American Journal of Food Science and Health
Vol. 1, No. 4, 2015, pp. 104-108
http://www.aiscience.org/journal/ajfsh

Effect of Processing Methods on Nutritional Value of Sorghum (*Sorghum bicolor L. Moench*) Cultivar

Azhari A. Mohammed Nour[1, *], Mohamed A. E. M. Ibrahim[2], Eman E. Abdelrhman[3], Eman F. Osman[3], Khadir E. Khadir[4], Nazik F. Hussain[3], Nahla A. Abdallatif[3], Amir A. Eldirany[3]

[1]Department of Basic Science, Faculty of Applied Medical Science, Albaha University, Albaha City, KSA
[2]Albaha University, FAMS, Albaha City, KSA
[3]Department of Nutrition and Food Technology, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan
[4]Department of Food Science and Technology, Faculty of Agriculture, Omdurman Islamic University, Omdurman, Sudan

Abstract

The objective of this study is to examine the effect of processing methods(cooking, fermentation and sprouting)on proximate composition, tannin content, IVPD% and some minerals (Ca^{++}, Na^{+}, Fe^{++} and Cu^{++}) of Sorghum. The results obtained showed that the moisture, protein, fiber and total energy were increased after processing methods except the protein was decreased after cooking, whereas ash, oil and carbohydrates were decreased. Tannin content was decreased after processing methods concomitant with a significant increase in *in vitro* protein digestibility of fermented and sprouted sorghum. Also the minerals contents (Ca^{2+}, Na^{+}, Fe^{2+} and Cu^{2+}) were increased after processing methods. Fermentation has been found increase significantly the minerals compared to the others treatments.

Keywords

Proximate Composition, Minerals, Fermentation, Cooking, Sprouting, Tannin, Processing Methods

Received: August 19, 2015 / Accepted: October 10, 2015 / Published online: October 26, 2015

1. Introduction

Sorghum (sorghum *bicolor* L. Moench) is a staple food 0f the poor people in semi-arid zones of Africa, Asia and South America because of it's drought tolerance (Belton and Taylor, 2004). Sorghum is the fifth most important world cereal, following wheat, maize, rice and barely (Onwume and Sinha, 1991). The leading sorghum production countries are the USA, China, India, Nigeria, Mexico, Argentina, Sudan and Egypt (Kent 1980). Sorghum is cultivated in many parts of the Sudan mainly in Gezira and Gadarief Regions. According to the Ministry of Agriculture (1995) the annual production of sorghum is about 3.7 million tons in Sudan while the area under cultivation is 6.5 to 15.3 million feddans. Sorghum generally consumed as fermented flat bread (*Kisra*), thick Porridge (*Aceda*), thin fermented gruel (Nasha), boiled grain (*Balela*) and beverages like *Abresh* and *Hulu-mur*. It is also used for the production of alcoholic beverage (*merisa*). Grain sorghum as a staple food is also used as feed for animal and as industrial raw material. Sorghum like other cereals is deficient in lysine (El Tinay *et al.,* 1985). Sorghum Proximate composition varies significantly due to genetics and environment factories (Ralph, *et al*., 2000). For example, high nitrogen fertilizer level increases grains protein content and decrease the amount of starch in the grain. Starch is the major grain component followed by protein (Serna and Roony, 1995). Sorghum grains contain low quality protein and considerable amounts of anti-nutritional factors. Efforts, however, are directed to improve the nutritional value of the seeds. Processing methods, such as soaking, sprouting and coking has been found to improve the nutritional value of

* Corresponding author
E-mail address: azhari1933@gmail.com (A. A. M. Nour), azharinoor@hotmail.com (A. A. M. Nour)

plant grains (Jirapa *et al*., 2001). Sprouting is one of the processing methods that improve the *in vitro* protein digestibility and minerals availability by reduction of ant nutritional factors (Tannin and phytate). Fermentation is found to be highly beneficial in improving the quality of cereals, it is one of oldest and most economical methods that provide away to preserve food, destroy undesirable factors enhance nutritive value, and improve appearance and taste of some foods.

This study will evaluate the effect of fermentation, cooking and sprouting on proximate composition, total energy, total minerals contents (Ca^{+2}, Na^{+}, Fe^{+2} and Cu^{+2}) and sensory characteristics of thick porridge from sorghum (Tabat) flour.

2. Materials and Methods

2.1. Materials

Sorghum (sorghum *bicolor* L. Moench) grains locally known as Tabat was purchased from Omdurman local market, Sudan. The grains were cleaned and freed from foreign materials. Some of these grains were milled into flour (0.4 mm screen) and stored at 4°C for processing or subsequent analysis. The rest of the grains were used in the germination process.

2.2. Fermentation

Natural fermentation of sorghum flour was carried out by mixing flour with distilled water (1:2 w/v). Two hundred and fifty grams of sample was mixed with 500 ml distilled water in 750 ml beaker and then incubated (Gallenkamp, England) at 37°C for 24h. After the incubation period the sample was mixed using a glass rod and transferred to aluminium dishes (30 cm diameter), and dried in a hot air oven at 70°C for 3-4 hours. Dried sample was ground using house blender and mortar to pass through 0.4 mm screen and stored at 4°C for further analysis.

2.3. Cooking

Cooking of the sample was performed by suspending the flour of sample in distilled water in the ratio of 1:2 (flour: water, w/v) and the slurry was shaken to avoid lumps while boiling in a water bath for20 min. The viscous mass was spread out thinly in a dish and oven dried at 70°C. The dried flakes were milled into fine flour using house blender and mortar to pass through 0.4 mm screen and stored for further analysis.

2.4. Sprouting

About 250 gram of sorghum cultivars was germinated according to the method of Bhise et al. (1988). The grains of the sorghum cultivars were steeped over night in distilled water. The wet grains were then soaked in 1-2 volumes of 0.2% formaldehyde solution for 40 minutes to prevent mould growth during germination. The soaked seeds were then washed with distilled water several times and re-soaked in water for 20 minutes to remove remaining formaldehyde. The wet grains were then spread out thinly on jute bags moistened with distilled water and allowed to germinate at room temperature (30°C) or 48 hour. The grains after the removal of roots and shoots were sun dried, milled into fine flour and stored as before.

2.5. Proximate Analysis

Lipid, ash, total carbohydrate and total nitrogen (micro-Kjeldahl) of sorghum flour were determined according to AOAC (1990). Protein was calculated as N% × 6.25. Moisture content was determined by drying a sample at 105 °C overnight. Crude fiber content was determined according to the acid/alkali digestion method of Southgate (1976). The energy values of samples were calculated on Atwater factors (Sukkar, 1985), protein (4 kcal $g^{-1)}$, oil (9 kcal g^{-1}) and carbohydrates (4 $kcal^{-1}$).

2.6. Tannin Content

Quantitative estimation of tannins was carried out using the modified vanillin – HCl methanol, according to Price *et al*, (1978). The vanillin HCl reagent was prepared by mixing equal volumes of 8% concentrated HCl in methanol and 1% vanillin in methanol, the two solvents of the reagent were mixed just prior to use, it was discarded if a trace of colour appeared. Catching was used as reference standard.

2.7. *In vitro* Protein Digestibility

In vitro protein digestibility of the samples was measured according to the method described by Monjula & Johon (1991), in which a pepsin digestion method was used in the determinations. The digestible protein was analyzed for nitrogen using micro Kjeldahl procedure (AOAC, 1990) and expressed as a percent of the total N.

2.8. Total Minerals

Minerals were determined in samples extracts prepared by the dry - ashing method as described by Pearson (1981) according to the analytical method of atomic absorption spectroscopy (Perkin-Elmer 1100 V, Waltham. MA, USA).

2.9. Statistical Analysis

Each determination was carried out on three separate samples and analyzed in triplicate on dry weight basis; the figures were then averaged. Data were assessed by the analysis of variance (Snedecor and Cochran, 1987). Comparisons of means for treatments were made using Duncan's multiple range tests. Significance was accepted at P≤ 0.05.

3. Results and Discussion

The proximate composition of Raw Sorghum Flour (RSF), Cooked Sorghum Flour (CSF), Fermented Sorghum Flour (FSF) and Sprouted Sorghum Flour (SSF) are shown in Table 1. The moisture content ranged from 7.47 to 8.38%. Insignificant (P≤0.05) increase was observed in moisture content of the processed flours compared with the control. The highest increase in moisture content was observed in the cooked flour (8.38%). The increase in moisture content of processed flours may be due to the water added before processing. Ash content of sorghum flour was 1.55%, it was significantly (P≤0.05) decreased after cooking, fermentation and sprouting to1.46, 1.52 and 1.33%, respectively. The decrease in ash content after fermentation of sorghum flour may be due to the utilization of ash during the growth of microorganisms, but the decrease in ash content of sprouted sorghum may be due to the consumption of ash during the growth of the germ. The protein content of raw sorghum flour was found to be 11.21%, it was significantly (P≤0.05) increased after fermentation to 14.63%, but significantly (P≤0.05) decreased after cooking and sprouting to 10.21 and 10.66%, respectively. The increase in protein content of fermented sorghum flour is similar to the study reported by Mohammed Nour (2013) who reported that fermentation increased the protein content of millet flour and composite flour.

Table 1. Effect of processing methods on proximate composition of sorghum cultivar.

Treatment	Moisture (%)	Ash (%)	protein (%)	Oil (%)	Fibre (%)	Carbohydrate (%)	Total energy (kcal)
Raw	7.46^{b} (±0.113)	1.55^{a} (±0.025)	11.38^{c} (±0.239)	3.66^{a} (±0.108)	2.34^{a} (±0.024)	74.76^{a} (±0.20)	372.9^{a} (±0.37)
Cooked	8.38^{b} (±0.207)	1.46^{a} (±0.05)	10.21^{a} (±0.017)	2.70^{c} (±0.23)	2.36^{a} (±0.06)	73.69^{a} (±0.57)	364.66^{a} (±1.09)
Fermented	7.48^{b} (±0.013)	1.52^{a} (±0.02)	14.63^{b} (±0.22)	3.32^{b} (±0.17)	2.43^{a}(±0.116)	70.47^{a} (±0.83)	370.46^{a} (±0.93)
Spouted	7.54^{b} (±0.44)	1.33^{a} (±0.043)	10.61^{a} (±0.30)	1.33^{d} (±0.38)	4.84^{b} (±0.09)	74.35^{a} (±0.18)	370.4^{a} (±0.92)

*Means of three replicate samples
*Values in parentheses are standard deviations
*Means not sharing the same letter within a column are significantly different at P≤0.05

The increase in protein content of fermented flour may be due to protein synthesis, but the decrease in the protein content after cooking was due to heating which causes the native protein to unfold and exposing anionic groups to cross link with divalent cations and sulphohydrile groups to form disulphide linkages (Clark and Switzo, 1975), while decrease in protein content during sprouting may be attributed to the fact that water soluble nitrogen was lost during soaking of seeds before sprouting and part of the protein was utilized for the growth and development of the embryo (Wu and Wall, 1980). The oil content ranged from 3.66 to 1.33%. Significant decrease (P≤0.05) was observed in the crude oil content of processed flours compared with the control. The highest increase was observed in the control sample (3.66). The low fat content recorded in samples will extend the shelf life by decreasing the changes of rancidity and will also contribute to the low energy value of the samples. The fiber content of samples ranged from 2.34 to 4.84%. The sprouted sorghum has highest fiber content (4.84%) and the other sample has 2.34, 2.36 and 2.43%, respectively for Raw, cooked and sprouted samples. The reduction in crude fiber content of fermented flour may be due to sugar utilization in the seeds for metabolic sprouting activity leavening fibrous seeds and enzymatic degradation of the fiber during fermentation (Ikenebomah et al., 1986). Similar observation has been reported for fluted Pumpkin (Giami and Bekebain, 1992) and cowpea (Padmasshree et al., 1987). The carbohydrate content of control sample flour was found to be 74.76%, which is greater than the carbohydrate of cooked (73.69%), fermented (70.47%) and sprouted (74.35%). The decrease in carbohydrate content of both fermented and sprouted sorghum flours may be due to utilization of some sugars during the growth metabolic activity. The total energy was 372.9 kcal. Insignificant decrease (P≥0.05) was observed in total energy between control sample and processed flours. Cooked sorghum flour has the lowest energy (364.66 kcal) which can be attributed to the low fat content.

Table 2. Effect of processing on tannin content and in vitro protein digestibility (IVPD) of sorghum (Tabat).

Samples	Tannin (mg/100g)	IVPD
Raw sorghum	0.15^{a} (±0.01)	5.12^{a} (±2.76)
Cooked	0.14^{a} (±0.00)	75.93^{a} (±2.7)
Fermented	0.14^{a} (±0.01)	65.03^{a} (±3.40)
Spouted	0.13^{a} (±0.00)	54.66^{a} (±2.01)

*Means of three replicate samples
*Values in parentheses are standard deviations
*Means not sharing the same letter within a column are significantly different at P≤0.05

As shown in table 2, the tannin content of raw sorghum flour was found to be 0.15mg/100g, insignificant (P≥0.05) decrease was observed in tannin content after cooking, fermentation and sprouting (0.14, 0.14and 0.13mg/100g), respectively. The highest decrease in tannin content was shown after sprouting whereas the lowest decrease was observed after both cooking and fermentation. The decrease in tannin content after processing may be according to the activation of peroxidase enzyme. The IVPD% of raw and treated sorghum is presented in Table 2. The IVPD% of raw sorghum flour was found to be 54.66% and insignificantly ($P \geq 0.05$) decreased after cooking, fermentation and sprouting. The highest increase in IVPD was observed after cooking, while the lowest increase was shown after sprouting. The improvement in IVPD of sorghum after processing may be due to the degradation of anti –nutrient.

Table 3. Effect of processing methods on minerals content (mg/100g) of sorghum.

Treatments	Ca	Na	Fe	Cu
Raw sorghum	14.33^a (±0.024)	8.04^a (±0.08)	6.58^a (±0.59)	0.19^a (±0.00)
Cooked	20.15^a (±0.16)	14.87^b (±0.2)	11.62^b (±0.01)	0.25^a (±0.01)
Fermented	19.89^a (±0.008)	26.15^c (±0.16)	29.16^c (±0.02)	0.86^a (±0.00)
Spouted	21.95^a (±0.20)	11.75^b (±0.16)	10.02^b (±5.73)	0.40^a (±0.005)

*Means of three replicate samples
*Values in parentheses are standard deviations
*Means not sharing the same letter within a column are significantly different at $P \leq 0.05$

As shown in Table 3. The Ca^{+2} content of sorghum flour was found to be 14.33mg/100g it was increased insignificantly ($P \leq 0.05$) after cooking, fermentation and sprouting to 20.15, 19.89 and 21.95mg/100g, respectively. Results indicated that the sprouting was more effective in increasing the calcium content. Na^{+} content of raw Sorghum was found to be 8.04mg/100g. A significant increase ($P \leq 0.05$) in Na^{+} content was observed after cooking, fermentation and sprouting to 14.87, 26.15 and 11.25mg/100g, respectively. Fe^{+2} contents were significantly ($P \leq 0.05$) increased after cooking, fermentation and sprouting to 11.62, 29.16 and 10.02mg/100g, respectively compared to raw sorghum flour sample. Cu^{+2} content of raw sorghum flour was found to be 0.19mg/100g and after cooking, fermentation and sprouting were 0.25, 0.86 and 0.40mg/100g, respectively. No significant variation in Cu values was observed among all processed and raw sorghum flours. The improvement in minerals contents after processing may be attributed to degradation of phytate which bind the minerals into low molecules.

4. Conclusion

Fermentation has been found significantly increase the protein, oil and total energy, Na, Fe and Cu contents. The tannin content was decreased after processing methods with a concomitant improvement in IVPD%.

References

[1] AOAC (1990). Official Methods of Analysis. 15thedn. Washington, DC: Association of Official Analytical Chemists.

[2] Bhise, V.J; Chavan, J.K. and Kadam, S.S. (1988). Effect of malting on proximate composition and in vitroprotein and starch digestibility of grain sorghum. J. Food Sci. Technol. 25(6), 327.

[3] Chakravorty, S. C. (1967).Chemical Study of sorghum as a staple food in India. 11 Protein content in relation tosize of Jodar Grains. (Sorghum Vulgare). India. Agriculturalist 11,113-116.

[4] Champman, H.D. and Pratt, F.P. (eds.). (1982). Methods of Analysis Soils Plant and Water, University of California, Agriculture Division, USA. pp. 169.

[5] Clark, J.M. and switzo, R. L. (1975). Experimental biochemistry: Amino acid, Protein and Enzymology. San Francisco: E.H. Freeman and Company, pp.67-77.

[6] El-Tinay, A.H., EL-Mahdi, Z.M. and El soubki, A. (1985). Supplementation of Fermented sorghum Kisra bread with legume protein isolates. Journal of Food Technology, 20: 679–687.

[7] Giami, S.T. and D.A. Bekebain, 1992. Proximate composition and functional properties (Telfairia occidental) seed flour .J. Sci. Food Agric., 59: 321-325.

[8] Ikenebomah, M.J., Kok and J.M. Ingram, 1986. Processing and fermentation of African locust bean (Parkia Felocoidea). Can. I. Food. Sci. Tecnol. J., 17: 48-80.

[9] Jirapa. P., Normah, H., Zamaliah, M.M., Asmah. R & Mohamad, K (2001). Nutritional quality of germinated cowpea flour (Vignaunguiculata) and its application in home preparing weaning foods. plant foods for human Nutrition. 56, 203-216.

[10] Manjula, S. and John, E. (1991). Biochemical changes and in vitro protein digestibility of the endosperm of germinating Dolichos Lablab. J. Sci. Food. Agric., 55: 529-538.

[11] Marfo, E. K. Simpson, B. K., Idowu, J.S. and Oke, O.I. (1990). Effect of local food processing on phytate levelsin cassava, cocoyam, yam, maize. Sorghum, rice, cowpea and soybean, J. Agric. Food Chem., 38: 1580-1585.

[12] Minstry of Agriculture (1995). Department of Planning and Agriculture Policy; Khartoum, Sudan.

[13] Mohamed Nour, A.A. (2013). Chemical and Nutritional quality of millet flour supplemented with Moringa or Fenugreek seeds flour, Ph.D. thesis Omdurman Islamic University, Sudan.

[14] Onwueme, I.C. and Sinha, T. D. (1991). Field crop production in tropical Africa principles and practice. TechnicalCenter for Agriculture Rural Co-operation.

[15] Padmashree, T. S., L. Vijayalakshmi and S. Puttara, 1987. Effect of traditional processing on the functional properties of Cowpea (Vigna Cajan) flour .J. Food Sci. Technol., 24: 221-226.

[16] Pearson, D. (1981). Chemical Analysis of Food. Edn. Published by Egon, H; Kirk, R.S and Sawyer, New York.

[17] Peterson, R. G. (1985). Design and analysis of experiments. March Dekker Inc., New York, PP: 429.

[18] Price, M. L.; Van Scoyoc, S. and Butler, L. G. (1978). A critical evaluation of the vanillin reactions as an assayfor tannin in sorghum grain. J. Agric. Food Chem. (26). 1214.

[19] Ralph, D.; Wanisk and Rooney, L. W. (2000). Structure and chemistry of the sorghum caryopsis. Ch. 4 In: Sorghum Origin, Histroy Technology and Production. (C.W. Smith, R.A. Frederiksen eds.). Texas anduniversity. John Wiley and Sons. Inc.

[20] Serna-Saldivar, S. and Rooney, L.W. (1995). Structure and chemistry of sorghum and millets. In: Sorghum and Millets: Chemistry and Technology. Dendy, D. A.V. (ed.). A.A.C.C, USA.

[21] Southgate, D.A. (1976). The Analysis of Dietary Fiber, in. G.A. Spiller and R. J. Amen (eds). Fiber in Human Nutrition. Plenur Press. New York, U.S.A, pp. 73.

[22] Sukkar, M. Y., (1985). Human Nutrition for Medical studies and Applied Health Science. Ith (ed.). Thaca, Press 13 South work street. London.

[23] Wu, Y.V. and Wall, J.S. (1980). Lysine content of protein increase by germination of normal and high lysinesorghum J. Agric. Food Chem., 28: 455-458.