European Journal of Nutrition & Food Safety

9(2): 122-133, 2019; Article no.EJNFS.2019.026
ISSN: 2347-5641

Development and Evaluation of Amaranth-Soy-Wheat Composite Flours

Kanchan Joshi[1], Archana Kushwaha[1*] and Kalpana Kulshrestha[1]

[1]Department of Foods and Nutrition, College of Home Science, G. B. Pant University of Agriculture and Technology, Pantnagar, India.

Authors' contributions

The study was carried out in collaboration among authors KJ, AK and KK. Authors AK and KK designed the study. Author KJ carried out the experimentation gathered the initial data and performed the statistical analysis. Author AK managed the literature searches and wrote the first draft. The three authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2019/v9i230051

Original Research Article

Received 12 October 2017
Accepted 26 February 2019
Published 12 March 2019

ABSTRACT

Aims: Malnutrition among all ages is still a persistent problem in India, especially in areas where the poor largely depend on rice and wheat staples with limited access to diverse diets using underutilized foods. This study was conducted to nutritionally enhance traditional food products like *roti* and *lapsi* utilizing suitable composite flours based on amaranth, soybean and wheat without affecting their sensory quality.

Study Design: Different combinations of amaranth, soybean and wheat flours were made to suit the quality characteristics of *roti* and *lapsi*.

Place and Duration of Study: Department of Foods and Nutrition, G. B. Pant University of Agriculture & Technology, Pantnagar (India), between January and June 2016.

Methodology: The sensory evaluation of food products and estimation of nutritional composition of composite flours was done using standard procedures.

Results: The composite flours having 25% amaranth, 15% soybean and 60% wheat flour and 25% amaranth, 10% soybean and 65% wheat flour were found to be most acceptable sensorially and were significantly superior to their control counterparts for protein, ash, fibre, carbohydrate calcium and iron content (p=.05).

Conclusion: *Roti* made from amaranth and soybean incorporated composite flours with better protein quality and low available carbohydrates and physiological energy almost same as control would be better diet alternative to diabetic and overweight patients whereas *lapsi* may be effectively used as supplementary food. Many other traditional food products like *laddoo*, *halwa*, *puri*, *parantha*, *burfi* etc. may also be made from such composite flours.

**Corresponding author: Email: archkush08@gmail.com;*

Keywords: Amaranth; soybean; wheat; composite flour; roti; lapsi; nutritional quality; acceptability.

1. INTRODUCTION

The concept of composite flour technology was introduced by Food and Agriculture Organization (FAO) in 1964. Main purpose behind making a composite flour is having a composition that combines optimal nutritive value with good processing characteristics. In terms of quality if possible mixtures should be comparable to similar products made from wheat it should bring about a further increase in the nutritive value of the flour mixtures concerned. For these mixtures, the FAO has coined the name "Composite Flours" [1]. At that time, it was targeted for reducing the cost of mostly used flours by encouraging the use of indigenous crops such as cassava, yam, maize and others in partial substitution of wheat flour [2]. Composite flour has been defined as a combination of wheat and non-wheat flours or wholly non wheat flour prepared from mixtures of flours from cereals, roots, legumes, tubers or other raw materials for the production of traditional or novel products [3]. These can be either binary or tertiary mixtures of flours from some other crops with or without wheat flour. Nowadays composite flour is considered advantageous in developing countries like India as it encourages the use of locally grown nutritious crops as flour [2].

Roti is a flat unleavened baked product. Synonyms such as *chapatti*, *chapathi, rotla*, *phulka* and *flatbread* are generally used for *roti*. It is a most common traditional food product consumed by a majority of the population of India and it comprises a major portion of the Northern Indian diet. Among the traditional products, it takes away around 85% of the total wheat of the country [4]. Major ingredients are in making *roti* are wheat flour and water. For the preparation of *roti* whole wheat flour is mixed with water required for optimum dough consistency and kneaded by hand [5]. Then the dough is normally given a minimum rest period of 15 to 30 min, at room temperature before it is sheeted to a thickness of about 3 to 4 mm [6]. It should be circular in shape with a diameter of around 10-15 cm and then baked on a hot iron plate at 120-250 °C. After baking on one side, it is turned over and baked for different times. Finally, puffed on a live flame for few seconds [7]. Desirable quality parameters for *roti* are a soft texture with chewy characteristics. Rotis are mostly made from whole wheat, which is low in amino acid lysine. So, substitution of wheat with nutrient dense materials gives nutritional advantage which led to the initiative of using composite flour.

Lapsi is a sweet flavoured dessert of Uttarakhand, made by boiling fine ground wheat flour in water or milk with sugar [8]. Generally it is cooked with flavorings such as sugar, honey etc. It is very easy to digest and usually used as an instant breakfast generally for infants, old persons and for those who are unable to chew. Other synonyms such as *porridge*, *gruel, groats, stirabout, kasha, polenta* and *grits* are used for *lapsi*.

Several attempts have been made for the incorporation of many cereals, pulses and millets in wheat flour by many researchers, among which have been wheat/soya [9], wheat/maize [10], wheat/sorghum [11], amaranth/maize [12] and amaranth/wheat [13] in different food items such as bread, cake, biscuits, porridge and cookies, respectively. Scarce information has been available on the development of composite flour made from amaranth, soybean and wheat.

The necessity for nutritional enhancement of traditional food products like *roti* and *lapsi* using composite flours without compromising their sensory quality cannot be over emphasized. Since the two crops viz. amaranth and soybean have been grown in hills of Uttarakhand, nutritional improvement of food products like *roti* and *lapsi* from composite flours using amaranth, soybean and wheat for the health benefits of a general population through utilization of these crops was considered the rationale of present study.

2. MATERIALS AND METHODS

2.1 Materials

Raw materials like wheat grains, white soybean grains and sugar were purchased from the local market of Pantnagar. Locally grown, pale yellow colour amaranth grains were purchased from local market of Almora, Uttarakhand.

2.2 Preparation of Flours

For the preparation of soybean flour, grains were cleaned free of broken/damaged grains, washed and soaked for 3h in clean potable water in the proportion of 1 kg soybean:3l water (w/v). Grains were then boiled in a pressure cooker for 10 min followed by manual dehulling and drying in the oven at 50ºC for 24 h and subsequent grinding in an electric grinder (Inalsa mixer grinder, Compact Lx, Delhi, India) followed by sieving through 20 mesh (0.841 mm) sieve [14,15].

Whole wheat flour was prepared by manually cleaning the grains to remove dust, grit, chaff and other impurities followed by washing, and drying at 50-55°C for 3 h. After this grinding was done in an electric grinder (Inalsa mixer grinder, Compact Lx, Delhi, India) followed by sieving with a 0.841 mm sieve [9].

Clean and dry amaranth grains were popped by high-temperature short time (HTST) treatment at 240°C for 3 min in a domestic grain popper (Skyline Hot Air Popper VI-4040) and ground and sieved to make flour after passing though sieve (0.841 mm) [16].

2.3 Standardization of Composite Flours

Preliminary experimental work was done with different levels of whole popped amaranth flour and full fat soybean flour so as to select the range of percent incorporation of both, which could be used in formulating composite flours in the present study [17]. For this, two preliminary trials were done. Under one trial, various proportions (5 to 50%) (Table 1) of amaranth substitution in wheat flour were tried and their dough, *roti* and *lapsi* characteristics were studied. Another trial was run to study the dough, *roti* and *lapsi* characteristics of soybean flour incorporation into wheat flour in many proportions (5 to 50%) (Table 1). The recipes were evaluated simultaneously through informal sensory evaluation by a panel for sensorial acceptability by feel and visual perception.

2.4 Proximate Composition and Mineral Estimation of Flours

Proximate composition and mineral estimation was done for selected composite flours including control as whole wheat flour. The chemical analysis of samples was done in triplicates. This includes estimation of the moisture [18], ash [18], crude protein [18], crude fat [18] and crude fibre [18], calcium [18], and iron [18] content in composite flours. Total [19] and available [19] carbohydrate by difference and physiological energy [20] was also determined.

2.5 Preparation of Food Products

Roti from different composite flours was prepared [6]. For the preparation of *roti,* 100 gm flour was taken in a bowl and water at room temperature was delivered from a measuring cylinder with simultaneous mixing with hand. The dough ball formed was kneaded by hand for several turns and was divided into four equal parts. Then each ball was rolled into a thickness of 1-3mm, and a diameter of seven inches, on a floured rolling board. The residual dry flour was shaken off and the rolled chapattis were cooked on a hot griddle (*tava*) at 125-250°C on both sides and allowed to puff on a live flame for few seconds.

For preparation of *lapsi*, 100g flour was taken in a *kadhai* and continuous stirring was done until the desired aroma was obtained or to even browning of flour. Then in a container, 800ml lukewarm water was added and flour was slowly mixed with continuous stirring to avoid lumps. After that in a low flame 16% sugar was added into it [21].

2.6 Sensory Evaluation of Developed Food Products

Five (four experimental and 1 control) variants of each of *roti* and *lapsi* were evaluated for sensory analyses using nine-point Hedonic scale (ranging from 1: dislike extremely to 9:like extremely) [22]. Sensory evaluation was done by a semi-trained panel consisting 20 members (staff and postgraduate students) from the Department of Foods and Nutrition, Home Science College, G. B. P. U. A. & T., Pantnagar for sensory characteristics viz. colour, texture, aroma, taste, mouthfeel, and overall acceptability.

2.7 Statistical Analysis

The data obtained for each parameter in proximate and mineral composition of different composite flours and each sensory characteristic for *roti* and *lapsi* were analysed statistically by one-way ANOVA at p=.05 to find out the significant difference between experimental and control samples [23].

3. RESULTS AND DISCUSSION

3.1 Standardization and Formulation of Composite Flours

Different blends of amaranth (A) and soybean (S) with wheat flour (W) were formulated viz.

proportions A/S:W in 5:95 to 50:50 and evaluated for their suitability [12] in making traditional staple food *roti*, which is almost consumed daily in Northern India and a sweet preparation *lapsi*, which is occasionally prepared as sweet alternative. The characteristics of dough and *roti* made of these blends were evaluated for hardness and texture (chewiness) and the rollability by handfeel and mouthfeel for dough and roti, respectively. In case of *lapsi*, mainly texture (consistency) and flavour were compared for each of these blends.

The results presented in Table 1 showed that the incorporation of amaranth up to 25% in wheat gave the acceptable results. And same investigation with incorporation of soybean in wheat flour showed 15% as the best acceptable level of incorporation as evident from Table 2. Addition of bean flour beyond 15% in wheat tortillas resulted in negative impact on physical properties of both dough (dough development time and stability) and tortillas (firmness and cohesiveness). Rollability of tortillas was seriously affected with increase of bean flour substitution of 35% [24]. Wheat breads with 10% chickpea flour addition showed minor changes in their quality, but 20% substitution resulted in significant loss of the quality [25].

The composite flours of amaranth, soybean and wheat thus developed with varying levels of amaranth and soybean in present investigation were used for further experiments (Table 3). These composite flours were also used for *roti* making and *lapsi* preparation and were tested for their acceptability in terms of colour, aroma, texture, mouthfeel and data was analysed using ANOVA.

3.2 Nutritional Quality Evaluation of Different Composite Flours

Results of nutritional quality evaluation of different composite flours as presented by proximate composition, physiological energy value and mineral estimation have been given in following text.

3.2.1 Proximate composition

Proximate composition included analysis of the samples for moisture, ash, crude protein, crude fat, crude fibre and carbohydrate by difference content. Results in form of mean values of triplicate observations on dry weight basis are presented in Table 4.

The moisture content of any food stuff determines its nutrient density and in case of flours it decides its storage stability. Higher the moisture content lower will be the nutrient density as well as storage stability and vice-versa. The moisture content ranged from 8.8-13.15%.

Table 1. Preliminary trials for selecting promising proportions of popped amaranth flour in wheat flour for *roti* and *lapsi* preparations

Different proportions (%)		Observed Characteristics of *Roti*				Observed Characteristics of *Lapsi*	
		Dough		*Roti*			
Wheat	Amaranth	Hardness (Strong/ Weak)	Texture (Smooth/ Grainy)	Rolling (Easy/ Difficult)	Texture (Soft/ Semi soft/ Hard)	Flavour (Acceptable/ Not acceptable)	Texture (Smooth/ Grainy)
100	0	Strong	Smooth	Easy	Soft	Acceptable	Smooth
95	5	Strong	Smooth	Easy	Soft	Acceptable	Smooth
90	10	Strong	Smooth	Easy	Soft	Acceptable	Smooth
85	15	Strong	Smooth	Easy	Soft	Acceptable	Smooth
80	20	Strong	Smooth	Easy	Soft	Acceptable	Smooth
75	25	*Strong*	*Smooth*	*Easy*	*Soft*	*Acceptable*	*Smooth*
70	30	Strong	Smooth	Difficult	Semi soft	Acceptable	Smooth
65	35	Strong	Grainy	Difficult	Semi soft	Acceptable	Smooth
60	*40*	*Strong*	*Grainy*	*Difficult*	*Semi soft*	*Acceptable*	*Smooth*
55	45	Weak	Grainy	Difficult	Hard	Acceptable	Grainy
50	50	Weak	Grainy	Difficult	Hard	Acceptable	Grainy

Table 2. Preliminary trials for selecting promising proportions of full fat soybean flour in wheat flour for *roti* and *lapsi* preparations

Different proportions (%)		Observed Characteristics of *Roti*				Observed Characteristics of *Lapsi*	
Wheat	Soybean	Dough		*Roti*			
		Hardness (Strong/ Weak)	Texture (Smooth/ Grainy)	Rolling (Easy/ Difficult)	Texture (Soft/ Semi soft/ Hard)	Flavour (Acceptable/ Not acceptable)	Texture (Smooth / Grainy)
95	*5*	*Strong*	*Smooth*	*Easy*	*Soft*	*Acceptable*	*Smooth*
90	*10*	*Strong*	*Smooth*	*Easy*	*Soft*	*Acceptable*	*Smooth*
85	*15*	*Strong*	*Smooth*	*Easy*	*Soft*	*Acceptable*	*Smooth*
80	20	Strong	Smooth	Difficult	Semi soft	Not acceptable	Smooth
75	25	Strong	Smooth	Difficult	Semi soft	Not acceptable	Smooth
70	30	Strong	Smooth	Difficult	Semi soft	Not acceptable	Grainy
65	35	Strong	Smooth	Difficult	Semi soft	Not acceptable	Grainy
60	40	Strong	Smooth	Difficult	Hard	Not acceptable	Grainy
55	45	Strong	Smooth	Difficult	Hard	Not acceptable	Grainy
50	50	Strong	Smooth	Difficult	Hard	Not acceptable	Grainy

Table 3. Selected combinations of different composite flours

Ingredients / Flours	Percentage (w/w)		
	Amaranth flour	Soybean flour	Wheat flour
Control	0	0	100
Composite flour 1 (CF1)	25	15	60
Composite flour 2 (CF2)	25	10	65
Composite flour 3 (CF3)	25	5	70
Composite flour 4 (CF4)	40	0	60

Total ash represents total mineral content of foodstuff. The data presented in Table 4 shows that the total ash content ranged from 1.84 (Control) to 2.67% (CF1) in the composite flours. This will be an advantage in the preparation of complementary food formulation. All the composite flours were significantly different with control at p=.05. Results imply that the supplementation with amaranth and soybean has positively impacted the inorganic constituents of experimental composite flours. Composite flours made from wheat and soybean blends generally had increased ash contents [26].

The quantity and quality of protein in flour serves as an index of flour quality, as it relates with the strength, elasticity and extensibility of the dough. Protein is an important component that enhances the rheological properties of composite flours. Protein content in control (100% wheat) was found to be 10.34% which was observed to increase significantly (p=.05) in composite flours (15.5-18.12%). This increase in protein content in composite flours could be attributed to significantly higher protein content of individual flour components namely soybean [3] and amaranth [27] that were incorporated in composite flour formulation. Addition of bean flours in tortillas resulted in significant increase in protein content even at 15% substitution levels with more evident changes at 25 and 35% substitutions [24].

Fat content in foodstuff raises the energy density of food products made from it. High fat flours are also good as flavour enhancers and useful in improving palatability of foods in which it is incorporated [28]. The data presented in (Table 4) showed that the crude fat content in the composite flours ranged from 1.51 (Control) to 3.62% (CF1). The increase in fat content of composite flours increased with the level of full fat soy flour supplementation [29,30]. Similar results have been reported in crude fat content upon substitution of amaranth in wheat [31,32]. The fat content increased with increasing proportions of soybean and amaranth in composite flours [25].

Crude fibre includes the compounds which make up most of the bulk in the diet and are not hydrolyzed by the digestive fluids of human beings [33]. Fibre adds bulk or weight to food products and it requires much water during hydration [34]. All the experimental composite flours (2.67-4.87%) except CF1 had significantly (p=.05) higher fibre content than that of control. It might have been caused due to the incorporation of whole amaranth flour without removal of hull (in case of CF4) whereas the soybean was dehulled before making it into full fat flour (CF1 having maximum of 15% incorporation). Similarly crude fibre content increased upon addition of soy flour to wheat [35].

Total carbohydrate by difference is the sum of nutritionally available carbohydrates (dextrins, starches, and sugars); nutritionally unavailable carbohydrate (pentosans, pectins, hemicelluloses, and cellulose) and non-carbohydrates such as organic acids and lignin. The maximum carbohydrate content has been recorded in control (76.44%) followed by CF4 (71.46%). The other composite flours CF1, CF2 and CF3 contained 62.43, 64.39 and 66.85% carbohydrate, respectively. The difference between experimental composite flours and control was significant (p=.05). A proportional decrease in total carbohydrates content was observed upon substitution of amaranth and soybean in wheat flour.

Available carbohydrate has been defined as "starch and soluble sugars" and can be estimated by the difference method by subtracting the proximate constituents viz. moisture, fat, ash, protein and fibre from 100. The available carbohydrate content decreased significantly upon supplementation of amaranth and soybean on comparison of experimental composite flours (CF1:CF4) versus control. High percentage of available carbohydrate content in all the composite flour blends (59.75-74.02%) suggested that the blends could serve as good source of energy. Carbohydrate content decreased in all composite flours [25].

The physiological energy content in composite flours has been observed in the range of 344 (CF1) to 351 Kcal/ 100g (Control). The energy values of the composite flours were better when compared with the recommendations of WHO [36] which specify 1.0 Kcal/g for children 2 to 5 years.

3.2.2 Minerals

In the present study, two minerals viz. calcium and iron was estimated in all the composite flours (CF1:CF4) and compared with control and the results are presented in Table 5. Significantly higher calcium content was observed in the all the experimental composite flours (CF1: 228.74; CF4: 223.68; CF2: 209.92 and CF3: 185.91 mg/100g) over control (66.55 mg/100g). It was found that the calcium content of composite flours increased with the increasing amount of soybean and amaranth flour incorporation.

The data presented in Table 5 revealed that the iron content in different composite flours was in the range of 5.54 (Control) to 9.79 mg/100 g. From the present study it was concluded that all the experimental flours contained an appreciably good (8.74-9.79 mg/100 g) amount of iron. This is supported by the high values of iron in amaranth (7.59-17.4 mg/100 g) and soybean (44.9-83.7 mg/100 g) [37,38]. Composite flour having soy and wheat flour blends contained significantly higher amount of calcium and iron over control [35].

3.3 Sensory Evaluation of Food Products Made from Composite Flours

Two traditional food products namely *roti* (Fig. 1) and *lapsi* (Fig. 2) were made of composite flours under study and evaluated for their sensory characteristics viz. colour, aroma, texture, taste, mouth feel and overall acceptability and the results observed are given below.

Table 4. Proximate composition of four composite flours (CF1-CF4) and control [1,2,3]

Components	Moisture (g)	Dry Weight Basis (per 100 g) [1]						
		Ash (g)	Crude protein (g)	Crude fat (g)	Crude fibre (g)	TCHO (g)	ACHO (g)	PE (Kcal)
CF1	13.15±0.47[a]	2.67±0.14[a]	18.12±0.47[a]	3.62±0.05[a]	2.67±0.18[c]	62.43±0.73[e]	59.75±0.84[d]	344.1±3.19[b]
CF2	12.35±0.3[b]	2.51±0.2[ab]	17.29±0.51[a]	3.45±0.03[b]	2.99±0.09[bc]	64.39±0.36[d]	61.4±0.45[cd]	345.86±1.47[ab]
CF3	11.06±0.55[c]	2.32±0.14[b]	16.88±0.37[ab]	2.88±0.10[c]	3.27±0.4[b]	66.85±0.96[c]	63.48±1.2[c]	347.4±3.97[ab]
CF4	8.8±0.3[d]	2.55±0.11[a]	15.5±0.52[b]	1.69±0.05[d]	4.87±0.1[a]	71.46±0.50[b]	66.26±0.41[b]	343.61±0.84[b]
Control	9.84±0.35[e]	1.84±0.13[c]	10.34±0.59[c]	1.51±0.02[e]	2.42±0.14[c]	76.44±1.00[a]	74.02±0.97[a]	351.1±1.72[a]

Notes- 1=Values are mean ± SD of triplicate observations; 2 Mean values sharing the same superscript within a column are not significantly different from each other at p=.05
3 TCHO= Total carbohydrate; ACHO= Available carbohydrate; PE= Physiological energy

Table 5. Calcium and iron content of per 100 g of composite flours (CF1-CF4) and control on dry weight basis [1,2]

	Calcium (mg)	Iron (mg)
CF1	228.74 ± 1.79[a]	9.79 ± 0.08[a]
CF2	209.92 ± 0.72[b]	9.17 ± 0.11[b]
CF3	185.91 ± 3.62[c]	8.74 ± 0.09[c]
CF4	223.68 ± 4.3[d]	9.22 ± 0.08[b]
Control	66.55 ± 0.25[e]	5.54 ± 0.03[d]

Notes: 1 Values are mean ± SD of triplicate observations; 2 Mean values sharing the same superscript within a column are not significantly different from each other at p=.05

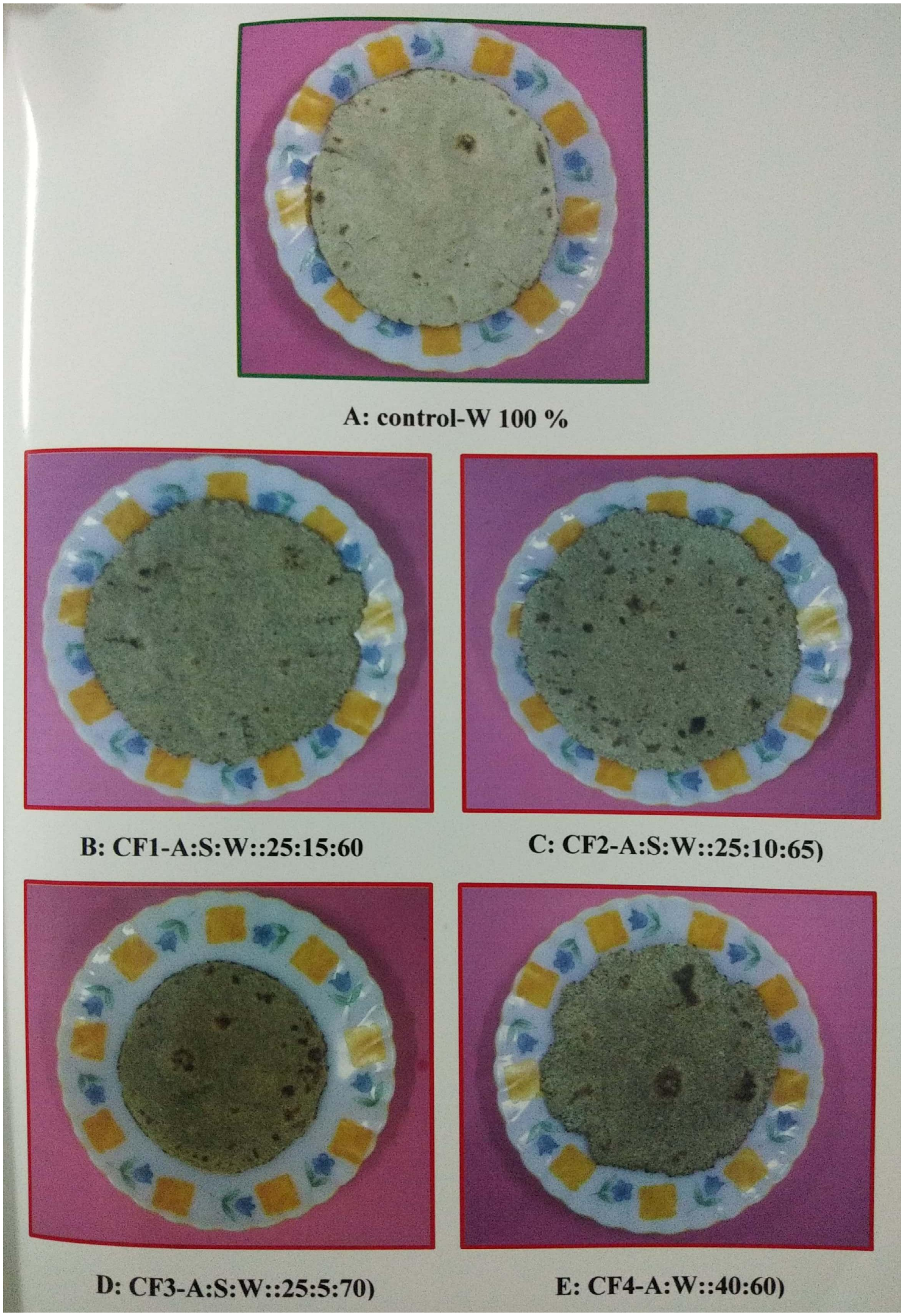

Fig. 1. *Roti* prepared from control and experimental composite flours (CF1:CF4)

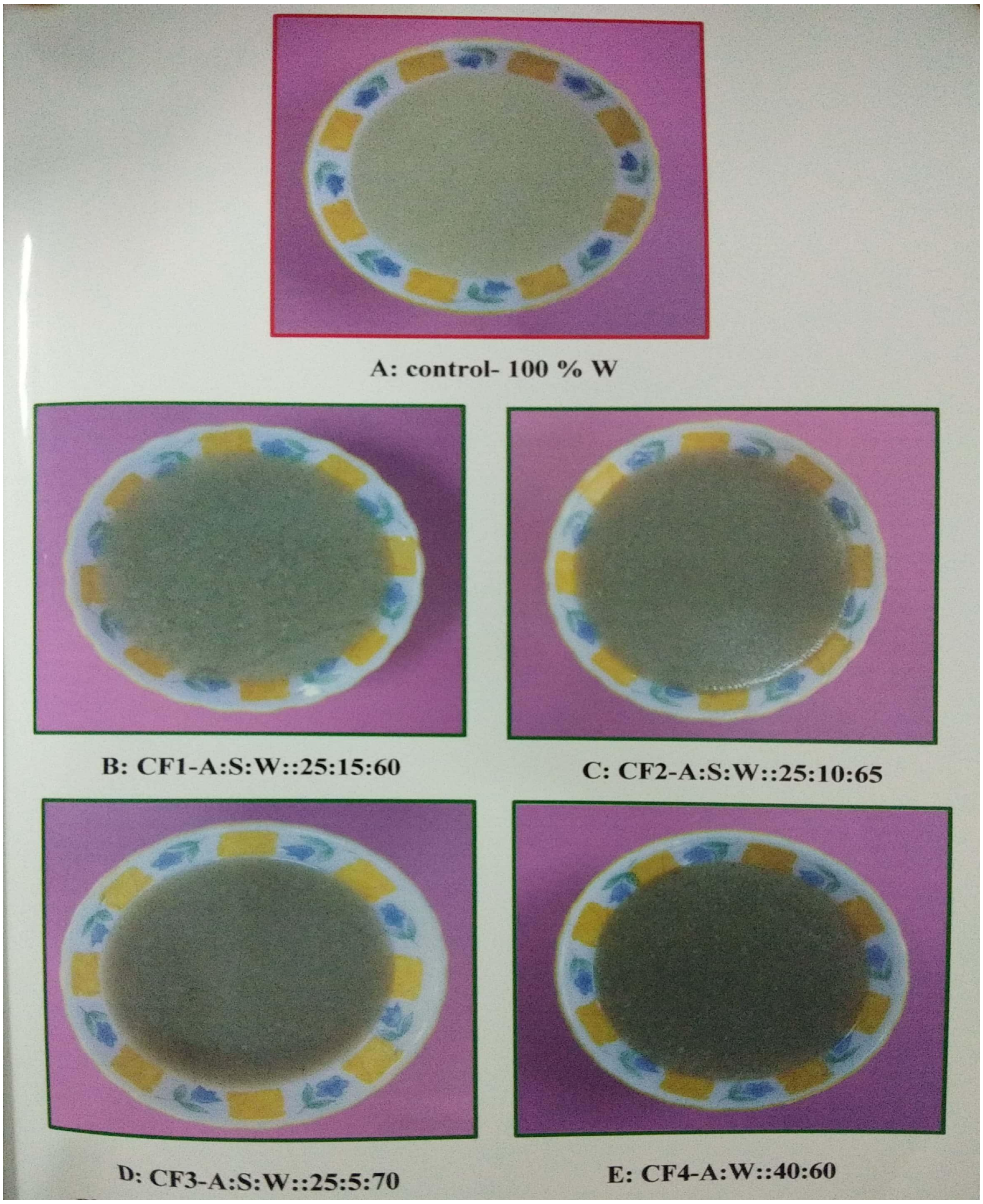

Fig. 2. *Lapsi* prepared from control and experimental composite flours (CF1:CF4)

3.3.1 Sensory evaluation of *roti*

Sensory quality is the ultimate criterion for the acceptance of *rotis* [39]. The texture of *roti* determines their chewing and folding ability and therefore it plays an important role in justifying their overall acceptability. Mouth feel of *roti* relates to its easy tearing in mouth i.e. the *roti* should be chewy without being tough [40]. Mouth feel of *roti* should be smooth and not gritty [41].

Data on sensory evaluation for various sensory characteristics viz. colour, aroma, texture, mouth feel, taste and overall acceptability of *roti* made from different composite flours are given in Table 6. There was no significant difference found by incorporating 25% amaranth and 15% soybean in wheat in comparison to control *roti*s with respect to colour, aroma, texture, mouth feel, taste and overall acceptability (Table 6).

Table 6. Mean sensory scores of *roti* on a nine point Hedonic scale (N=20) [1,2]

Composite Flours	Colour	Aroma	Texture	Taste	Mouthfeel	Overall acceptability
CF1	7.8^{a}	8.0^{b}	8.3^{a}	8.3^{a}	7.7^{a}	8.0^{a}
CF2	8.0^{a}	8.6^{a}	8.4^{a}	8.4^{a}	7.8^{a}	8.4^{a}
CF3	7.8^{a}	8.8^{a}	8.1^{a}	8.2^{a}	7.9^{a}	8.3^{a}
CF4	6.6^{b}	8.7^{a}	7.0^{b}	6.7^{b}	6.2^{b}	6.9^{b}
Control	8.1^{a}	8.8^{a}	8.6a	8.6^{a}	8.3^{a}	8.6^{a}

Notes- 1 Mean values sharing the same superscript within a column are not significantly different from each other at p=.05; 2 Scores 9= Liked extremely, 8= Liked very much, 7= Liked moderately, 6=Liked slightly, 5= Neither like nor dislike, 4= Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely

Table 7. Mean sensory scores of *lapsi* on a nine point Hedonic scale (N=20) [1,2]

Composite Flours	Colour	Aroma	Texture	Taste	Mouthfeel	Overall acceptability
CF1	6.8^{c}	7.2^{a}	7.4^{a}	7.0^{b}	7.8^{a}	7.2^{b}
CF2	7.4b^{a}	7.4^{a}	7.6^{a}	8.2^{a}	7.8^{a}	8.6^{a}
CF3	7.8^{a}	7.0^{a}	7.4^{a}	8.0^{a}	7.6^{a}	8.5^{a}
CF4	7.0^{ac}	7.6^{a}	6.5^{b}	6.5^{bc}	6.5^{b}	6.4^{c}
Control	8.0^{a}	7.4^{a}	8.0^{a}	8.0^{a}	8.2^{a}	8.0^{a}

Notes- 1 Mean values sharing the same superscript within a column are not significantly different from each other at p=.05; 2 Scores 9= Liked extremely, 8= Liked very much, 7= Liked moderately, 6=Liked slightly, 5= Neither like nor dislike, 4= Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely

3.3.2 Sensory evaluation of *lapsi*

Data on sensory evaluation of *lapsi* made from different composite flours is given in Table 7. The sensation of taste and smell are functions of flavour, which is a complex of sensations [42]. Flavour of a food ultimately determines its acceptance or rejection, even though its appearance induces the first response. The mouth feel is very important in a complementary food as it will determine the amount of food consumed since smooth gruels are preferred over coarse ones.

Graininess in CF4 composite sample led to lower scores for textural properties of *lapsi*. Beyond 10% soybean incorporation in wheat along with amaranth 25% was not acceptable in *lapsi*. Hence it can be concluded that replacing wheat flour with 25% popped amaranth and 10% soybean flour gave a greatly acceptable blend for preparing *lapsi*. Popping and puffing imparted acceptable taste and desirable aroma to the products made from pseudo-cereals like amaranth [43].

The above results revealed that all composite flours were found as an excellent source of nutrients and marked up to a satisfactory level for the sensory parameters. The most acceptable were CF1 (composite flour having 25% amaranth, 15% soybean and 60% wheat flour)and CF2 (composite flour having 25% amaranth, 10% soybean and 65% wheat flour) for *roti* and *lapsi* preparations, respectively.

4. CONCLUSION

This study has shown that blending wheat flour with soybean and amaranth resulted in a healthy nutritive product. Sensory evaluation showed different response. The *roti* and *lapsi* became more acceptable with decrease in soybean and amaranth content. All the food products samples were edible. Further studies to find methods of improving the sensory qualities of *roti* and *lapsi* need to be carried out. *Roti* made from amaranth and soybean incorporated composite flours with better protein content and low available carbohydrates and physiological energy almost same as control would be better diet alternative to diabetic and overweight patients. *Lapsi* from amaranth and soybean incorporated composite flours may be included in the supplementary nutrition programmes like Integrated Child Development Services and Mid Day Meal programme and will go a long way in alleviating malnutrition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pomeranz Y. Advances in cereal science and technology. Minnesota, USA: American Association of Cereal Chemists Inc.; 1972.
2. Noorfarahzilah M, Lee JS, Sharifudin MS, Mohd Fadzelly AB, Hasmadi M. Applications of composite flour in development of food products. International Food Research Journal. 2014;21(6):2061-2074.
3. Menon L, Majumdar SD, Ravi U. Development and analysis of composite flour bread. Journal of Food Science and Technology. 2015;52(7):4156-4165.
4. Singh M, Sharma NS, Khatkar BS. End use quality of Indian wheats: Milling properties and composition. Journal of Food Science and Technology. 2006; 43(3):322-324.
5. Sharma A, Rao VS, Bhagwat SG, Bapat MM. Elongation curve for evaluating chapatti making quality of whole wheat flour and its relation with other quality parameters. Journal of Food Science and Technology. 2004;41(2):160-164.
6. Rao PH, Leelavathi K, Shurpalekar SR. Test baking of chapati- Development of a method. Cereal Chemistry. 1986;63(4): 297-303.
7. Hemalatha MS, Prasada Rao UJS, Leelavathi K, Salimath PV. Influence of amylases and xylanase on chemical, sensory, amylograph properties and microstructure of chapatti. LWT-Food Science and Technology. 2010;43(9): 1394-1402.
8. Mehta PS, Negi KS, Ojha SN.Native plant genetic resources and traditional foods of Uttarakhand Himalaya for sustainable food security and livelihood. Indian Journal of Natural Products and Resources. 2010; 1(1):89-96.
9. Ndife J, Abdulraheem LO, Zakari UM. Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends. African Journal of Food Science. 2011; 5(8):466-472.
10. Onuegbu NC, Ihediohanma NC, Odunze OF, Ojukwu M. Efficiency of wheat: maize composite flour as affected by baking method in bread and cake production. Sky Journal of Food Science. 2013;2(8):5-13.
11. Adebowale AA, Adegoke MT, Sanni SA, Adegunwa MO, Fetuga GO. Functional properties and biscuit making potentials of sorghum-wheat flour composite. American Journal of Food Technology. 2012;7(6): 372-379.
12. Mugalavai VK. Effect of amaranth: Maize flour ratio on the quality and acceptability of Ugali and Porridge (Kenya cereal staples). Journal of Agricultural and Biological Science. 2013;8(1):6-12.
13. Sindhuja A, Sudha ML, Rahim A. Effect of incorporation of amaranth flour on the quality of cookies. European Food Research Technology. 2005;221:597-601.
14. Kulkarni SD. Importance of soy food products for food and nutrition security. In National Seminar on Food Security- Issues and Challenges in New Delhi, India. New Delhi: Institution of Engineers; 2015.
15. Julianti E, Rusmarilin H, Ridwansyah EY. Functional and rheological properties of composite flour from sweet potato, maize, soybean and xanthan gum. Journal of the Saudi Society of Agricultural Sciences. 2015;16(2):171-177.
16. Lara N, Ruales J. Popping of amaranth grain (*Amaranthus caudatus*) and its effect on the functional, nutritional and sensory properties. Journal of the Science of Food and Agriculture. 2002; 82(8):797-805.
17. Austin A, Ram A. Studies on chapatti making quality of wheat. Technical Bulletin No. 31. New Delhi: Indian Council of Agricultural Research; 1971.
18. AOAC. Official Methods of Analysis of the Association of Official Analytical Chemists. 16th ed. Washington D. C., U. S. A; 1995.
19. Pearson D. The dictionary of nutrition and food technology. 5th Ed. London: Butterworth Publication; 1976.
20. Mudambi RS, Rao MS. Food science. Chennai: New Age International (P) Publishers Ltd.; 1989.
21. Yadav R, Singh SS, Jain N, Singh GP, Prabhu KV. Wheat production in India: Technologies to face future challenges. Journal of Agricultural Science. 2010; 2(2):164-173.
22. Amerine NA, Pangborn RM, Roessler EB. Principles of sensory evaluation of food. New York: Academic Press; 1965.
23. Snedecor GW, Cochran, W.G. Statistical Methods. 6th Ed. Calcutta: Oxford IBH Publishing Co.; 1967.

24. Anton AA, Ross KA, Lukow OM, Fulcher RG, Arntfield SD. Influence of added bean flour (*Phaseolus vulgaris* L.) on some physical and nutritional properties of wheat flour tortillas. Food Chemistry. 2007;109: 33-41.
25. Ouazib M, Dura A, Zaii F, Rosell CM. Effect of partial substitution of wheat flour by processed (germinated, toasted, cooked) chickpea on bread quality. International Journal of Agricultural Science and Technology. 2016;4(1):8-18.
26. Fenn D, Lukow OM, Humphreys G, Fields PG, Boye JI. Wheat-legume composite flour quality. International Journal of Food Properties. 2010;13:381-393.
27. Emire SA, Arega M. Value added product development and quality characterization of amaranth (*Amaranthus caudatus* L.) grown in East Africa. African Journal of Food Science and Technology. 2012;3(6): 129-141.
28. Aiyesanmi AF, Oguntokun MO. Nutrient composition of *Dioclea reflexa* seed an underutilized edible legume. Rivista Italiana delle Sostanze Grasse. 1996; 73:521-523.
29. Khan MI, Anjum FM, Zahoor T, Sarwar M, Wahab S. Nutritional characterization of the wheat-soy unleavened flat bread by rat bioassay. Sarhad Journal of Agriculture. 2009;25(1):73-80.
30. Kadam ML, Salve RV, Mehrajfatema ZM, More SG. Development and evaluation of composite flour for *missi roti* and *chapatti*. Journal of Food Processing and Technology. 2012;3(1):1000134.
31. Awolu OO, Osemeke RO, Ifesan BOT. Antioxidant, functional and rheological properties of optimized composite flour, consisting wheat and amaranth seed, brewers' spent grain and apple pomace. Journal of Food Science and Technology. 2016;53(2):1151-1163.
32. Chauhan A, Saxena DC, Singh S. Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. Cogent Food & Agriculture. 2016;2:1125773.
33. Okaka JC, Akobundu ENT, Okaka ANC. Human Nutrition (An Integrated Approach). Enugu: Esut Publ. 1992;92-94.
34. Li W, Dobras Zezyk BJ, Schofield JD. Stress relaxation behaviour of wheat dough, gluten and gluten protein fractions. Cereal Chemistry. 2003;80:333-338.
35. Khan MA, Anjum FQ, Zahoor T, Sarwar M, Wahab S. Nutritional characterization of the wheat-soy unleavened flat bread by rat bioassay. 2009;25(1):73-80.
36. WHO. Report on energy and protein requirements. WHO Technical report series No.724. Geneva: WHO; 1985.
37. Rastogi A, Shukla S. Amaranth: A new millennium crop of nutraceutical values. Critical Reviews in Food Science and Nutrition. 2013;53(2):109-125.
38. Sood A, Singh BB, Saxena MC. The value of Indian soybean. Agriculture Journal of India. 1980;9:308-309.
39. Mir SA, Naik HR, Shah MA, Mir MM, Wani MH, Bhat MA. Indian Flat Breads: A Review. Food and Nutrition Sciences. 2014;5:549-561.
40. Al-dmoor HM. Flat bread: Ingredients and fortification. Quality Assurance and Safety of Crops & Foods. 2012;4:2-8.
41. Ebeler SE, Walker CE. Wheat and composite flour *chapaties*: Effect of soy flour and sucrose-ester emulsifiers. Cereal Chemistry. 1983;60(4):270-275.
42. Iwe MO. Current Trends in Sensory Evaluation of Foods. Enugu: Rojoint Comm. Services Ltd. 2007;46-47.
43. Mishra G, Joshib DC, Panda BK. Popping and puffing of cereal grains: A review. Journal of Grain Processing and Storage. 2014;1(2):34-46.