The Pharma Innovation Journal 2022; 11(1): 729-733

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 729-733
© 2022 TPI
www.thepharmajournal.com
Received: 23-11-2021
Accepted: 29-12-2021

K Santhi Sirisha
Ph.D., Scholar, Department of Foods and Nutrition, Post Graduate and Research Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Dr. TV Hymavathi
Professor and Head, Department of Foods and Nutrition, Post Graduate and Research Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

S Suchiritha Devi
H.Sc. Senior Scientist, ACRIP Home Science, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

R Neela Rani
H.Sc. Senior Scientist, ACRIP Home Science, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
K Santhi Sirisha
Ph.D., Scholar, Department of Foods and Nutrition, Post Graduate and Research Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Nutritional properties of browntop millet (*Brachiaria ramosa*)

K Santhi Sirisha, Dr. TV Hymavathi, S Suchiritha Devi and R Neela Rani

Abstract

The present study was aimed at analyzing the chemical properties of Browntop millet (*Brachiaria ramosa*) after subjecting to various processing methods i.e. soaking, germination, fermentation, dryheating, hydrothermal treatment and extrusion cooking. Analyzed samples found to have moisture in the range of 1.92±0.05 to 8.99±0.06%; protein- 6.10±0.06% to 17.31±0.25%; ash -1.06±0.07% to 5.80±0.15%; fat- 3.78±0.12% to 7.08±0.03%; crude fibre -2.22±0.07% to 20.17±0.09%; carbohydrate-58.00±1.06% to 76.33±0.25%; energy-306.8±4.6 K. Cal/100 g to 396.5±0.8 K. Cal/100 g. Decreasing trend was observed for moisture, protein and ash after processing compared to control (whole and dehulled) samples whereas carbohydrate content and energy values were improved due to processing. Fat and crude fibre content was also decreased except for fermented samples. Germination favored enhancement of ash content. The chemical properties of Browntop millet was on par with the other millets, indicating that the dehulled and processed Browntop millet flours can be efficiently used in processing and formulating various healthy food products as is done with other minor millets.

Keywords: Browntop millet, processing, nutrients, c

Introduction

Transition in consumer demand for health-promoting foods than hunger-satisfying foods is taking place. Hence there is a need to develop health-promoting foods especially cereal based foods. The millets are small-seeded cereals with excellent nutritional attributes that are even superior to staple cereals i.e. wheat and rice (Ragaee *et al*., 2006) [21]. They rank as sixth most important cereal that feeds one third of the total world population (Saleh *et al*., 2013) [22]. Millets are non-glutinous, non-acid forming and easy to digest (Thilagavathi *et al*., 2015) [27], loaded with high phytochemicals and antioxidant levels (Banumathi *et al*., 2015) [27]. Browntop millet is one of the nutritious minor millets which is called “Korale” in Kannada and “Karlakki” in Mandya region and “Andukorralu” in Telangana and AP, Karnataka. An understanding of suitable processing, salubrious alternatives, are key factors in determining the usage of Browntop millet for domestic consumption or product development with optimum nutrients. There are very few studies conducted on the effect of processing on the physico-chemical properties on Browntop millet. Hence, there is a need to explore the potentiality and utility of the grain in daily diet by demonstrating the suitability of best processing methods with optimal physico-chemical properties for consumption.

Material and Methods

Procurement of raw materials

Browntop millets were procured directly from the farmers and thoroughly cleaned to remove any foreign material, dust and light materials by using de-stoner. All the chemicals used for the investigation were of food grade and analytical reagent (AR) grade. Chemicals and glassware were obtained from the Post Graduate and Research Centre (PG & RC).

Soaking

The soaking process was carried by immersing whole and dehulled browntop millet grains into distilled water with the ratio of 1:5 (w/v) at 70 °C for 6 h for maximum water absorption and then grains were rinsed with clean water and dried in tray drier at 60 °C. Soaked grains were ground and stored for further analysis.

Germination

Browntop millet grains were germinated at 30°C for 24 h in BOD incubator after overnight steeping in distilled water. Germination time and temperature were optimized according to Al-Mudaris (1998) [2]. Then, the germinated grains were dried in tray dryer at 60°C for 6 h. Dried germinated grains were ground and stored in an air tight bag for further analysis.

Fermentation

With slight modifications to the fermentation method of Usha *et al*., 1996 [28] whole and dehulled browntop millet grains were steeped in double distilled water in 1: 5 ratio for 36 h and allowed for natural fermentation at 30 °C after which they were rinsed with clean water and dried in an oven at 55-60 °C for 8 h, ground and stored for further analysis.

Hydrothermal Treatment

As per the suggested method of Jacobs and Delcour,1998 whole and dehulled browntop millet grains were soaked for 12 hours, boiled in double distilled water at 100 °C for 3 and 2 minutes respectively and dried in tray drier at 60 °C. Hydrothermally treated grains were ground and stored for further analysis.

Extrusion cooking

Both the whole and dehulled browntop millet grits were extruded in an extruder (BTPL Culcutta) with 3 mm die diameter at barrel temperature 150°C, feed moisture 20%**.** The setting of extrusion parameters refers to the study of Liu *et al*. (2020) [14] with slight modification. The extrudates were ground and stored at -4 °C stored for further analysis.

Dry-heating

Whole and de-hulled browntop millet grains were subjected to dry heat at 100° C in hot air oven for 60 minutes (Hou *et al*., 2013). Dry-heated samples were ground and stored for further analysis.

Proximate analysis

Proximate composition of raw and processed millet flours was done using standard AOAC methods such as moisture-oven drying method (AOAC, 2005) [3], ash-charring method (AOAC, 2005) [3], protein-kjeldhal method (AOAC 992.23 - 2005) [3], crude fiber-acid-base extraction method (AOAC 962.09 - 2016) and fat-soxhlet extraction method (AOAC 922.06 - 2016). Carbohydrate content was calculated by subtracting the total of moisture, fat, protein, and ash from 100.Energy values were obtained by the formula:

Energy value= Protein × 4 + Carbohydrate × 4+ Fat × 9

Statistical analysis

All data were presented as means+ the standard deviation of the mean. As for multiple group comparison, the significance of the differences among the treatment groups and their respective control groups were analysed using Window stat 9.1 software. Statistical significance was assessed by one-way analysis of variance (ANOVA). Differences between means were considered statistically significant at 5% level.

Results and Discussion

Chemical parameters of whole and processed browntop millet flour

Moisture

The results obtained indicate that moisture content in differently treated browntop millet flours ranged from 1.92±0.05% to 8.99±0.06%. The highest values were observed for control whole browntop millet flour (8.99±0.06%) and control de-hulled flour (8.97±0.04%) followed by germinated whole browntop millet flour GWBF (8.66±0.33%), fermented whole and de-hulled browntop millet flours (7.61±0.18% and 8.36±0.12%), extruded whole and de-hulled browntop millet flours (7.43±0.27% and 7.82±0.08%). Moisture content was 6.56±0.28%, 6.33±0.22%, 5. 17±0.09%, 4.74±0.14% in SWBF, SDBF, HDBF and HWBF respectively. The least amount of moisture content was observed in roasted whole and de-hulled BF (2.07±0.11% and 1.92±0.05% respectively. Processing had significant effect on moisture content of whole and dehulled BT. Moisture content of whole BT samples decreased by 3.67% to 76.97% after processing. A significant difference was observed for dry heated whole and de-hulled BF, fermented whole and de-hulled BF. Results of the present investigation were in accordance with the study of Sravani *et al*., 2021 [26]. As per the results, desirable moisture content for all the differently treated browntop millet flours was within a specified percentage of < 12% as shown in the work of Saleh *et al*.,2013 [22]. Malik *et al*. (2002) [15] observed that the drying effect of roasting reduced the moisture content in pearl millet flour as influenced by cooking methods. The results are an indication that browntop millet when processed and dehydrated will have better keeping quality due to low moisture content as compared to control whole and de-hulled. Pearl millet processed by soaking, germination, microwave treatment and fermentation (open & closed) was shown to have minimized moisture content after processing compared to control untreated samples (Singh *et al*., 2017) [23]. Mohankumar and Vaishnavi (2012) [16] reported mean moisture content to be 11.2% in raw and processed foxtail millet and proso millet by various cooking methods like wet and dry heating.

Protein

Protein content in the whole and de-hulled processed BT was found to be in the range of 6.10±0.06% to 17.31±0.25%. Whole and de-hulled BT samples had a protein content of 8.8±0.23% and 17.31±0.25%. Further, it was observed that de-hulled browntop millet samples subjected to different pretreatments had significantly ($p< 0.05$) high protein than processed whole browntop millet samples. The protein content of the whole processed BT were in the order of WBF (8.8±0.23%) > GWBF (8.27±0.14%) > DWBF (8.21±0.17%) >HWBF (8.21±0.11%). Increase in the protein content was observed on de-hulling the browntop millet and follows the order, untreated (17.31±0.25%)>dry-heating (14.56±0.29%)> >hydrothermal treatment (14.23±0.18%)> fermentation (13.40±0.84)> Soaking (12.72±0.90%)> extrusion (10.77±0.11%). Similar results about improvement in protein and protein digestibility were reported by Ghavidel and Prakash, 2007 [10] in green gram, cowpea, lentil, and chickpea. About 2.2–5.1% and 13.2–16.7% increase in the protein and protein digestibility respectively was reported.

The probable reason for increment in the protein content and its digestibility on De-hulling the grains was due to the removal of the bran from endosperm thereby reducing tannin and phytate content which binds protein and enabling protein digestibility (Oghbaei and Prakash, 2016 and Harland & Morris, 1995) [20, 12]. A decrease in the protein on germination was due to the loss of water-soluble nitrogen during soaking of seeds before sprouting and utilization of the protein for growth and development of the embryo (Wu and Wall, 1980)

[30]. Ahmed *et al*., (2006) [1] reported that there was a reduction in protein content of guar gum seeds after germination (44.8%) compared to control seeds (52.6%).

In contrary to the study by Nour *et al*., 2015 [19], protein content on fermentation was decreased compared to control whole and de-hulled BT. The increased content of protein, fat, fibre and total ash are only apparent and attributable to the disappearance of starch. Roasting is an important unit operation in the processing of grain, where *in vitro* protein and starch digestibility of weaning foods increased by 15 - 21% and 16 - 19%, respectively (Mridula *et al*., 2008) [17]. De-hulled control BT had the highest protein content compared to processed BT but the moisture content in the processed BF was lower it is assumed that the shelf life of the BT flours would be better compared to control de-hulled BT. Differently treated de-hulled BF can serve as a good source of protein when consumed.

Total ash content: Total ash content generally represents the total mineral content. Ash content in the whole and dehulled processed BT was found to be in the range of 1.06±0.07% to 5.80±0.15%. Germinated BT had the highest ash content followed by control whole and dehulled BT with 5.80±0.15%, 5.43±0.27%, 2.36±0.09% respectively. It was observed that dehulled samples treated differently i.e., soaking, fermentation, hydrothermal treatment, dry heating and extrusion cooking had lower ash content (1.79±0.17%, 1.06±0.07%, 2.08±0.04%, 2.42±0.23%, 2.16±0.17% respectively) than differently treated whole samples (4.75±0.15%, 5.17±0.11%, 5.06±0.33%, 5.29±0.15%, 3.54±0.22% respectively). As per the results it was noted that ash content was reduced significantly ($p < 0.05$) on dehulling. Decrease in ash content after fermentation could be due to utilization of ash during the growth of micro-organisms. Similar results were reported by Nour *et al*., (2005) in sorghum flour. Duhan *et al*. (1999) [8], Gernah *et al*. (2011) [9], Mubarak (2005) [18], reported that germination and cooking processes cause a significant decrease in ash content of dehulled grains. Whereas in whole samples germinated BT high ash content was reported. Possible reasons for the reduction in ash content in soaked samples were leaching out of solid matter during soaking.

Fat content: Fat content in the whole and dehulled processed BT (Table 1) was found to be in the range of 3.78±0.12% to 7.08±0.03%. Highest fat content was observed for fermented dehulled sample (7.08±0.03%) whereas least was for extruded whole sample (3.78±0.12%).The results indicate that the fat content was less in whole samples compared to dehulled BT samples. A decreasing trend was observed for all the treated samples except for fermented and hydrothermally treated samples. The presence of water and high temperatures of these two processing methods could lead to cell wall rupture which may enhance the diffusion of oil into hexane during the lipid determination. Decrease in the fat content can be attributed to loss of low molecular weight during soaking and hydrolysis of lipid and oxidation of fatty acids during germination whereas in roasting this might be due to shrinkage of the grain which may prevent the collapse of cell structures thereby limiting the diffusion of oil into hexane during the lipid determination. Giami (1993) [11]; Choudhury *et al*. (2011) [7] reported that there was 17.65% decrease in fat content (1.4 g) after germination and 11.76% increase in fat content (1.9 g) after fermentation, when compared to raw cowpea flour (1.7 g).

Crude fibre content: As indicated in Table 1, germinated whole BT flour had the highest crude fibre content (20.17±0.09%) followed by fermented whole BT flour (5.17±0.11%), whole BT flour (16.33±0.23%), soaked whole browntop millet flour (14.08±0.07%) respectively. The crude fibre content in the dehydrated BT and hydrothermally treated BT were found to be 13.00±0.58% and 12.50±0.32% respectively. It was observed that there is a significant difference in the ash content of whole treated BT flours and dehulled treated BT flours ($p < 0.05$). Crude fibre content was reduced after dehulling and processing the BT. Among all the treatments germination and fermentation favoured increment in the crude fibre content while remaining samples had shown to have lower ash content when compared with control BT samples. In contrary to the present findings concerning fermentation Singh *et al*., 2017 [23] reported a little reduction in the fibre content of fermented samples compared with untreated pearl millet flour. Whereas Chauhan and Saritha (2018) [5] reported that the crude fibre content of whole raw finger millet flour and germinated finger millet flour was 18.9±0.2 g and 20.0±0.3 g respectively in which there was an increase in fibre content after germination.

Table 1: Nutrient content of differently treated browntop millet flours

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	CHO (%)	Energy K.Cal/100 g
WBF	8.99±0.06^{a}	8.8±0.23^{f}	4.6±0.27^{e}	5.43±0.27^{ab}	16.33±0.23^{b}	58.00±1.06^{b}	306.8±4.6^{c}
DBF	8.97±0.04^{a}	17.31±0.25^{a}	6.27±0.15^{b}	2.36±0.09^{e}	3.53±0.29^{g}	61.54±0.20^{g}	371.9±1.1^{b}
SWBF	6.56±0.28^{e}	8.08±0.04^{f}	4.27±0.17^{f}	4.75±0.15^{c}	14.08±0.07^{c}	76.33±0.25^{bc}	376.1±1.8^{ab}
SDBF	6.33±0.22^{e}	12.72±0.90^{d}	5.08±0.06^{c}	1.79±0.17^{f}	2.22±0.07^{g}	74.02±0.61^{de}	386.6±6.7^{ab}
GWBF	8.66±0.33^{ab}	8.27±0.14^{f}	4.32±0.14^{f}	5.80±0.15^{a}	20.17±0.09^{a}	72.94±0.56^{e}	365.2±2.4^{b}
FWBF	7.61±0.18^{d}	6.10±0.06^{g}	5.34±0.13^{c}	5.17±0.11^{bc}	19.44±0.29^{a}	75.09±0.42^{cd}	366.9±8.9^{b}
FDBF	8.36±0.12^{bc}	13.40±0.84^{cd}	7.08±0.03^{a}	1.06±0.07^{g}	10.83±0.12^{e}	70.08±0.89^{f}	382.6±10.9^{ab}
HWBF	4.74±0.14^{f}	8.21±0.11^{f}	5.03±0.03^{cd}	5.06±0.33^{bc}	13.00±0.58^{d}	76.95±0.26^{bc}	385.9±0.4^{ab}
HDBF	5.17±0.09^{ef}	14.23±0.18^{bc}	5.21±0.05^{c}	2.08±0.04^{ef}	2.42±0.16^{g}	73.17±0.19^{e}	396.5±0.8^{a}
DWBF	2.07±0.11^{g}	8.21±0.17^{f}	4.16±0.08^{fg}	5.29±0.15^{b}	13.07±0.07^{d}	79.68±0.75^{a}	374.7±16.2^{b}
DDBF	1.92±0.05^{h}	14.56±0.29^{b}	5.42±0.18^{c}	2.42±0.23^{e}	3.08±0.07^{f}	75.33±0.49^{cd}	383.8±14.0^{ab}
EWBF	7.43±0.27^{d}	7.74±0.20^{fg}	3.78±0.12^{g}	3.54±0.22^{d}	12.50±0.32^{d}	77.70±0.32^{b}	375.8±0.6^{ab}
EDBF	7.82±0.08^{cd}	10.77±0.11^{e}	4.86±0.18^{de}	2.16±0.17^{e}	3.53±0.52^{f}	74.37±0.20^{de}	384.3±1.7^{ab}
CD	0.44	1.09	0.41	0.45	0.75	1.64	21.80

WBF- whole browntop millet flour; DBF- dehulled browntop millet flour; SWBF- soaked browntop millet flour; SDBF-soaked browntop millet flour; GWBF-germinated browntop millet flour; FWBF- fermented whole browntop millet flour; FDBF- fermented dehulled browntop millet flour; HWBF-hydrothermally treated whole browntop millet flour; HDBF-hydrothermally treated dehulled browntop millet flour; DWBF- dry heated whole browntop millet flour; DDBF- dryheated dehulled browntop millet flour; EWBF- extruded whole browntop millet flour; EDBF- extruded dehulled browntop millet flour

Carbohydrate content: The carbohydrate content in the whole treated browntop millet flours was in the range of 58.00±1.06% to 76.33±0.25% whereas dehulled treated flours had carbohydrate in the range of 61.54±0.20% to 75.33±0.49%. The carbohydrate content of whole BT samples subjected to various methods of processing i.e., soaking, fermentation, germination, dehydration, hydrothermal treatment and extrusion were found to be 76.33±0.25%, 75.09±0.42%, 72.94±0.56%, 79.68±0.75%, 76.95±0.26% and 77.70±0.32% respectively. Processed dehulled BT samples had 76.33±0.25%, 70.08±0.89%, 73.17±0.19%, 75.33±0.49% and 74.37±0.20% after subjecting to soaking, fermentation, hydrothermal treatment, dry-heating and extrusion cooking respectively. According to the results whole and dehulled BT had significantly less CHO content compared to processed flours. Verma *et al*. (2015) [29], who reported 69.95% carbohydrate content in foxtail millet flour, 71.87% carbohydrate content in barnyard millet flour and 80.58% of carbohydrates in rice flour. The carbohydrate content was significantly different ($p < 0.05$) in all the processed whole and dehulled flour samples.

Energy Content: Energy content in the whole and dehulled processed BT was found to be in the range of 306.8±4.6 to 396.5±0.8 K. Cal/100 g. Control whole and dehulled BT samples had energy content of 306.8±4.6 and 371.9±1.1 K. Cal/100 g respectively. It was observed that dehulled BT subjected to various methods of processing i.e., soaking, fermentation, hydrothermal treatment, dry heating and extrusion cooking had higher energy content (386.6±6.7, 382.6±10.9, 396.5±0.8, 383.8±14.0 and 384.3±1.7 K. Cal/100 g) than whole BT (376.1±1.8, 366.9±8.9, 385.9±0.4, 374.7±16.2 and 375.8±0.6 K. Cal/100 g respectively). The whole germinated BT sample had an energy content of 365.2±2.4 K. Cal/100 g.

Conclusion

This study confirms that browntop millet was an excellent source of nutrients. Different processing methods (soaking, germination, fermentation, hydrothermal treatment, dry-heating and extrusion cooking) brought slight changes in the nutrients analyzed suggesting processed browntop millet flour could be considered as a healthy and suitable ingredient for food industry to develop cereal based products and gluten free products. The chemical properties of Browntop millet was on par with the other millets, indicating that the dehulled and processed Browntop millet flours can be efficiently used in processing and formulating various healthy food products as is done with other minor millets.

References

1. Ahmed MB, Hamed RA, Ali ME, Hassan AB, Babiker EE. Proximate composition, anti-nutritional factors and protein fractions of guar gum seeds as influenced by processing treatments. Pakistan Journal of Nutrition. 2006;5(5):481-484.
2. Al-Mudaris MA. Notes on various parameters recording the speed of seed germination. Der Tropenlandwirt-Journal of Agriculture in the Tropics and Subtropics. 1998;99(2):147-154.
3. AOAC. Approved methods of analysis. The American Association of Cereal Chemists, St. Paul., Minnesota. 2005.
4. AOAC. Official Methods of analysis.16th Edn. Wshington DC, Association of Analytical Chemists. 2016.
5. Chauhan ES, Saritha. Effects of processing (germination and popping) on the nutritional and anti-nutritional properties of finger millet (*Eleusine Coracana*). Current Research in Nutrition and Food Science Journal. 2018;6(2):566-572.
6. Chauhan ES, Saritha. Effects of processing (germination and popping) on the nutritional and anti-nutritional properties of finger millet (*Eleusine Coracana*). Current Research in Nutrition and Food Science Journal. 2018;6(2):566-572.
7. Choudhury M, Das P, Baroova B. Nutritional evaluation of popped and malted indigenous millet of Assam. Journal of Food Science and Technology. 2011;48(6):706-11.
8. Duhan A, Khetarpaul N, Bishnoi S. Effect of various domestic processing and cooking methods on phytic acid and HCl-extractability of calcium, phosphorus and iron of pigeonpea. Nutrition and Health. 1999;13(3):161-169.
9. Gernah DI, Ariahu CC, Ingbian EK. Effects of malting and lactic fermentation on some chemical and functional properties of maize (*Zea mays*). American Journal of Food Technology. 2011;6(5):404-412.
10. Ghavidel RA, Prakash J. The impact of germination and dehulling on nutrients, antinutrients, *in vitro* iron and calcium bioavailability and *in vitro* starch and protein digestibility of some legume seeds. LWT-Food Science and Technology. 2007;40(7):1292-1299.
11. Giami SY. Effect of processing on the proximate composition and functional properties of cowpea (*Vigna unquiculata*) flour. Food Chemistry. 1993;47:153-158.
12. Harland BF, Morris ER. Phytate: a good or a bad food component. Nutrition Research. 1995;15(5):733-754.
13. Jacobs H, Delcour JA. Hydrothermal modifications of granular starch, with retention of the granular structure: A review. Journal of Agricultural and Food Chemistry. 1998;46:2895-2905.
14. Liu P, Cheng J, Li M, Li J, Zhu H, Wang S, Yu G. Effects of Extrusion Conditions on Physicochemical Properties of Finger Millet (Gramineae Setaria). Journal of Agricultural Science. 2020;12(9):149-158.
15. Malik M, Singh U, Dahiya S. Nutrient composition of pearl millet as influenced by genotypes and cooking methods. Journal of Food Science and Technology. 2002;39(5):463-468.
16. Mohankumar JB, Vaishnavi R. Nutrient and antioxidant analysis of raw and processed minor millets. Elixir Food Science. 2012;52:11279-11282.
17. Mridula D, Goyal RK, Manikantan MR. Effect of roasting on texture, colour and acceptability of pearl millet (*Pennisetum glaucum*) for making sattu. International Journal of Agricultural Research. 2008;3(1):61-68.
18. Mubarak AE. Nutritional composition and anti-nutritional factors of mung bean seeds (*Phaseolus aureus*) as affected by some home traditional processes. Food Chemistry. 2005;89(4):489-495.

19. Nour AAM, Ibrahim MAEM, Abdelrahman EE, Osman EF, Khadir KE, Hussain NF, *et al*. Effect of processing methods on nutritional value of sorghum (*Sorghum bicolor L. Moench*) cultivar. American Journal of Food Science and Health. 2015;1(4):104-108.
20. Oghbaei M, Prakash J. Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review. Cogent Food and Agriculture. 2016;2(1):1-14.
21. Ragaee S, Abdel-Aal ESM, Noaman M. Antioxidant activity and nutrient composition of selected cereals for food use. Food Chemistry. 2006;98:32-38.
22. Saleh AS, Zhang Q, Chen J, Shen Q. Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. Comprehensive Reviews in Food Science and Food Safety. 2013;12:281-295.
23. Singh M, Adedeji A, Santra D. Physico-chemical and functional properties of nine proso millet cultivars. Transactions of the ASABE. 2017;61(3):1165-1174.
24. Singh P, Raghuvanshi RS. Finger millet for food and nutritional security. African Journal of Food Science. 2012;6(4):77-84.
25. Snedecor GW, Cochran WG. Statistical Methods. Seventh Edition. Ames Iowa: The Iowa State University Press. 1980.
26. Sravani. Effect of Processing Methods on Nutritional and Anti-nutritional qualities of Browntop Millet (*Brachiaria ramosa*). MSc Thesis. PJTSAU, Rajendranagar, Hyderabad, India. 2021.
27. Thilagavathi T, Kanchana S, Banumathi P, Hemalatha G, Vanniarajan C, Sundar M, *et al*. Physico-chemical and Functional Characteristics of Selected Millets and Pulses. Indian Journal of Science and Technology. 2015;8:147-155.
28. Usha A, Sripriya G, Chandra TS. Effect of fermentation on the primary nutrients in finger millet (*Eleusine coracana*). Journal of Agricultural and Food Chemistry. 1996;44(9):2616-2618.
29. Verma S, Srivastava S, Tiwari N. Comparative study on nutritional and sensory quality of barnyard and foxtail millet food products with traditional rice products. Journal of Food Science and Technology. 2015;52(8):5147-5155.
30. Wu YV, Wall JS. Lysine content of protein increased by germination of normal and high-lysine sorghums. Journal of Agricultural and Food Chemistry. 1980;28(2):455-458.