The most acceptable and storable value added products were analyzed for shelf life study.
- Biscuits of desirable properties comparable to 100% wheat flour have been produced from sorghum – wheat composite flour.
- In the conducted sensory evaluation, the most acceptable sorghum biscuit was of sample S4 and of the Sorghum Biscuits Incorporated with Spices was T1 (ginger T1, Garlic T1, Ajwain T1, Jeera T1) respectively.
- Under the room conditions the biscuits packed in metallised polyester pouches showed the shelf life of about 60 days respectively.

Future Works

- Further rheological properties and physical properties of the products should be done.
- Also shelf life of the developed products should be done with different packaging materials at different temperatures respectively.
- In this research work the observed shelf life of the product was 60 days, at the time of 60th day of storage of the product the product was not completely deteriorated. So the shelf life may still extend to 90 days approximately.

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