The Pharma Innovation Journal 2022; SP-11(8): 508-512

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(8): 508-512

www.thepharmajournal.com
Received: 08-06-2022
Accepted: 12-07-2022

Mamta
Department of Food Science, Nutrition and Technology, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Anupama Sandal
Department of Food Science, Nutrition and Technology, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Corresponding Author
Mamta
Department of Food Science, Nutrition and Technology, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Impact of roasting and soaked roasting on sesame seed for nutritional traits

Mamta and Anupama Sandal

Abstract
Oilseed crops are one of the utmost imperative crops in the world. Their role in the human diet and industrial application cannot be under-estimated. Therefore, the present experimentation entitled "Impact of roasting and soaked roasting on a sesame seed for Nutritional Traits" was undertaken at the Department of Food Science, Nutrition and Technology, CSKHPKV, Palampur, Himachal Pradesh. To standardize the processing techniques and to analyse the nutritional aspects of the sesame seed (Brajeshwari) was given treatments viz. roasting and soaking+ roasting. Sesame seed was soaked in water for six hours and roasted at 95-120 °C for 6-10 minutes. Soaked roasted treatment decreased the crude protein, crude fibber, crude fat, total ash content, carbohydrate content, total energy, physic acid, calcium, and copper, whereas it increased the antioxidant, Mg, Fe, and Zn significantly ($p \leq 0.05$) when compared to roasted seeds.

Keywords: Sesame, nutritional traits, roasting, soaked roasting, crude protein

Introduction
The nutritive potential of the oilseed crops is known for improvising the human diet because these crops provide food security and assurance of employment generation in the society. Sesame (*Sesamum indicum* L.) is the earliest known oleaginous, belongs to the Pedaliaceae family, and its centre of origin is the African continent [35]. It is commonly known as Til, Tila, Bija, etc. The major contributor states in India for the production of sesame are West Bengal, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, Andhra Pradesh, and Telangana, which contributes more than 85 percent. It adds a nutty taste and a delicate, almost invisible crunch to many Asian dishes, while it has been extensively engaged in culinary purposes and traditional medicines as it comprises a very fair amount of nutritive, preventive, and curative properties. Apart from this, it is an excellent source of phytonutrients like vitamins, omega-6 fatty acids, flavonoids, phenolic compounds, antioxidants, dietary fibber and is also known for containing potential anti-cancer, diuretic, galactogogue, hepato-protective, and laxative. It is a traditional health beneficial food that has been used to improve nutritional status and prevent various diseases in Asian countries for thousands of years. It contains a little low amount of lysine, besides this, it contains a fair amount of other sulfur-containing amino acids such as arginine, methionine, cysteine, and leucine considerably more often the limiting amino acid in a legume-based diet [22]. Sesame contains 43 percent of poly-unsaturated fatty acids and 40 percent monounsaturated fatty acids [31]. Numbers of bioactive components are present in sesame seed including phytosterols, tocopherols, and lignans such as sesamolin and sesamin, and sesaminol, which play a vital role against oxidation of oil and contributes to anti-oxidative activity [13]. It has some potential of nutraceutical compounds such as phenolic and tocopherols with antioxidant activity that have a noteworthy outcome on reducing the blood pressure, degeneration of vessels and lipid profile and have an impact on the reducing chronic diseases [11]. As per choice and desire, sesame seeds can be used in combination with other food ingredients for the standardization of a variety of food products having additional functional and health properties. The primary marketable products of sesame seed are whole seeds, seed oil, and meal. [33] variety 32-15 of sesame was studied for mineral content and reported that for 100g of seed there was the highest rate of calcium (689.92 ± 15.97mg) followed by phosphorus (575.99 ± 16.75mg), magnesium (315.84 ± 8.66mg), zinc (38.56 ± 1.86mg) and iron (122.50 ± 4.21mg). Sesame oil extract contained higher total phenolic content compared to other commonly available vegetable oils like sunflower, corn, rapeseed, and soy oils are 12.0, 12.6, 13.1, and 14.8mg GAE/g of methanolic extract [3]. Sesame is rich in sulfur-containing amino acids and limited in lysine and contains significant amounts of oxalic

(2.5 percent) and phytic (5 percent) acids [13].

Material and Methods

The seeds of Sesame variety – Brajeshwari has commonly grown oilseeds crop in Himachal Pradesh were procured from the Department of Crop Improvement, College of Agriculture and Krishi Vigyan Kendra, Kangra, CSKHPKV. The processing of seed was done with two major treatments has been initiated, including roasting and soaked roasting. The processes are elaborated in detail as mentioned viz., (1) Roasted sesame seed: Raw sesame seeds without any treatment were roasted at 95 °C for 6-8 minutes to get the desired aroma. (2) Soaking: The sesame seeds were soaked in water at the temperature of 20 °C for six hours and after six hours the seeds were dried in a hot air oven for one hour at 60 °C temperature and then roasted at 120 °C for 6-8 minutes to get the desired aroma. The nutritional composition of roasted and soaked roasted sesame seeds was evaluated and studied. Proximate composition is the term usually used in the field of feed/food and means the six components of moisture, crude protein, crude fat, crude fibber, crude ash, and crude protein, which are expressed as the content (%) in the food, respectively [4]. The above proximate parameters were analyzed by using standard methods. The observations were made in triplicate. Carbohydrate Content was determined by the method mentioned by Hedge and Hofreiter, Energy through O'Shea and Maguire [22]. The mineral content was calculated by the Diacid method given for Ca, Fe, Zn Mg Cu. From the data obtained for various parameters, the mean values for each sample were calculated. The antioxidant activity was determined for total phenols [4] and DPPH percent inhibition activity in samples [34] and phytic acid [9]. The significant difference between the nutritional compositions, minerals, antioxidants, and phytic acid of the samples was tested using the analysis of variance in one-way ANOVA.

Result and Discussion

Nutritional composition of roasted and soaked roasted sesame seed

Moisture Content: The moisture content of raw, roasted, and soaked + roasted sesame seeds were 6.02, 5.87, and 5.22 percent respectively. There was no significant difference in moisture content (table-1). The moisture content decreased after soaking and roasting because after soaked seeds were dried in an oven for 1h at 60 °C temperature and then roasted at a particular temperature which decreased the moisture content in decimals in both seeds. The results can be confirmed with other author [37] who reported that whole seeds, dehulled seeds, and hull contained 5.40, 6.20 and 4.20 percent moisture content, respectively.

Crude protein: Crude protein in roasted sesame seeds (19.61 percent) followed by soaked + roasted sesame seeds (17.53 percent), the results were significant this happened maybe because of roasting after soaking treatment [7] that the value of foaming capacity for horse gram before soaking was 38mL after soaking for 6 hours it was 39.67mL there was an increase in the total protein at the surface which concluded that when seeds were roasted at particular temperature more protein gets denatured because of the presence of high total protein on the surface area. Similar results of the crude protein content of whole seed were reported [22] as 19.71 percent, Asghar and Majeed [5] reported it as 19.12 percent, whereas Makinde and Akinso [16] and another research [20] showed 21.94 and 33.54 percent crude protein respectively. The crude protein of roasted sesame seeds was 16.45 percent [2]. Kaur [15] reported 19.72 percent for raw 19.53 percent crude protein for roasted sesame seeds and 17.65 percent for soaked + roasted sesame seeds which confirmed the present findings.

Crude fat: The crude fat content was highest in roasted sesame seeds containing 50.64 percent while soaked + roasted sesame seeds contained 50.01 percent, similar results were reported by [2] where the fat content in raw and roasted sesame seeds was 49.51 and 51.35 percent. Hassan (2012) reported higher results of fat content in raw sesame seeds (59.8 percent) and roasted sesame seeds (59.89 percent). The highest fat content recorded in roasted sesame seeds could be attributed to the disruption of cell structure and membrane partitions of the seeds by heat during cooking and roasting, causing the fat to melt and easily release from the cell [2]. Raw sesame contained 50.97 percent, roasted seeds contained 51.19 percent, and soaked + roasted sesame seeds contained 50.04 percent crude fat which is similar to the present findings [15].

Table 1: Proximate composition, carbohydrate and energy content of roasted and soaked+ roasted sesame seeds

Treatment	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Total Ash (%)	Carbohydrate (%)	Energy (Kcal)
Roasted sesame seed	5.87^{a}	19.61^{a}	50.64^{a}	5.71^{a}	6.54^{a}	18.01^{a}	592.94^{a}
Soaked + roasted sesame seed	5.22^{a}	17.53^{b}	50.01^{a}	5.68^{a}	3.49^{b}	11.32^{b}	581.16^{b}
CD ($P \leq 0.05$)	(0.70)	(0.54)	(1.5)	(0.23)	(0.96)	(2.05)	(6.24)

*Means having different superscripts within the column are significantly different at $p \leq 0.05$

Crude Fibre: There is no significant difference in seeds treatment, maximum crude fibber was present in roasted (5.71) while non-significantly low in soaked + roasted (5.68 percent). The results can be confirmed with other author [15] who reported 5.23 percent for roasted and 5.21 percent for soaked + roasted sesame seeds. The difference between the varieties and agro-climatic conditions may be the cause of different values of crude fibber.

Total Ash: In sesame seed, roasted seeds contained 6.54 percent, and soaked + roasted contained 3.49 percent of total ash content. Kaur [15] reported the same results for the same variety of sesame seeds, for roasted it was 6.74 percent while for soaked + roasted it was 3.4 percent which was similar to present findings. Mares [17] reported a reduction in ash content in white sesame due to higher absorption of water by soaking treatment, which diluted the total ash content furthermore, Rusydi *et al.* [27] and Ruiz and Bressani [26] found a similar trend of results in rice and amaranth seeds evaluation.

Carbohydrate: For roasted and soaked + roasted sesame seeds it was 18.01 and 11.32 percent which was significant

statistically. Adegunwa [2] and Kaur [15] reported the carbohydrate content for treated sesame seeds which was similar to the present studies. Maria and Victoria reported that the carbohydrate content in sprouts of sesame seed decreased continuously with increasing soaking and germination time, from 13.1 to 9.6per cent. This observation could be due to the utilization of fat and carbohydrate for biochemical activities of the germinating seeds.

Energy: Roasted sesame seeds contained 592.94Kcal followed by soaked + roasted sesame seeds (581.16Kcal), the results can be confirmed with Kaur [15] who reported 595Kcal for oven-dried and for soaked + roasted sesame seeds and 583Kcal for raw. Due to a decrease of crude protein, crude fat, and carbohydrate content, there was a decrease in total energy in soaked + roasted sesame seeds in comparison to roasted sesame seeds.

The mineral content of roasted and soaked + roasted sesame seeds

Data presented in Table-2 indicates the mineral content of roasted and soaked + roasted sesame seeds. Roasted sesame contained 1103.81, 427.1, 8.02, 8.46 and 2.41mg/100g calcium, magnesium iron, zinc, and copper respectively whereas soaked + roasted sesame contained 1089.68, 438.88, 8.74, 8.83 and 2.39mg/100 g calcium, magnesium iron, zinc, and copper respectively.

Table 2: Mineral content of roasted and soaked + roasted sesame seeds (mg/100g)

Treatment	Calcium	Magnesium	Iron	Zinc	Copper
Roasted sesame seed	1103.81^{a}	427.1^{b}	8.02^{a}	8.46^{a}	2.41^{a}
Soaked + roasted sesame seed	1089.68^{b}	438.88^{a}	8.74^{a}	8.83^{a}	2.39^{a}
CD (P≤0.05)	(2.3)	(1.65)	(0.82)	(0.78)	(0.49)

*Means having different superscripts within the column are significantly different at p≤0.05

The results can be confirmed with another researcher [15] who reported 1115.81, 1089.6, and 1097.17mg calcium, 427.1, 438.88 and 426.77mg magnesium, 8.22, 8.74 and 8.04mg iron, 8.66, 8.83 and 8.39mg zinc and 2.41, 2.39 and 2.29mg copper in raw, soaked + roasted and oven-dried sesame seeds. A similar result of calcium content which ranged from 1172.08 to 1225.71mg/100 g, iron content was 10.24 to 10.75mg/100 g [37]. Another author [16] reported that iron content in raw sesame seeds dehulled sesame seeds and the hull was 6.21, 6.06, and 6.28mg/100 g, respectively. The calcium and copper content decreased after soaking and roasting treatment may be because of loss of cooper in drained water as [7] reported copper content as 2.15 and 3.48mg/100g in raw sesame seeds and seed coat after soaking there was a loss in copper content. There was an increase of iron and zinc non-significantly which can be confirmed with the results of Rao [25] who reported for groundnuts that after germination there was a decrease in antinutritional factors, such as tannin, and increased the bioavailability forms of iron and zinc, namely ionisable iron and soluble zinc contents of groundnut kernel.

Antioxidant content of roasted and soaked + roasted sesame seeds

Table-3 depicts the values of total phenols and DPPH inhibition activity in seeds. The highest total phenol was found in soaked + roasted sesame seed contained 75.36mg followed by roasted sesame seed (61.55mg). The phenolic content varied significantly. The soaked + roasted treatment of seeds significantly increased the total phenols.

Table 3: Antioxidant content of roasted and soaked + roasted sesame seeds (mgGAE/100g)

Treatment	Total phenol (mg GAE/100g)	DPPH (per cent inhibition) activity
Roasted sesame seed	61.55^{b}	14.74^{b}
Soaked + roasted sesame seed	75.36^{a}	20.70^{a}
CD (P≤0.05)	(0.29)	(0.37)

*Means having different superscripts within the column are significantly different at p≤0.05

The germination increases the number of phenolic compounds and antioxidant capacity in grains [1]. Due to the biochemical process, bioactive compounds formed with antioxidant function, such as phenolic compounds and tocopherol [38]. Similar results were reported by [11] that total phenol content was in the range of 20.1 to 70.95mg GAE/g for 8 Iranian sesame varieties, there was 61.23mg total phenol in roasted sesame seed while 74.92mg total phenol in soaked + roasted sesame seed [15]. The phenolic compounds in white sesame seed were analyzed during the germination time and an increasing amount was reported which was directly proportional to time [17, 35] found an increase of phenolic compounds in oatmeal in different germination times (12, 24, 36 and 48h), this fact could be justified because the soaking releases the phenolic compounds that were connected and then increases the quantity of total phenolic [14]. In contrast, Randhir *et al.* [24] found a decrease in phenolic levels in mungo beans seeds and this reduction was justified due to the pigmentation loss in legumes when germination occurs.

DPPH inhibition activity also varied significantly where DPPH for soaked + roasted sesame seeds contained 20.70 percent and in roasted sesame, it was 14.74 per cent while for raw it was 13.45 percent. Oven-dried sesame seeds contained 14.48 percent soaked + roasted sesame contained 20.66 percent [15]. Oher [30] reported that sesame seed had 27.2 percent DPPH inhibition activity. Similar results that ranged from 14.10 to 20.66 percent [28].

Antinutritional factor of roasted and soaked + roasted sesame seeds

Table 4: Antinutritional factor of roasted and soaked + roasted sesame seeds (mg/100g)

Treatment	Total phytic acid (mg/100g)
Roasted sesame	49.33^{a}
Soaked + roasted sesame	47.50^{b}
CD (P≤0.05)	(2.69)

*Means having different superscripts within the column are significantly different at p≤0.05

The anti-nutrient factor of roasted and soaked + roasted sesame seeds was determined in the study as phytic acid shown in Table-4. Phytate was highest in roasted sesame seed contained 49.33mg and soaked + roasted sesame seed contained 47.5mg phytic acid per 100g all the values are significantly different which showed that the soaked + roasted treatment lowered the amount of phytic acid. Reduction in phytic acid content may be attributed to increased synthesis of phytase during germination and the subsequent increase in

phytic acid degradation. Because germination is mainly a catabolic process that supplies important nutrients to the growing plant through hydrolysis of reserve nutrients, reduction in phytic acid was expected as it was a primary source of phosphorus and captions during the process [31]. The phytate contents of raw sesame seed was 47.98mg followed by roasted and soaked + roasted sesame seeds were 46.61mg and 45.59mg / 100g which was near to present findings [15]. There was a significant decrease in phytic acid after soaked + roasted treatment.

Conclusion

Sesame seeds being rich in so many nutrients like crude protein, crude fat, carbohydrate, and energy also prevents age-related degenerative diseases for successful aging. It is also a good source of minerals and antioxidants. So, it can be incorporated in the development of nutritious products for all age groups of people to provide an adequate amount of nutrients in an easy and affordable form and which can be consumed as a snack as well as meal also. One can get highly nutritive, cheap, and convenience bars.

Orcid: https://orcid.org/0000-0001-9268-2376

Acknowledgements

We thank "Department of Food Science, Nutrition and Technology, CSK Himachal Pradesh Krishi Vishvavidalaya, Palampur-176062, India" for technical support.

Data Availability: The authors declare that the data supporting the findings of this study are available within the article.

Declarations

Ethics Declaration: This article does not contain any studies with human or animal subjects.

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that influenced the work reported in this paper.

References

1. Abderrahim F, Huanatico E, Repo-Carrasco-Valencia R, Arribas SM, Gonzalez MC, Condezo-Hoyos L. Effect of germination on total phenolic compounds, total antioxidant capacity, Maillard reaction products and oxidative stress markers in canihua (*Chenopodium pallidicaule*). Journal of Cereal Science. 2012;56:410-417, Available at: 10.1016/j.jcs.2012.04.01..
2. Adegunwa MO, Adebowale AA, Solano EO. Effect of thermal processing on the biochemical composition, anti-nutritional factors and functional properties of beniseed (*Sesamum indicum*) flours. American Journal of Biochemistry and Molecular Biology. 2012;2:175-182.
3. Aleksander S, Malgorzata N, Elenora L. The content and antioxidant activity of phenoilc compounds in cold pressed plant oils. Journal of Food Lipids. 2008;15:137-149.
4. AOAC. Official methods of analysis, 18th edition, Association of Official Analytical Chemists, Washington DC, 2010.
5. Asghar A, Majeed MN. Chemical characterization and fatty acid profile of different sesame verities in Pakistan. American Journal of Science and Industrial Research. 2013;4(6):540-545.
6. Elleuch M, Besbes S, Roiseux O, Blecker C. Quality characteristics of sesame seeds and by-products. Food Chemistry. 2007;103(2):641-650.
7. Handa V, Kumar V, Panghal A, Suri S, Kaur J. Effect of soaking and germination on physicochemical and functional attributes of horsegram flour. Journal of Food Science Technology. 2017;54(13):4229-4239, Available at: DOI: 10.1007/s13197-017-2892-1
8. Hassan MAM. Studies on Egyptian sesame seeds (*Sesamum indicum* L.) and its products 1-Physicochemical analysis and phenolic acids of roasted Egyptian sesame seeds (*Sesamum indicum* L.) World Journal of Dairy & Food Sciences. 2012;7:195-201.
9. Haug W, Lantzch HT. Sensitive method for rapid determination of phytate in cereals and cereal products. Journal of the Science of Food and Agricultural, 1983, 1423.
10. Hedge JE, Hofreiter BT. In: carbohydrate chemistry 17 (Eds Whistler RL and Be Miller JN) Academic Press, New York, 1962.
11. Jannat B, Oveisi MR, Sadeghi N, Hajimahmoodi N, Behzad M, Choopankari E, *et al.* Effect of roasting temperature and time on healthy nutraceuticals of antioxidant and total phenolic content in Iranian sesame seed (*Sesamum indicum*. L). Iranian Journal of Environment Health Science and Engineering. 2010;7:97-102.
12. Kanu PJ, Bahsoon JZ, Kanu JB, Joseph BAK. Nutraceutical importance of sesame seed and oil: A review of the contribution of their lignans. Journal of Biomedical Research. 2010;2(1):4-16.
13. Kapadia G, Azuine M, Tokuda H, Takasaki M, Mukainaka T, Konoshima T, *et al.* Chemo preventive effect of resveratrol, sesamol, sesame oil and sunflower oil in the Epstein-Barr virus early antigen activation assay and the mouse skin two-stage carcinogenesis. Pharmacological research: The Official Journal of The Italian Pharmacological Society. 2002;45:499-505. Available at: https://10.1006/phrs.2002.0992
14. Kaukovirta-Norja A, Wilhelmsson A, Poutanem K. Germination: A means to improve the functionality of oat. Agricultural and Food Science. 2004;13(1/2):100-112.
15. Kaur G. Biochemical evaluation and utilization of sesame seeds in preparation of functional foods. Ph.D. Thesis, p 1-177. Department of Food Science Nutrition and Technology, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India, 2018.
16. Makinde FM, Akinoso R. Nutrient composition and effect of processing treatments on antinutritional factors of Nigerian sesame (*Sesamum indicum* L) cultivars. International Food Research Journal. 2013;20:2293-2300
17. Mares LFM, Passos MC, Menezes CC. Interference of germination time on chemical composition and antioxidant capacity white sesame (*Sesamum indicum*). Food Science and Technology, 2017, 1-6. Available at: http://dx.doi.org/10.1590/1678-457X.2021.
18. Mbithi-Mwikya S, Camp JV, Rodriguez R, Huyghebaert A. Effects of sprouting on nutrient and anti-nutrient composition of kidney beans (*Phaseolus vulgaris* var. Rose Coco). European Food Research and Technology. 2001;212(2):188-191. Available at: 10.1007/s002170000200

19. Ogungbenle HN, Onoge F. Nutrient composition and functional properties of raw, defatted and protein concentrate of sesame (*Sesamum indicum*) flour. European Journal of Biotechnology and Bioscience. 2014;2:37-43.
20. Ojiako OA, Igwe CU, Agha NC, Ogbuji CA, Onwuliri VA. Protein and amino acid compositions of *Sphenostylis stenocarpa, Sesamum indicum, Monodora myristica* and *Afzelia africana* seeds from Nigeria. Pakistan Journal of Nutrition. 2010;9:368-372.
21. Okudu HO, Oguizu AD, Nwaokoro CF. Nutrients and ant nutrients contents of white beniseed cultiver (*Sesamun indicum* L) in Nigeria. Direct Research Journal of Agriculture and Food Science. 2016;4:290-293.
22. O'shea J, Maguire MF. Determination of calorific value of feedstuffs by chromic acid oxidation. Science of Food and Agriculture. 1962;13(10):530-534.
23. Pellett PL, Young VR. Nutritional evaluation of protein foods. United Nations University Press The United Nations University 53-70 Jingumae 5-chrome, Shibuya-KU, Tokyo 150, Japan, 1980, 1-162.
24. Randhir R, Lin YT, Shetty K. Stimulation of phenolics, antioxidant and anti-microbial activates in dark germinated Mungo bean sprouts in response to peptide and phytochemical elicitor. Process Biochemistry. 2004;39(5):637-646. Available at: 10.1016/S0032-9592(03)00197-3.
25. Rao PU. Effect of germination on tannin, mineral, and trace element composition of groundnut varieties. Journal of the American Oil Chemists Society. 1995;72:477-480.
26. Ruiz ASCD, Bressani R. Effect of Germination on the Chemical Composition and Nutritive Value of Amaranth Grain. American Association of Cereal Chemists, Inc, 1990;67:519-522.
27. Rusydi MR, Noraliza CW, Azlan A, Amom Z. Nutritional changes in germinated legumes and rice varieties. International Food Research Journal, 2011, 18.
28. Saeed F, Qamar A, Nadeem MT, Ahmed RS, Arshad MS, Afzaal M. Nutritional composition and fatty acid profile of some promising sesame cultivars. Pakistan Journal of Food Science. 2015;25:98-103.
29. Sankar D, Rao MR, Sambandam G, Pugalendi KV. Effect of sesame oil on diuretics or Beta-blockers in the modulation of blood pressure, anthropometry, lipid profile, and redox status. The Yale Journal of Biology and Medicine. 2006;79(1):19-26.
30. Sarkis JR, Correa, AP, Michel I, Tessaro IC. Evaluation of the Phenolic Content and Antioxidant Activity of Different Seed and Nut from the Edible Oil Industry. Journal of the American Oil Chemists Society. 2014;91(10):1773-1782.
31. Sehgal AS, Kawatra A. Reduction of polyphenol and phytic acid content of pearl millet grains by malting and blanching. Plant Foods Human Nutrition. 1998;53:93-98. Available at: DOI: 10.1023/A:1008060604880.
32. Sene B, Sarr F, Sow M, Diouf D, Niang M, Traore D. Physico-chemical composition of the sesame variety (*Sesamum indicum* L.) 32-15 and characterization of its derived products (seeds, oil and oilcake) in Senegal. Food Science and Quality, 2017.
33. Sreeramulu DR, Kumar CV, Raghunath M. Antioxidant activity of commonly consumed cereals, millets, pulses and legumes in India. Indian Journal of Biochemistry and Biophysics. 2009;46:112-115.
34. Silva JCA, Fernandes PD, Bezerra JRC, Arriel NHC, Cardoso GD. Crescimento e producao de genotipos de gergelimemfuncao de laminas de irrigacao. Revista Brasileira de Engenharia Agricola e Ambiental. 2014;18:408-416.
35. Xu J G, Tian R, Hu P, Luo Y, Wang D, Tian D. Dynamic changes in phenolic compounds and antioxidant activity in oats (*Avena nuda* L.) during steeping and germination. Journal of Agricultural and Food Chemistry. 2009;57(21):10392-10398. Available at: http://dx.doi.org/10.1021/jf902778j
36. Yasothai R. Chemical composition of sesame oil cake-review. International Journal of Science Environment and Technology. 2014;3:827-835.
37. Zebib H, Bultosa G, Abera S. Physico-chemical properties of sesame (*Sesamum indicum* L.) varieties grown in northern area, Ethiopia. Agricultural Sciences. 2015;6:238-246.
38. Zilic S, Basic Z, Hadzi-Taskovic Sukalovic V, Maksimovic V, Jankovic M, Filipovic M. Can the sprouting process applied to wheat improve the contents of vitamins and phenolic compounds and antioxidant capacity of the flour? International Journal of Food Science & Technology. 2014;49(4):1040-1047. Available at: http:// dx.doi.org/10.1111/ijfs.12397