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Development of functional flour using malted cereals and legumes

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Abstract
New composite flour mixes are being introduced by emerging food industries and also by the health professionals and nutritionists in order to combat with the deep rooted food insecurity, malnutrition and certain diseases in children and adults. These composite flour mix prepared by combining cereals and legumes are economical which contain locally available ingredients to improve the overall food and nutritional quality. The composite flour mix was developed using sorghum flour, whole wheat flour, khesari dal flour, sweet potato flour and flax seed flour at different level of incorporation. Hence the present study was undertaken in an attempt to develop composite flour mix from functional ingredients.

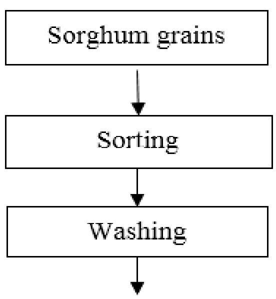
Keywords: functional foods, composite flour mix

1. Introduction
In the 21st century the new lifestyle adopted by people has changed their basic food leading to consumption of more processed foods which leads to a number of lifestyle disorders and onset of metabolic diseases due to improper nutrition. In 1964, FAO initiated the concept of composite flour technology targeting the use of indigenous crops such as millets, legumes and other root crops in substitution of wheat flour to improve the food availability and food security of the population. The composite flour concept is a growing concept that is gaining wider recognition and acceptance amongst nutrition scientists, being a simple sensible scientific approach in harnessing of nutrient sources to meet human needs. It has been used to develop food products for clinical and non-clinical population groups (Zotor *et al.*, 2015) [9].

New composite flour mixes are being introduced by emerging food industries and also by the health professionals and nutritionists in order to combat with the deep rooted food insecurity, malnutrition and certain diseases in children and adults. These composite flour mix prepared by combining cereals and legumes are economical which contain locally available ingredients to improve the overall food and nutritional quality (Almeida-Dominguez *et al.* 1993) [2].

2. Materials and Methods
White Sorghum (*Sorghum bicolor* Moench) grains, Khesari dal (*Lathyrus Sativus*), whole wheat flour, sweet potato and flax seeds were selected for the present study due to their easy availability, accessibility, high therapeutic value and nutraceutical properties.

2.1 Processing of raw materials



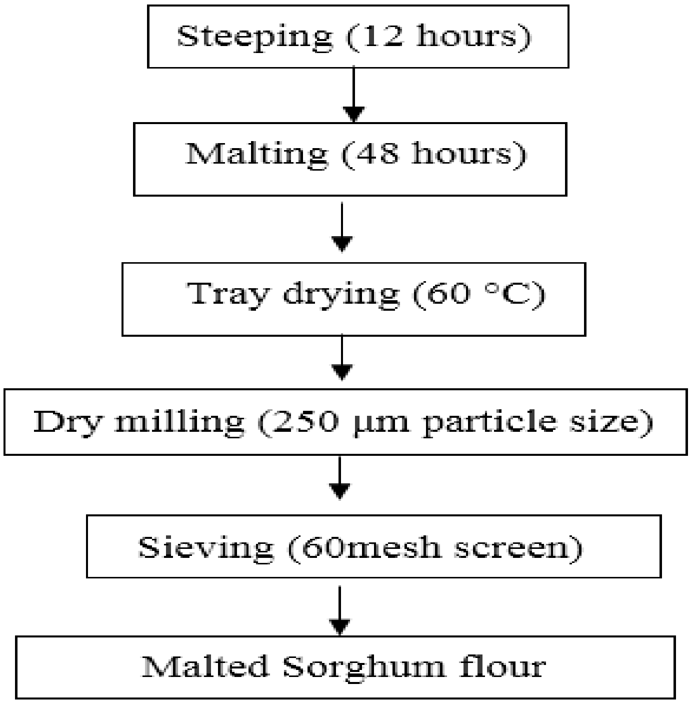


Fig (A): Flow Diagram of Processing Sorghum Grains into Malt Flour

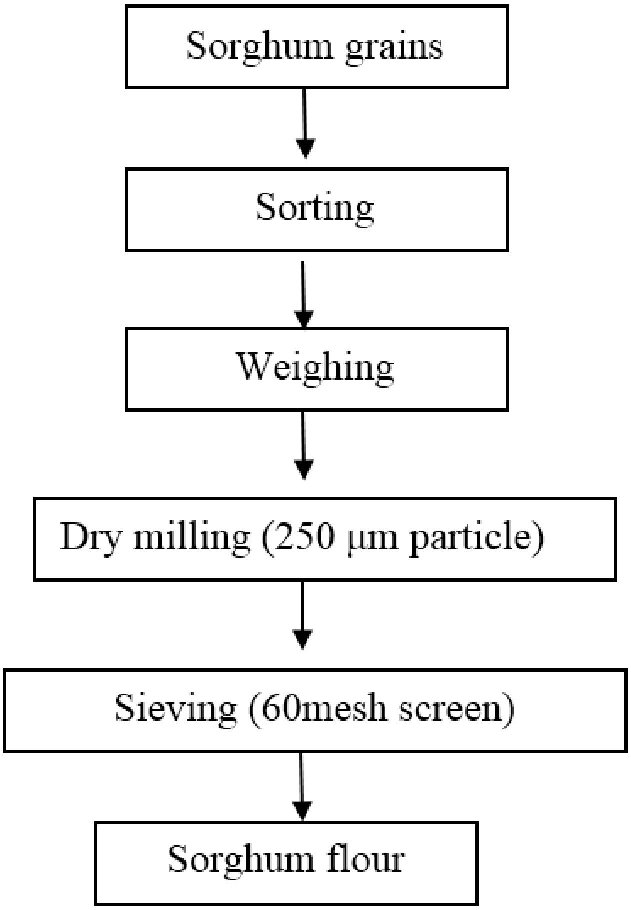


Fig (B): Flow diagram of processing sorghum grains into flour

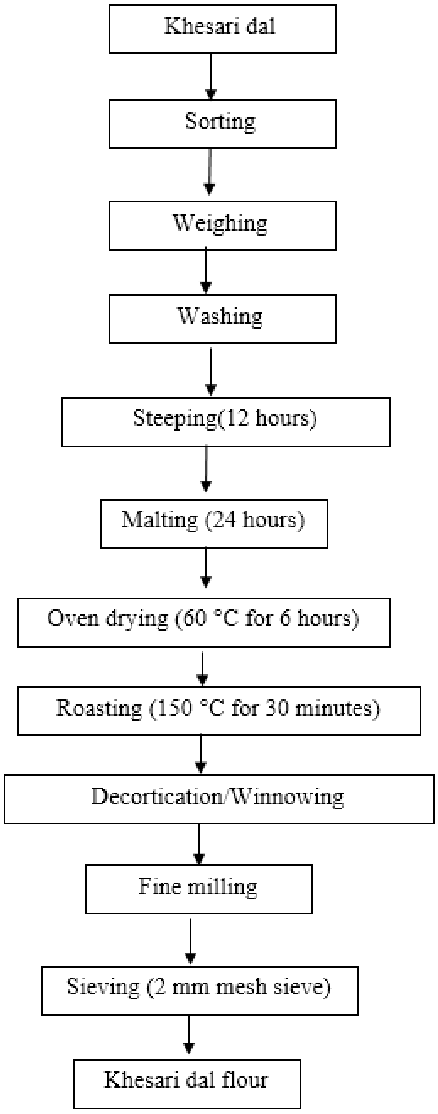


Fig (C): Flow Diagram of Processing Khesari Dal Into Malt Flour

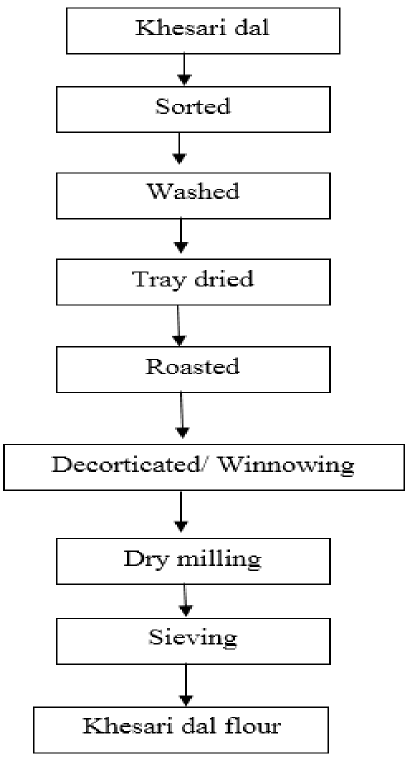


Fig (D): Flow Diagram of Processing Khesari Dal into Khesari Dal Flour

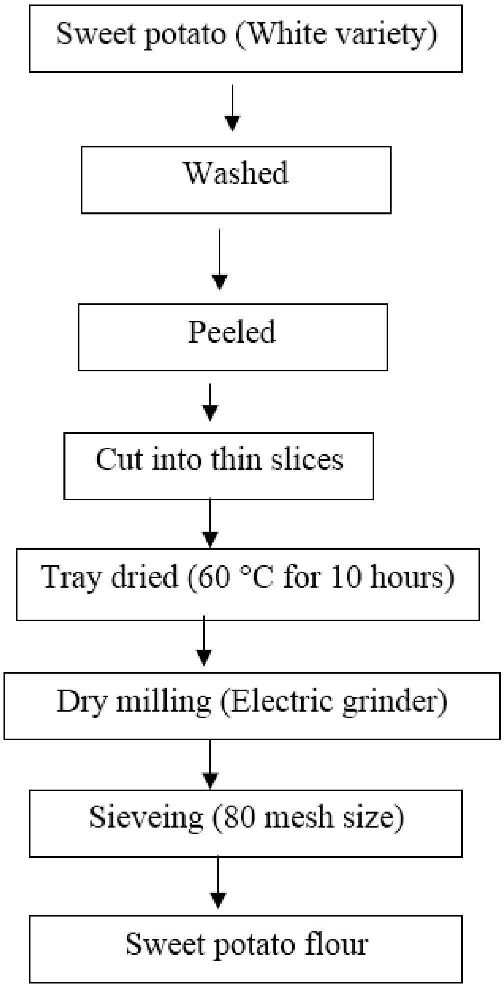


Fig (E): Flow Diagram of Processing Sweet Potato Into Flour

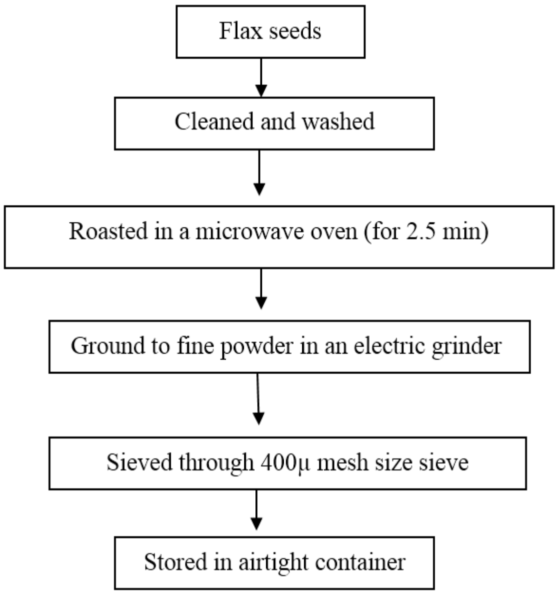


Fig (F): Flow Diagram of Processing Flax Seeds into Flour

2.2 Formulation of unmalted sorghum based composite flour and malted sorghum based composite flour

The composite flour was developed from both unmalted sorghum flour, whole wheat flour, unmalted khesari dal flour sweet potato flour and flax seed flour and malted sorghum flour, whole wheat flour, malted khesari dal flour sweet potato flour and flax seed flour at different level of incorporation. For development of composite flour different combinations were used, the flour were prepared using the ingredients in different levels of incorporation. The composite flour was prepared in five different ratios viz., 100, 80:20, 70:30, 60:40, 50:50.

2.3 Proximate analysis of the accepted sorghum based composite flour mix

The nutrient composition of composite flour developed from unmalted sorghum based composite flour mix and malted sorghum based composite flour mix were estimated with standard procedures of AOAC, 2000 [3].

3. Results and Discussion

The composite flour was prepared in five different formulations from both un malted sorghum based composite flour mix and malted sorghum based composite flour mix viz., UMSBCF1(100), UMSBCF2(80:5:5:5:5), UMSBCF3(70:7.5:7.5:7.5:7.5), UMSBCF4(60:10:10:10:10) and UMSBCF5(50:12.5:12.5:12.5:12.5) and MSBCF1(100), MSBCF2(80:5:5:5:5), MSBCF3(70:7.5:7.5:7.5:7.5),MSBCF4(60:10:10:10:10) and MSBCF5(50:12.5:12.5:12.5:12.5) respectively. For the development of functional foods and product categorization a total of five samples from each sorghum based composite flour mix were developed using un malted and malted cereals and legumes that include sorghum flour, khesari dal flour, whole wheat flour, sweet potato flour and flaxseed flour at different level of incorporation.

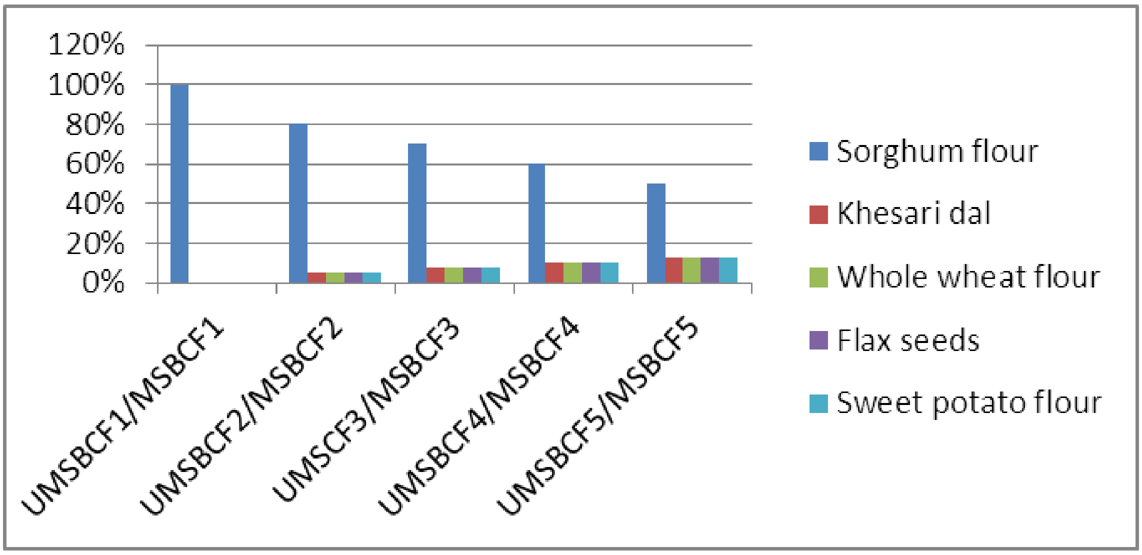


Fig 1: Formulation of sorghum based composite flour mix using unmalted and malted cereals and legumes

3.1 Physicochemical analysis of accepted sorghum based composite flour mix (unmalted and malted)

3.1.1 Determination of water holding capacity and oil absorbtion capacity

The highest water holding capacity among the unmalted sorghum based composite flour mix in UMSBCF4 was 2.23 g water/100g followed by UMSBCF3 was 2.22 g water/100g and UMSBCF2 had 2.17 g water/100 g respectively. Similarly in the malted sorghum based composite flour mix the highest water holding capacity of MSBCF4 was 3.09 g water/100g, MSBCF3 was 3.01 g water/100g and MSBCF2 was 2.82 g water/100 g respectively. Similarly the oil absorbtion of malted sorghum based composite flour mix was significantly higher ($P \le 0.05$) than the malted sorghum based composite flour mix. The highest oil absorbtion among unmalted sorghum based composite flour mix in UMSBCF4 was 2.65 g/100g followed by UMSBCF3 was 2.61 g/100g and UMSBCF2 was 2.56 g/100 g respectively. Similarly in malted sorghum based composite flour mix the highest oil absorbtion of MSBCF4 was 3.53 g/100g followed by MSBCF3 was 3.10 g/100g and MSBCF2 was 2.67 g/100 g respectively. The water holding capacity and oil absorbtion capacity of malted sorghum based composite flour mix was significantly higher ($P<0.05$) than the unmalted sorghum based composite flour mix. The increased capacity of flour to absorb and retain water and oil may help to improve binding of the structure, enhance flavor retention, improve mouth feel and reduce moisture loss from the food materials (Prinyawiwatkul *et al*., 1997) [8].

According to Abu *et al.* (2006) [1], oil absorption in starch relies predominantly on the physical entrapment of oil within the starch structures as starch doesnot poses nonpolar sites compared to those found in proteins.

Table 1: Physical characteristics of sorghum based composite flour mix

Treatment	Water holding capacity (g)	Oil absorbtion Capacity (g)
UMSBCF2	$2.17^d \pm 0.05$	$2.56^f \pm 0.05$
UMSBCF3	$2.22^d \pm 0.02$	$2.61^e \pm 0.04$
UMSBCF4	$2.23^d \pm 0.1$	$2.65^d \pm 0.01$
MSBCF2	$2.82^c \pm 0.2$	$2.67^c \pm 0.11$
MSBCF3	$3.01^b \pm 0.02$	$3.10^b \pm 0.2$
MSBCF4	$3.09^a \pm 0.01$	$3.53^a \pm 0.1$
CD (5%)	0.05	0.01

Values are expressed in mean ± SD (Standard Deviation)
Means within rows separated by Duncan’s multiple range test
NS- Not Significant
Means followed by the same letter shown in superscript(s) are not significantly different
UMSBCF 2-20% incorporation
UMSBCF 3-30% incorporation
UMSBCF 4-40% incorporation
MSBCF 2-20% incorporation
MSBCF 3-30% incorporation
MSBCF 4-40% incorporation

3.2 Proximate analysis of accepted sorghum based composite flour mix (unmalted and malted)

Table 2: Nutrient composition of the accepted sorghum based composite flour mix

Nutrients	Sorghum based composite flour mix					
	Un malted sorghum based composite flour mix			Malted sorghum based composite flour mix		
	UMSBCF2	UMSBCF3	UMSBCF4	MSBCF2	MSBCF3	MSBCF4
Moisture (g)	$6.6^{f}\pm0.08$	$6.9^{e}\pm0.09$	$7.3^{d}\pm0.08$	$7.9^{c}\pm0.08$	$8.4^{b}\pm0.09$	$9.6^{a}\pm0.08$
Fat (g)	$5.90^{c}\pm0.08$	$6.39^{b}\pm0.08$	$7.42^{a}\pm0.09$	$2.41^{f}\pm0.08$	$3.12^{e}\pm0.08$	$4.09^{d}\pm0.08$
Protein (g)	$13.00^{e}\pm0.09$	$13.08^{d}\pm0.09$	$13.37^{c}\pm0.09$	$14.01^{d}\pm0.08$	$14.50^{b}\pm0.05$	$14.90^{a}\pm0.04$
Crude fibre	$12.02^{NS}\pm0.09$	$12.62^{NS}\pm0.01$	$13.00^{NS}\pm0.01$	$13.63^{NS}\pm0.09$	$13.91^{NS}\pm0.08$	$14.26^{NS}\pm0.09$
Total Carbohydrate(g)	$74.64^{NS}\pm0.09$	$71.28^{NS}\pm0.09$	$66.05^{NS}\pm0.08$	$76.28^{NS}\pm0.06$	$71.71^{NS}\pm0.02$	$68.24^{NS}\pm0.08$
Total mineral content (g)	$2.28^{c}\pm0.08$	$2.20^{e}\pm0.08$	$3.01^{f}\pm0.08$	$2.04^{d}\pm0.09$	$2.27^{d}\pm0.05$	$2.67^{b}\pm0.02$

Values are expressed in mean ± SD (Standard Deviation)
Means within rows separated by Duncan's multiple range test P = 0.01

Means followed by the same letter shown in superscript(s) are not significantly different.
NS- Not Significant
UMSBCF 2: 20% incorporation
UMSBCF 3: 30% incorporation
UMSBCF 4: 40% incorporation
MSBCF 2: 20% incorporation
MSBCF 3: 30% incorporation
MSBCF 4: 40% incorporation

3.2.1 Moisture
Table 4.9 represent the moisture content of different sorghum based composite flour mix. The moisture content of unmalted sorghum based composite flour mix were UMSBCF2 was 6.6 ±0.08 g/100g followed by UMSBCF3 was 6.9±0.09 g/100g and UMSBCF4 was 7.3±0.08 g/100g. Similarly for malted sorghum based composite flour mix the moisture content of MSBCF2 was 7.9±0.08 g/100g followed by MSBCF3 was 8.4±0.09 g/100g and MSBCF4 was 9.6±0.08 g/100g respectively. It was observed that the malted sorghum based composite flour mix had significant increase ($P\leq0.05$) in moisture content compared to unmalted sorghum based composite flour mix.
The values of the present study was similar to the study conducted by Luo *et al.* (2014), They stated that the high moisture content might be due to the fact that during germination and malting, the whole grains absorbs moisture from the soaking medium for their physiological and biochemical changes. Seed germination starts with the imbibition of water by dry seed coat which becomes permeable during steeping and as a result an enormous increase in moisture content occurs.

3.2.2 Crude Fat
Fat is a concentrated source of energy which increases the energy density of a diet (Gopalan *et al*. 2004) [4]. The fat content of unmalted sorghum based composite flour mix UMSBCF2 was 5.90±0.08 g/100g followed by UMSBCF3 was 6.39±0.08g/100g and UMSBCF4 was 7.42±0.09 g/100g. Similarly the fat content of malted sorghum based composite flour mix MSBCF2 was 2.41±0.08 g/100g followed by MSBCF3 was 3.12±0.08 g/100g and MSBCF4 was 4.09±0.08 g/100g respectively. The fat content of unmalted sorghum based composite flour mix was significantly lower ($P<0.05$) than that of the malted sorghum based composite flour mix. In 2013, D'souza also found significant decrease ($P\leq0.01$) in fat content of a composite flour developed from mixed cereal grains and germinated field beans which was due to loss of fat content in steeping water and the use of stored fats for sprouts to grow during germination.

3.2.3 Crude Protein
The protein content of unmalted sorghum based composite flour mix UMSBCF2 was 13.00±0.09 g/100g followed by UMSBCF3 was 13.08±0.08 g/100g and UMSBCF4 was 13.37±0.09 g/100g. Similarly the protein content of malted sorghum based composite flour mix MSBCF2 was 14.01±0.08 followed by MSBCF3 was 14.50±0.05 g/100g and MSBCF4 was 14.90±0.04 g/100g respectively. The malted sorghum based composite flour mix had significant increase ($P\leq0.05$) in protein content compared to unmalted sorghum based composite flour mix The higher value of protein content may be due to *in-situ* composition of food ingredients viz. Sorghum flour, khesari dal, sweet potato and flax seeds**.** The enhancement of protein concentration of the malted grains are significantly higher than that of the unmalted grains, this could be attributed to the metabolic processes occurring during grain germination which has led to the mobilization of storage nitrogen of the grains to produce the nutritionally high quality protein needed by the developing radical and plumule for their growth (Hussain, 2008) [7].

3.2.4 Crude fiber content
Numerous studies have shown that crude fibre prevents constipation, increase the mass and volume of feaces, accelerates intestinal peristalsis and has an inhibitory effect on the development of tumors in the large intestine. The crude fibre content of unmalted sorghum based composite flour mix UMSBCF2 was 12.02±0.09g/100g followed by UMSBCF3 was 12.62±0.01 g/100g and UMSBCF4 was 13.00±0.01g/100g. Similarly the crude fibre content of malted sorghum based composite flour mix MSBCF2 was 13.63±0.09 g/100 g followed by MSBCF3 was 13.91±0.08 g/100g and MSBCF4 was 14.26±0.09 g/100g respectively. Many researchers reported that intake of functional ingredients like cereals, legumes and oilseeds in the diet had a tremendous mode to increase daily dietary fiber by 10-15% in the diet (Lohia and Udipi 2015) [6].
The crude fibre content of malted sorghum based composite flour mix were *at par* with the crude fibre content of unmalted sorghum based composite flour mix

3.2.5 Total Carbohydrate
The available Carbohydrate of unmalted sorghum based composite flour mix UMSBCF2 was 74.64±0.09 g/100g followed by UMSBCF3 was 71.28±0.09 g/100g and UMSBCF4 was 66.05±0.08 g/100g. Similarly the available Carbohydrate of malted sorghum based composite flour mix MSBCF2 was 76.28±0.06 g/100g followed by MSBCF3 was 71.71±0.02g/100g and MSBCF4 was 68.24±0.08 g/100g respectively.

FAO/WHO recommended that a composite flour mix should provide more than 45% of carbohydrate per 100g of sample. The developed composite flour mixes provide an average 60-70 g of carbohydrates per 100 g of composite flour mixes which is sufficient to meet approximately 51% of daily carbohydrate requirement in adult man and woman as per Recommended Dietary Allowances. Thus, it can be concluded that all the sorghum based composite flour mixes developed were higher as compared with the recommended carbohydrate values.

3.2.6 Total mineral content

The total mineral content of unmalted sorghum based composite flour mix UMSBCF2 was 2.28±0.08 g/100g followed by UMSBCF3 was 2.20±0.08g/100g and UMSBCF4 was 3.01±0.08g/100g. Similarly the total mineral content of malted sorghum based composite flour mix MSBCF2 was 2.04±0.09g/100g followed by MSBCF3 was 2.27±0.05g/100g and MSBCF4 was 2.67±0.02 g/100g respectively (Table 4.9). Unmalted sorghum based composite flour mix had significant increase ($P \leq 0.05$) in total mineral content compared to malted sorghum based composite flour mix. Similar findings were reported by HB *et al.* (1999) [10] also observed that mineral content of sorghum flour significantly decreased after germination due to leaching of soluble minerals into water during soaking.

4. Conclusion

The present study provides substantial evidence that malting improves the nutritional and physico-chemical characteristics of formulated sorghum based composite flour mix. The food products developed using sorghum based composite flour mix has proven to possess immense functional properties in terms of protein, crude fibre, phytonutrients particularly phenolic compounds like total phenolics and total flavonoids and minerals with potent antioxidant capacity.

5. Recommendation

Sorghum considered as poor man's food and does not find place in the food purchase lists of the elite. Emphasis must be laid on to the popularization of consumption of sorghum through commercialization of value added products which is the need of time to suit the ever changing lifestyle of people.

6. Acknowledgement

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