Original Research Article

DEVELOPMENT AND EVALUATION OF AMARANTH-SOY-WHEAT COMPOSITE FLOURS

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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: Sample: 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.

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]. 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[4], wheat/maize[5], wheat/sorghum[6], amaranth/maize[7] and amaranth/wheat[8] in different food items such as bread, cake, biscuits, porridge and cookies, respectively. Scanty information has been available on the development of composite flour made from amaranth, soybean and wheat. The need for nutritional enhancement of traditional food products like *roti* and *lapsi* utilizing 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. MATERIAL AND METHODS

2.1 Materials

Raw materials like wheat grains, white soybean grains and sugar were procured from the local market of Pantnagar. Locally grown, pale yellow colour amaranth grains were purchased from local market of Almora, Uttarakhand. The preparation of popped amaranth flour was done[9]. Amaranth grains were cleaned and washed with potable water and dried in an air oven at 50-55°C for 1h then popped by a domestic grain popper (Skyline Hot Air Popper, VI-4040, India) based on high temperature short time (HTST) principle at 240°C for 2-3 min.

2.2 Preparation of flours

For the preparation of soybean flour, grains were cleaned free of broken/damaged grains, washed and soaked for 2-3h in clean potable water in the proportion of 1kg soybean:3l water (w/v). Grains were then boiled in a pressure cooker for 5-10min followed by dehulling and drying in the oven at 50ºC for 24h and subsequent grinding in an electric grinder (Inalsa mixer grinder, Compact Lx, Delhi, India) followed by sieving through 20 mesh or 0.841mm sieve[10, 11].

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 3h. After this grinding was done in an electric grinder (Inalsa mixer grinder, Compact Lx, Delhi, India) followed by sieving with a 0.841mm sieve[4].

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 % incorporation of both, which could be used in formulating composite flours in the present study. 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[12], ash[12], crude protein[13], crude fat[14] and crude fibre[14], calcium[12], and iron[12] content in composite flours. Total[15] and available[15] carbohydrate by difference and physiological energy[16] was also determined[15].

2.5 Preparation of food products

Roti from different composite flours was prepared[17]. For the preparation of *roti,* 100gm 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[18].

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)[19]. Sensory evaluation was done by a semi-trained panel consisting 20 members 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[20].

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[21] 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. In case of *lapsi*, minly 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.

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

Different proportions: Wheat	Different proportions: Amaranth	Observed Characteristics of *Roti* – Dough: Hardness (Strong/ Weak)	Observed Characteristics of *Roti* – Dough: Texture (Smooth / Grainy)	Observed Characteristics of *Roti* – *Roti*: Rolling (Easy/ Difficult)	Observed Characteristics of *Roti* – *Roti*: Texture (Soft/ Semi soft/ Hard)	Observed Characteristics of *Lapsi*: Flavour (Acceptable / Not acceptable)	Observed Characteristics of *Lapsi*: 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***	
		Dough		***Roti***			
Wheat	**Soybean**	**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

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 nalysed using ANOVA.

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

3.2 Sensory Evaluation of Food Products made from Composite Flours

Two traditional food products namely *roti* and *lapsi* 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.

3.2.1 Sensory evaluation of *roti*

Sensory quality is the ultimate criterion for the acceptance of *rotis*[22]. 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[23]. Mouth feel of *roti* should be smooth and not gritty[24]. 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 4. 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 4).

Table 4. 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

3.2.2 Sensory evaluation of *lapsi*

Data on sensory evaluation of *lapsi* made from different composite flours is given in Table 5. The sensation of taste and smell are functions of flavour, which is a complex of sensations[25]. 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[26].

Table 5. Mean sensory scores of *lapsi* on a nine point Hedonic scale (N=10)[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 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.

3.3.1 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 6.

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 %, which were below the African standard for composite flour i.e. 13.5 %[27].

Total ash represents total mineral content of foodstuff. The data presented in Table 5 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.

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[28] that were incorporated in composite flour formulation.

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[29]. The data presented in (Table 5) 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[30,31]. Similar results have been reported in crude fat content upon substitution of amaranth in wheat[32,33].

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[34]. Fibre adds bulk or weight to food products and it requires much water during hydration[35]. 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).

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.

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 or 4.19 kJ/g for children 2 to 5 years.

Table 6. Proximate composition of four composite flours (CF1-CF4) and control[1, 2]

Components	Moisture (g)	Dry Weight Basis (per 100g)[1]						
		Ash (g)	Crude protein (g)	Crude fat (g)	Crude fibre (g)	TCHO (g)	ACHO (g)	PCHO (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

3.3.2 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 7. 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 7 revealed that the iron content in different composite flours was in the range of 5.54 (Control) to 9.79 mg/100g. From the present study it was concluded that all the experimental flours contained an appreciably good (8.74-9.79 mg/100g) amount of iron. This is supported by the high values of iron in amaranth (7.59-17.4 mg/100g) and soybean (44.9-83.7 mg/100g)[37,38].

Table 7. Calcium and iron content of per 100g 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

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

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. *Lapsi* from amaranth and soybean incorporated composite flours may be included in the supplementary nutrition programmes like ICDS and Mid Day Meal programme and will go a long way in alleviating malnutrition.

COMPETING INTERESTS

None

CONSENT (WHERE EVER APPLICABLE)

Not applicable

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Not applicable

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