Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 148 (2020) 54908-54911

ISSN: 2229-712X

Formulation and Quality Evaluation of Cereal-Legume Composite Flour prepared from Underutilized Crops

Abhitosh Dhungel[1,2], Waleed Al-Ansi[1,2,3],Md.Easdani[1,4] and Mingcong Fan[1,2]

[1] School of Food Science and Technology, State Key Laboratory of Food Science and Technology, Jiangnan University, 1800 Lihu Avenue, Wuxi 214122, China.

[2]National Engineering Research Center for Functional Food, Jiangnan University, 1800 Lihu Avenue, Wuxi 214122, China.

[3]Department of Food Science and Technology, Faculty of Agriculture, Sana'a University, Sana'a, Yemen.

[4]Department of Food Engineering and Technology, State University of Bangladesh.

ARTICLE INFO

Article history:

Received: 5 October 2020;
Received in revised form:
26 October 2020;
Accepted: 6 November 2020

Keywords

Composite flour,
Proximate Analysis,
Physical Properties.

ABSTRACT

This research was carried out to study of variation of composite flour prepared from underutilized staple food (Foxtail Millet, Naked Barley) and Legumes (Beans). Sensory, nutritional and physical properties of these products were analyzed. These variations were compared with composite flour prepared from commercially available cereal (wheat, maize) and legumes (Beans). Four formulations were prepared using foxtail millet, naked barley and legumes. The proportion of staple food and legumes were chosen in such a way that the resulting formulations contained crude protein not less than 14%. The formulations were coded as control A (wheat, maize and soybean in the ratio of 7:7:6), B1 (Foxtail Millet and Beans in the ratio of 3:2), B2 (Naked barley and beans in the ratio of 3:2), B3(Foxtail Millet and Bean in the ratio of 1:1), B4(Naked Barley and Bean in the ratio of 1:1). Crude protein in formulations ranged from 15.13±0.75 to 15.87±0.67, crude fat from 2.63±0.14 to 4.41±0.11, total ash from 2.49±0.06 to 3.36±0.36, carbohydrate from 70.71±0.45 to 73.2±0.75 and energy per 100gm from 369.99±0.78 to 386±0.65. Formulations B2 had highest Water Holding Capacity (1.77±50), Water Solubility of B1 was highest 12.86±0.24. Bulk Density of all the formulations including control A ranged from 0.49±0.07 to 0.53±0.067. Sensory evaluation of the formulations also scored high as compared with the control in taste, aroma and consistency.

1. Introduction

The application of cereal-legume blend to prepare different kinds of food products including porridge has been commonly practiced all over the world especially in African and Asian countries. Composite flours have also been used in many poor, economically backward community to alleviate the problems related with macro and micro nutrient deficiency (Udomkun et al., 2019). Kwashiorker, marasmus and other malnutrition related problem has been seen in the population consuming only cereal grains and other starchy roots and tubers are their staple food. As most of the cereals are deficient in essential amino acids like lysine and has low protein content, blending cereal flour with legumes increases the protein content of the composite flour and also legume complement the amino acid balance (Kayitesi et al., 2012) ,(Mosha, 2005). Solomon., 2000 has reported the increase in the protein content of the cereal-legume blend and suggested the blend to be used as weaning food and Suhasini and cereal-legume blend has also been reported to give complete amino acid profile to promote the growth (Suhasini & Malleshi, 2003). Composite flour mixture, stored as dry flour, should essential have high nutritional value in terms of both energy and protein content, supplement supplementary value, acceptability, low price and locally processed using local manufacture technique (E.M.DeMaeyer, 1976).

Underutilized crops, which has been used for centuries for their food, fibre and fodder, are cereals and legumes which have been reduced in their application and over time due to user constraints. Unrecognized nutritional value, poor product shelf life and quality and low consumer awareness might be an important factor for crops like naked barley, foxtail millet to be underutilized(Williams & Haq, 2000)

Foxtail millet (*Stalia italica*) is a small grained cereal, which is consumed by people living in arid and semi arid tropics of the world, distributed throughout the Asia and Africa. It is also very high in mineral content like calcium and phosphorus (Kajuna, 2001).Naked Barley (*Hordeum vulgare L.)* is a winter crop available in the high altitude region. It's outer cover called *pales* is loosely cemented to the grain and can be easily removed by normal threshing. Study suggests that it has been cultivated in the asia for thousands of years(E. Dickin1, 2010). These Asian varieties of hullless barley has different health traits and variation in food compared with the commercially available barley varieties. Mostly used dietary beans, which are the varieties of *Phaseolus vulgaris* L., herbaceous annual plants of the Fabaceae (legume or bean) family, are very diverse species of the legumes growing in wide range of geographical regions(Teixeira-Guedes et al., 2019). They are good source of protein, complex carbohydrate and low dietary fat along with low glycemic index. The main problem imposed by legumes like beans are related with their cooking difficulties, high flatulence, presence of antinutritional compounds like saponins, lectins and phytic acid. To reduce these hurdles imposed by the legumes in the diet many processing methods have been suggested and germination is one of the most cheapest method to alleviate these problems.(Setia et al., 2019)

Access to the composite flour made from commercially available cereals are usually expensive and are mostly out of reach to the economically challenged population living in rural and geographically challenged situation(M.R Haque, 2013). Use and application for these underutilized cereals and legumes can be used as an important food for the affordability of the population living in these areas, by making these cereal-legume blend nutritionally dense, easily digestible and cheap(Gulzar, 2011).

This paper compares the nutritional attributes of the composite flour prepared from the blend of foxtail millet, naked barley and germinated beans in different ratio with the commercially available blends prepared from wheat, maize and soybean.

2. Methods and Methodology

2.1 Procurement of materials and preparation of flour

Cereals (Naked barley, Foxtail millet, Wheat, Maize) and legumes (Soybean, Cranberry Beans) were procured from the Chinese market. All the cereals were dehulled prior to the procurement while legume were not dehulled. Cereals and legumes were cleaned separately to remove impurities such as stones, weed seeds and other foreign grains. Beans were steeped for 24 hr. Sprouted beans after 48 hr were transferred and dried in the hot air oven at 55℃.All the cereals and legumes were dehulled. Soybean and dried germinated beans were dehulled for the removal of the outer layer. All the cereals and legumes were roasted at 120℃ for 15 min. Roasted cereal grains were grinded into flour and the flour was properly sieved at 0.211 mm sieve. Cereal and legume flour prepared were blended in different ratio which has been shown in table 1.

Table 1. Compositional Variation of the different composite flour blended with cereals and legumes per 100 gm

Roasted flour	A(control)	B1	B2	B3	B4
Foxtail Millet	-	60	-	50	-
Naked Barley	-	-	60	-	50
Bean		40	40	50	50
Wheat	35	-	-	-	-
Maize	35	-	-	-	-
Soybean	30	-	-	-	-
Ratio^{A}	7:7:6	3:2	3:2	1:1	1:1

Superscript A= ratio of the flours used from top to bottom

2.2 Proximate Evaluation

Moisture content, crude fat, crude protein and total ash was determined as per methods given by AOAC, 1984. Carbohydrate was determined by difference method and total calorific value of the product was calculated.

2.3 Bulk Density

Bulk density of the composite flour were calculated as pet the method given by Al-ansi et al., 2018.Composite flour of 100 gm was measure in the measuring cylinder (250ml). Flours were until there was no reduction in volume and predicted volume and weight was calculated.

2.4 Water Holding Capacity and Oil Holding Capacity

WHC and OHC of the composite flour was calculated as per the method given by Ngamwonglumlert et al., 2016 was used for Oil Holding Capacity by replacing oil with water. One gram of composite flour prepared was mixed with 10 ml of water in a 50 ml centrifuge tube and the mixture was mixed using vortex mixture (G560E; Vortex-Genie 2, Bohemia, NY, USA) for 10s in every 10 mins for three times. Mixture was then centrifuged at 3500 RPM for 25 min. Supernatant was transferred to the evaporation dish and dried at 105℃ overnight to a constant weight. Water hold by the residue was calculated as water absorption capacity (WHC) while percentage of the dried supernatant was expressed as solubility percentage(WS). Similar method was used for Oil Holding Capacity by replacing oil with water.

2.5 Sensory Evaluation

The prepared composite flour gruels were evaluated for sensory attributes like taste, aroma, consistency, smoothness, color and overall acceptability. Evaluations were done on 9-point hedonic scale by semi-skilled 15 panelists. Sensory evaluation was carried out in individual booth with adequate light and free from obnoxious odors. Each panelist was provided with 6 samples coded with three digit random numbers and evaluation card.

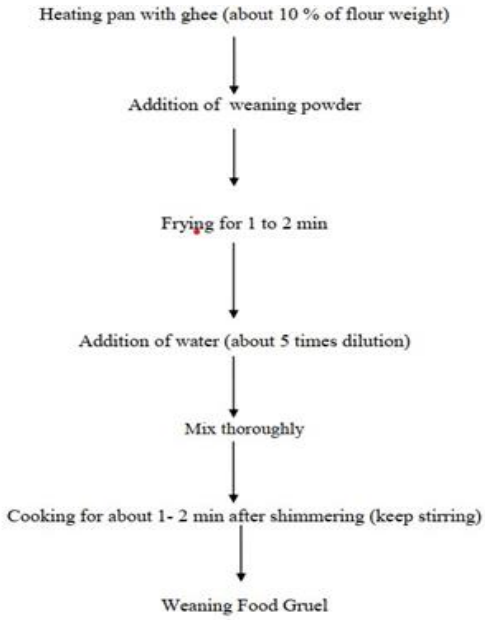

Figure 1. preparation of composite flour

2.6 Statistical Analysis

Results obtained from the experiments were expressed as mean values and standard deviations. All the experiments were done in triplicate and analysis of variance (ANOVA) were applied and the difference in the samples were considered to be significant at P≤ 0.05. Means were separated using the Duncan's multiple comparison test.

3. Result and Discussion

3.1 Proximate analysis

Table 2. Proximate analysis of the different composite flour blended with cereals and legumes per 100 gm

Sample	A	B1	B2	B3	B4
Moisture	4.08±0.29	5.46±0.49	5.95±0.08	5.93±0.44	6.02±0.14
Ash	2.47±0.18^{a}	3.36±0.36	2.57±0.38	3.15±0.31	2.49±0.06^{a}
Fat	10.16±0.8	4.41±0.11	3.15±0.79	3.24±0.18	2.63±0.14
Protein	17.59±0.14	15.67±0.45	15.13±0.75	16.14±0.78	15.87±0.67
Fibre	2.48±0.67^{a}	5.16±0.15	2.46±0.15^{a}	4.43±0.17	2.28±0.18^{a}
Carbohydrate	65.7±0.56	71.1±0.67	73.2±0.75	71.54±0.65	70.71±0.45
Energy	491.47±0.67	386±0.65^{a}	382±0.78^{a}	379.88±0.56	369.99±0.78

(superscript "a" in the row means flour not significantly different from each other(P≥0.05))

Table 2 shows the proximate analysis of the composite flour prepared from the mixture of cereals and legumes in different ratio. As all the flours were blended and dry roasted in the frying pan at 120℃ the moisture content of the flour ranged from 4.08±0.29 to 6.02±0.14. Low moisture content in the prepared flour samples is highly accepted for the proximate flour blend as it affects the shelf life of the product. High moisture content in the flour are susceptible to microbial degradation, retrogradation of starch and shelf life of the flour stored(Alamu et al., 2017). Fat content in the control(A) was significantly high (10.16±0.8) as due to the incorporation of the soybean in the control flour while the flours prepared from the underutilized cereals showed very less fat content which ranged from 3.15±0.79 to 4.41±0.11. Although the fat content in the composite flour is accepted as fat also plays a significant role in the energy density of the product, high fat content in the composite flour can lead to lipid oxidation and deteriorate the quality of the flour(Temba et al., 2017). Thus the reduction of the fat content in the flour can also be complemented by cooking the composite flour in little amount of oil. Protein content in the composite flour prepared is one of the very important parameter. High protein content the composite flour can solve the problems related with protein-energy malnutrition seen in the children in the rural society. The protein content of the composite flour prepared is in accordance with the WHO/FAO requirement which requires protein of the composite flour to be from 10 to 15%(WHO/FAO, 2003). Protein content of the flour prepared ranged from 15.13±0.75 to 17.59±0.14. Protein content of the underutilized cereals and legumes was also almost in the same range as the commercially available cereal-legume flour.

3.2 Physical properties of the composite flour

Table 3 shows the physical properties of the composite flour. WHC is a very desirable physical attribute in the composite flour (Onuoha et al., 2015). Molecular arrangement of the starch in the flour, compositional variation in the flour and differences in starch quality in the final formulation significantly affects the WHC of the product. Presence of hydroxyl group and covalent bonds between the starch generally affects the interaction of the flour with water(Kim et al., 2013). Compared with the control A (1.74±0.05) the WHC of the B2(1.77±50) is acceptable. This might be due to the incorporation of naked barley in the B2 which has high amylose content. Study has suggested that high amylose content in the product leads to the high WHC(Oyeyinka et al., 2015). It is interesting to note that due to the increase in the percentage of beans in the B3(1.4±0.08) and B4(1.56±0.07), WHC of the product decreased. OAC of control A (0.81±0.056) was not significantly different than B3 (0.80±0.056) and was the highest as well. This might be due to the incorporation of wheat in the control. Water solubility of the flour different significantly from flour to flour. B4 had the highest water solubility (12.86±0.24) while Control(A) had the lowest (9.06±.0.135). Water Solubility of the composite flour depends on the amount of starch conversion of the flour into the small molecules. It is also co-related with the fiber content of the composite flour prepared(Dias-martins et al., 2019). B1 and B3 which also had high fiber content (Table 2) of compared with the other formulations showed high fiber content as compared with other samples. Bulk Density of the composite flour ranged from 0.49±0.07 to 0.53±0.067. Low bulk density means the dietary bulk in the product will be low as high bulk density limits the caloric and nutrient intake per feed for children(Onuoha et al., 2015).

3.3 Sensory Evaluation

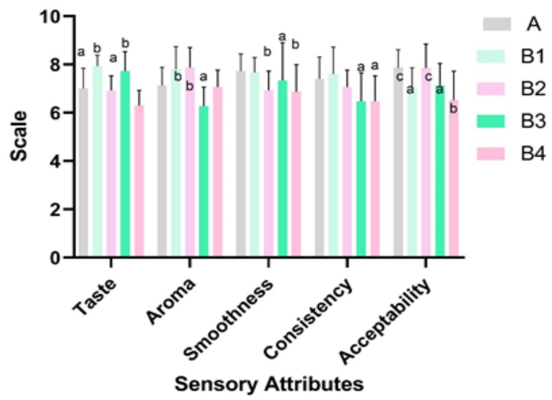

Figure 2: Sensory Evaluation of composite flour (same alphabet within the sensory attribute means sample not significantly different from each other(p≥0.05))

Figure 2. shows the overall result of the sensory evaluation done on the composite flour gruel. Panelists liked the taste of composite flour made by blending foxtail millet and beans (B1 and B3) while gave B4 lowest score, this might be due to the taste of beans masking the flavor of the samples as B4 had naked barley and beans in the ratio of 1:1. B1 and B2 ranked highest in aroma while B3 ranked the lowest. Smoothness of the gruel which had cereals and legumes in the ratio of 1:1 ranked the lowest in smoothness. Incorporation of naked barley in the composite flour reduced the smoothness of the product. Consistency of the gruel

Table 3. Physical properties of the flour

Samples	A	B1	B2	B3	B4
WHC	1.74±0.05	1.62±.007	1.77±50	1.4±0.08	1.56±0.07
OAC	0.81±0.056[a]	0.7335±0.078	0.7850±0.013	0.80±0.056[a]	0.7350±0.13
WS	9.06±.0.135	12.86±0.24	10.25±0.16	11.56±0.14	10.06±0.23
Bulk Density	0.49±0.07	0.50±0.03	0.52±0.06	0.53±0.067	0.52±0.067

(WHC=Water holding capacity, OAC=Oil Absorption Capacity, WS=Water Solubility)
(superscript "a" in the row means flour not significantly different from each other(P≥0.05))

Table 4. Sensory Analysis of the composite flour

	A	B1	B2	B3	B4
Taste	7±0.84(a)	7.93±0.46(c)	6.93±0.59(a)	7.73±0.80(c)	6.30±0.63(a)
Aroma	7.13±0.74(b)	7.80±0.94(bc)	7.87±0.83(c)	6.27±0.80(a)	7.07±0.70(b)
Smoothness	7.73±0.70(c)	7.67±0.62(c)	6.93±0.80(a)	7.34±1.57(b)	6.87±1.13(a)
Consistency	7.4±0.91(d)	7.60±1.12(b)	7.07±0.70(c)	6.47±1.19(a)	6.47±1.06(a)
Acceptability	7.86±0.74(a)	7.07±0.80(b)	7.56±0.99(a)	7.13±0.92(b)	6.53±1.19(c)

(Same alphabet in a single row means formulations not significantly different from each other) where the cereals and legumes were used in the ratio of 1:1 ranked the lowest in the consistency. In overall ranking panelist gave A and B2 highest ranking compared with other formulations.

4. Conclusion

Blending of the cereals and legume to prepare the processed composite flour using the household technology can produce composite flour with high calorific value. Utilization of underutilized cereals like naked barley, foxtail millet in the formulation of processed composite flour can help to alleviate the nutritional deficiency frequently seen in the rural setting and geographically challenged areas. These cereals like millet and barley as well as legumes like beans can grow in dry and arid climate as well as has appreciably good nutrition profile compared with other cereals and legumes. Further study can be carried out to check the protein efficiency ratio and amino acid profile of these composite flour.

References

Al-ansi, W., Mahdi, A. A., Li, Y., Qian, H., & Wang, L. (2018). Optimization and Acceptability Evaluation of Shapporah Biscuits Formulated by Different Ingredients : Using Response Surface Methodology (RSM). March. https://doi.org/10.12691/jfnr-6-3-9

Alamu, E. O., Maziya-Dixon, B., & Dixon, A. G. (2017). Evaluation of proximate composition and pasting properties of high quality cassava flour (HQCF) from cassava genotypes (Manihot esculenta Crantz) of β-carotene-enriched roots. LWT - Food Science and Technology, 86, 501–506. https://doi.org/10.1016/j.lwt.2017.08.040

AOAC. (1984). Official methods of analysis of the Association of Official Analytical Chemists (14th ed.). In Association of Official Analytical Chemists.

Dias-martins, A. M., Cappato, L. P., Mattos, C., Rodrigues, F. N., Pacheco, S., & Carvalho, C. W. P. (2019). Impacts of ohmic heating on decorticated and whole pearl millet grains compared to open-pan cooking. Journal of Cereal Science, 85(November 2018), 120–129. https://doi.org/10.1016/j.jcs.2018.11.007

E. Dickin1, K. S. and D. W. (2010). Project Report No. 472 hulless barley for functional food (Issue 472).

E.M.DeMaeyer.(1976). Processed Weaning Food.pdf. In Nutrition in preventive medicine (pp. 389–404).

Gulzar, M. A. (2011). Evaluation of weaning foods formulated from germinated wheat and mungbean from Bangladesh. 5(17), 897–903. https://doi.org/10.5897/AJFS11.180

Kajuna, S. T. A. R. (2001). Millet:Post-harvest Operations. INPho-Post-Harvest Compedium.

Kayitesi, E., Kock, H.L. De, Minnaar, A., & Gyebi, K. (2012). Nutritional quality and antioxidant activity of marama – sorghum composite flours and porridges. African Journal of Food and Nutritional Sciences, 131, 837–842. https://doi.org/10.1016/j.foodchem.2011.09.055

Kim, H., Patel, B., & Bemiller, J. N. (2013). Effects of the amylose–amylopectin ratio on starch–hydrocolloid interactions. Carbohydrate Polymers, 98(2), 1438–1448. https://doi.org/10.1016/j.carbpol.2013.07.035

M.R Haque, M.M hosain, H.khatun, M.G. (2013). Evaluation of nutritional composition and sensory attributes of weaning food prepared from sweet potato and soybean. Bangladesh Research Journal, 8(2), 127–133.

Mosha, T., & VICENT, M. (2005). Nutritional quality, storage stability and acceptability of home-processed ready-to-eat composite foods for rehabilitating undernourished preschool children in low-income countries. Journal of Food Processing and Preservation, 29, 331–356. https://doi.org/10.1111/j.1745-4549.2005.00032.x

Ngamwonglumlert, L., Devahastin, S., & Chiewchan, N. (2016). Original article Effects of pretreatment and drying methods on molecular structure , functional properties and thermal stability of fibre powder exhibiting colour from Centella asiatica L . 753–764. https://doi.org/10.1111/ijfs.12998

Onuoha, O. G., Chibuzo, E., & Badau, M. (2015). Studies on the Potential of Malted Digitaria exilis, Cyperus esculentus and Colocasia esculenta Flour Blends as Weaning Food Formulation. Nigerian Food Journal, 32(2), 40–47. https://doi.org/10.1016/s0189-7241(15)30116-8

Oyeyinka, S. A., Singh, S., Adebola, P. O., Gerrano, A. S., & Amonsou, E. O. (2015). Physicochemical properties of starches with variable amylose contents extracted from bambara groundnut genotypes. Carbohydrate Polymers, 133, 171–178. https://doi.org/10.1016/j.carbpol.2015.06.100

Setia, R., Dai, Z., Nickerson, MT., Sopiwnyk, E., Malcolmson, L., & Ai, Y. (2019). Impacts of short-term germination on the chemical compositions, technological characteristics and nutritional quality of yellow pea and faba bean flours. Food Research International, 122(January), 263–272. https://doi.org/10.1016/j.foodres.2019.04.021

Solomon.M. (n.d.). Nutritive value of three potential complementary. African Journal of Food and Nutritional Sciences, 5(6), 1–14.

Suhasini, A. W., & Malleshi, N. (2003). Nutritional and carbohydrate characteristics of wheat and chickpea based weaning foods. International Journal of Food Sciences and Nutrition, 54, 181–187. https://doi.org/10.1080/09637480120092035

Teixeira-Guedes, C. I., Oppolzer, D., Barros, A. I., & Pereira-Wilson, C. (2019). Impact of cooking method on phenolic composition and antioxidant potential of four varieties of Phaseolus vulgaris L. and Glycine max L. LWT, 103, 238–246. https://doi.org/https://doi.org/10.1016/j.lwt.2019.01.010

Temba, M. C., Njobeh, P. B., & Kayitesi, E. (2017). Storage stability of maize-groundnut composite flours and an assessment of aflatoxin B1 and ochratoxin A contamination in flours and porridges. Food Control, 71, 178–186. https://doi.org/10.1016/j.foodcont.2016.06.033

Udomkun, P., Tirawattanawanich, C., Ilukor, J., Sridonpai, P., Njukwe, E., Nimbona, P., & Vanlauwe, B. (2019). Promoting the use of locally produced crops in making cereal-legume-based composite flours: An assessment of nutrient, antinutrient, mineral molar ratios, and aflatoxin content. Food Chemistry, 286(February), 651–658. https://doi.org/10.1016/j.foodchem.2019.02.055

WHO/FAO. (2003). Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases.

Williams, J.T., & Haq, N. (2000). Global research on underutilised crops an assessment of current activities and proposals.