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EFFECT OF MALTING ON COMPOSITION OF NUTRIENTS AND ANTI-NUTRIENTS IN FINGER MILLET FLOUR

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ABSTRACT

Finger millet is a rich source of protein, dietary fibre, calcium, phosphorous, iron, zinc, other minerals and vitamins along with some anti-nutrients. The anti-nutrients present in finger millet grains bind with certain minerals such as iron, calcium, zinc to form soluble as well as insoluble complex compounds. Thus, these anti-nutrients decrease the bioavailability of these minerals. Malting is a pretreatment that helps in increasing the bioavailability of nutrients through inducing hydrolytic activity. Thus to optimize the availability, digestibility and rate of absorption of all the nutrients present in the grains, malting can be an efficient process. The aim of the present study was to determine the effect of malting on nutrient and anti-nutrient composition of finger millet flour. A local variety of brown finger millet was selected to evaluate the nutritional changes during the malting process. The nutrient profile of the malted finger millet flour showed significant increase in protein (8.64 g vs. 7.52 g), carbohydrate (68.84 g vs. 67.12 g), calcium (372 mg vs. 356 mg), iron (4.42 mg vs. 4.12 mg), magnesium (143.2 mg vs. 137.1 mg) and zinc (2.54 mg vs. 2.47 mg) content and a slight decrease in fat (1.9 g vs. 1.3 g), dietary fibre (10.71 g vs. 9.98 g), sodium (3.23 mg vs. 4.67 mg) and phosphorous(216 mg vs. 231 mg) content as compared to raw finger millet flour per 100 g. The total ash content decreased insignificantly, while the potassium content increased non-significantly during malting process. Additionally, the total phenol and alkaloid contents increased during malting. Significant reductions in phytate, tannin and saponin content were observed in malted finger millet flour as compared to raw finger millet flour.

***Keywords* :** Finger millet, Malting, Nutrients, Anti-nutrients, Bioavailability.

Introduction

Finger millet (*Eleucine coracana,* commonly called "ragi, rapoko, mandua"), a major millet of family *Poaceae* is cultivated in arid and semi-arid areas of Africa and India and consumed as a staple food worldwide. The naming of the grain is like this because of its morphology showing five finger like panicles radiating from a central point resembling human palm (Sood *et al.*, 2017). Different varieties of finger millet such as light brown, brown, black and white are cultivated in various regions (Devi *et al.*, 2014; Kumar *et al.*, 2016). Finger millet possesses higher content of dietary fibre, carbohydrates, iron and calcium than the other major food crops (Sood *et al.*, 2016). Finger millet contains 72-79.5% carbohydrates (Bhatt *et al.*, 2003); 15-22% total dietary fibre (Shobhana and Malleshi, 2007); 5.6-12.75% protein (Gautam, 2000; Bhatt *et al.*, 2003); 1.3-1.8% fat (Lupien *et al.*, 1990; Bhatt *et al.*, 2003) and 1.7%-4.14% total ash (Rao, 1994). Finger millet is the richest source of calcium and iron (Vijayakumari *et al.*, 2003). 100 g finger millet contains about 344 mg of calcium (Bhatt *et al.*, 2003).

Dark brown seed coat of finger millet is rich polyphenols in comparison to other cereal grains like rice, wheat and maize (Viswanath *et al.*, 2009) that show antioxidant activities but also decrease certain nutrients' bioavailability by hindering their digestion and absorption. Various anti-nutritional factors e.g. phytates, alkaloids, flavonoids, phenols and tannins are present whose concentration differs from one variety to another. Brown finger millet grains have higher amount of tannins and phytates as compared to white finger millet. Brown finger millet contains 360 mg tannins per 100 g (Rao and Prabhavati, 1982). Tannins decline the bioavailability and utilization of proteins by binding to it in digestive tract (Asquith and Butler, 1986). Tannins are polymeric phenolic secondary metabolites showing astringency widely distributed in legume seeds, millets, cereals, tea, coffee and nuts etc. (Tamakau *et al.,* 2019). In vitro protein digestibility is inversely proportional to the tannin content present in finger millet grains (Ramachandra *et al.*, 1977). The tannin content of brown finger millet decreases by 54% during malting (Rao, 1994). Phytate e.g. Inositol hexakisphosphate is the salt form of phytic acid with monovalent and divalent cations of sodium, magnesium, calcium, iron and zinc accumulated in seeds during maturation. Phytates interfere with bioavailability and absorption of calcium, iron and zinc and also inhibit the protease actions thus limiting the protein solubility and digestibility (Cheryan, 1980; Davis and Warrington, 1986). Saponins are secondary metabolites present in the form of triterpenoid in seeds, leaves, flowers and roots and being surface active agents possess foaming capacity (Liao *et al.,* 2021). Polyphenols are secondary plant metabolites that show protective action against various degenerative diseases like cancer, coronary artery disease, diabetes mellitus, osteoporosis and neurological disorders in human being (Arts and Hollman, 2005).

Malting is a combined process of steeping, germination, drying, roasting, grinding and sieving of grains to improve the total nutritive value and to reduce anti-nutritional components. Malting helps finger millet in developing higher amylase activity, thus enhances the protein and starch digestibility in sorghum and other millets (Malleshi and Desikachar, 1986). The anti-nutrient activity of phytic acid and tannin in brown finger millet are decreased by 58% and 54%, respectively during malting (Rao, 1994). Malting process is very much useful in preparation of infant formulas for weaning (Verma and Patel, 2013). The present study highlights the effect of malting process on nutritional composition as well as the amounts of anti-nutrients present in finger millet with following objectives.

- To find out the proximate and mineral composition of raw and malted finger millet flours.
- To assess the anti-nutrient composition of raw and malted finger millet flours.

Materials and Methods

Source of Materials

Finger millet grains of local brown variety were purchased from Parbhani market, Maharashtra in the month of July, 2023. All chemicals used for the analyses were of analytical grade.

Processing of raw and malted finger millet flour

The finger millet grains were winnowed, cleaned and washed in running water and soaked overnight in a volume of water and grains in proportion of 4:1. The water used for soaking was strained and soaked finger millet grains were tied in white muslin cloth and kept completely covered in a vessel and left for germination. The germination was completed after 4 days and the germinated grains were opened to dry in air flow followed by roasting in a pan. The germinated, roasted finger millet grains were rubbed to remove the germ shoot and milled and sieved to prepare fine flour using a 60 mesh sieve. Equal portion of finger millet grains were taken, washed and dried and pulverized into fine flour without any pretreatments application. The prepared flour from germinated, roasted (malted) finger millet and raw finger millet grains were kept in air tight plastic jars separately (Dahiya *et al.*, 2018).

Determination of proximate composition of millet flour

Proximate composition of raw and germinated flour was determined according to the method of Association of Official Analytical Chemists (AOAC, 2007).

Millet flour mineral content determination

The mineral composition (magnesium, calcium, phosphorous, sodium, potassium, zinc and iron) of the millet flour samples was determined using Association of Official Analytical Chemists (AOAC, 2007) methods.

Determination of anti-nutrient content of millet flour

The method of Makkar and Goodchild (1996) was used to determine the tannin content of millet. Phytate content of millet sample was determined following Wheeler and Ferrel (1971). Saponin content of millet flour was determined according to Brunner (1984). To determine the alkaloid content of millet flour sample, 5 g of millet flour was weighed into 200 ml of 10% ethanol-acetic acid and was allowed to stand for 4 min. This was filtered and concentrated ammonium hydroxide was added in drops to the filtrate until it formed precipitate. This was filtered and the extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide (NH_4OH) was added drop wise to the extract until the precipitation was completed. The whole solution was allowed to settle, the precipitate was collected, washed with dilute ammonium hydroxide, and then filtered. The residue was the alkaloid, which was dried and weighed (Harborne, 1973). Total phenol content of millet flour sample was determined following Singleton *et al.* (1999).

Statistical analysis

The mean and standard error of means of the triplicate analyses were calculated. The paired 't' test was performed to determine significant differences between the means.

Results and Discussion

Proximate composition of raw and malted finger millet flour

Table 1 describes the proximate composition of both raw and malted finger millet flour. The moisture content of pre-treated malted finger millet flour (10.28%) was found to be significantly higher than that of raw finger millet flour (8.96%). Similar results were reported by Tiwari *et al.* (2018). This increase in moisture content might be due to enhanced water absorption by finger millet grains during soaking prior to germination.

The total energy content of malted finger millet flour was estimated to be 321.7 Kcal per 100 g which was higher than the total energy content of raw finger millet flour that was 316 Kcal per 100 g. This net increase in calorific value of malted finger millet flour might be the result of increase in total carbohydrate content during malting process. This finding was similar to the results discussed by Tiwari *et al.* (2018), Bansal and Kaur (2018) and Hiremath and Geetha (2019).

The carbohydrate content of malted finger millet flour (68.84 g per 100 g) was found to be significantly higher than that of raw finger millet flour (67.82 g per 100 g) which is similar to the results reported by Bansal and Kaur (2018) and Hiremath and Geetha (2019). This increase in carbohydrate content might be observed as amylopectin might got partially degraded and increased content of amylose might have contributed to the net carbohydrate pool (Gokavi and Malleshi, 2000).

The malted finger millet flour was found to possess significantly lower amount of fat (1.9 g per 100 g) in comparison to the raw finger millet flour (1.6 g per 100 g). Similar results were also reported by Banusha and Vasantharuba (2013), Tiwari *et al.* (2018), Bansal and Kaur (2018), Hiremath and Geetha (2018) and Owheruo *et al.* (2019). This might be due to oxidation of fatty acids to carbon dioxide and water to provide energy for germination as well as due to activation of lipase during germination process (Hahm *et al.*, 2008; Choudhury *et al.*, 2010).

The protein content of malted finger millet flour was estimated to be 8.64 g per 100 g which was significantly higher than the protein content of raw finger millet flour that was found to be 7.52 g per 100 g. This finding was similar to the results of Tiwari *et al.* (2018) and Owheruo *et al.* (2019). It might be due to utilization of carbohydrates by microorganisms to form amino acids with simultaneous hydrolysis of proteins by activation of protease enzyme activation to produce amino acids and peptides (Kirk-Uthmar, 2007).

Total dietary fibre of finger millet flour decreased significantly during malting process from 10.71 g per 100 g to 9.98 g per 100 g. It might be due to mechanical loss of seed coat fractions during soaking, germination, grinding and sieving. Similar results were reported by Bansal and Kaur (2018).

The total ash content of malted finger millet flour (1.98 g per 100 g) was observed to be decreased insignificantly as compared to the ash content of raw finger millet flour (1.94 g per 100 g). This decrease in ash content might be loss of pericarp and other parts of the grains during soaking, germination, kilning and milling process. Similar results were obtained by Banusha and Vasantharuba (2013), Tiwari *et al.* (2018), Owheruo *et al.* (2019) and Hiremath and Geetha (2019).

Table 1: Proximate compositions of raw and malted finger millet flours

Sr. No	Nutrients per 100 g	Raw flour	Malted flour	't' value	Increase / decrease
1	Moisture (%)	8.96 ± 0.02	10.28 ± 0.04	397.00**	+1.32
2	Energy (Kcal)	316 ± 4.16	321.7 ± 4.04	14.02^{NS}	+5.70
3	Carbohydrate (g)	67.12±0.11	68.84 ± 0.62	3.36^{NS}	+1.72
4	Fat (g)	1.9 ± 0.04	1.3 ± 0.03	19.00**	-0.6
5	Protein (g)	7.52 ± 0.03	8.64 ± 0.09	35.32*	+1.12
6	Dietary fibre (g)	10.71± 0.06	9.98 ± 0.03	50.47**	-0.73
7	Total Ash (g)	1.98 ± 0.02	1.94 ± 0.03	1.38^{NS}	-0.04

Note. Values represent mean of triplicate ± standard deviation. *significant at 5% level of significance, **significant at 1% level of significance, NS: non-significant

Mineral composition of raw and malted finger millet flour

Table 2 shows the mineral composition of finger millet flour before and after the malting process. The calcium and iron contents of malted finger millet flour i.e. 372 mg per 100 g and 4.42 mg per 100 g, respectively were found to be significantly higher as compared to the calcium content of raw finger millet flour (356 mg per 100 g and 4.12 mg per 100 g, respectively). This is similar to the results reported by Tiwari *et al.* (2018) and Owheruo *et al.* (2019). This might be due to decrease in anti-nutrients such as phytates, oxalates and tannins through leaching during soaking and germination, thus increasing the total bioavailability of these minerals. The zinc content of malted finger millet flour increased significantly than that of raw finger millet flour which might be due to dissociation of phytates through leaching during steeping and germination with simultaneous increase in bioavailability of both the minerals. This result is at par with the findings of Tiwari *et al.* (2018) and Owheruo *et al.* (2019). The phosphorous and sodium contents of malted finger millet flour were observed to be decreased significantly in comparison to that of raw finger millet flour due to their solubility in water and their loss through leaching into water during soaking for long hours. Similar results were also given by Tiwari *et al.* (2018) and Owheru *et al.* (2019).

Table 2 : Mineral compositions of raw and malted finger millet flours

Sr. No	Nutrients per 100 g	Raw flour	Malted flour	't' value	Increase / decrease
1	Calcium (mg)	356 ± 3.05	372 ± 1.52	27.71**	+16.00
2	Phosphorous (mg)	231± 4	216 ± 0.01	7.01*	-15.00
3	Sodium (mg)	4.67 ± 0.03	3.23 ± 0.02	38.3**	-1.44
4	Potassium (mg)	398.7± 4.04	403.34± 3.31	1.54^{NS}	+4.64
5	Iron (mg)	4.12 ± 0.03	4.42 ± 0.04	46.00**	+0.30
6	Zinc (mg)	2.47 ± 0.01	2.54 ± 0.01	6.06^{*}	+0.07
7	Magnesium (mg)	137.1± 4.18	143.2 ± 1.63	2.86^{NS}	+6.1

Note. Values represent mean of triplicate ± standard deviation. *significant at 5% level of significance, **significant at 1% level of significance, NS: non-significant

Anti-nutrient composition of raw and malted finger millet flours

Table 3 depicts the concentrations of various anti-nutritional factors such as tannin, phytate, saponin and other phenolic compounds present in raw and malted finger millet flours. The tannin content of raw finger millet flour was found to be decreased significantly from 1624 mg to 1561 mg per 100 g flour during malting process. This might be due to leaching of tannin from the germinated mass and decreased activity of metabolic enzymes i.e. polyphenol oxidase (Shimelis & Rakshit, 2008). Similar results were found by Owheruo *et al.* (2019) during studying physicochemical properties of malted finger millet and pearl millet. The total phytate content of malted finger millet flour (1236 mg per 100 g) was observed to be lower than that of raw flour (1429 mg per 100 g) which could be the result of loss of soluble phytate during soaking and germination process and also dissociation of phytate complex on application of heat during soaking (Shimelis & Rakshit, 2008). This result was at par with the result of Owheruo *et al.* (2019). Saponin content decreased from 1902 mg to 1746 mg per 100 g due to leaching in water during soaking as shown in previous studies (Shimelis & Rakshit, 2008). The alkaloid and phenol contents increased in malted finger millet flour as compared to the raw finger millet flour which was similar to the findings of Owheruo *et al.* (2019). This increase in phenol content during germination might be due to enzymatic activation and release of bound phenolic compounds (Maillard and Berset, 1995).

Table 3 : Anti-nutrient composition of raw and malted finger millet flour

Sr. No.	Anti-nutrients (per 100 g)	Raw flour	Malted flour	't' value	Increase/decrease
1	Tannin (mg)	1624 ± 12.82	1561 ± 6.48	6.123*	-63.00
2	Phytate (mg)	1429 ± 3.06	1236 ± 8.47	24.799*	-193.00
3	Saponin (mg)	1902 ± 10.34	1746 ± 14.16	48.940**	-156.00
4	Alkaloid (%)	3.76 ± 1.08	5.12 ± 1.23	8.365*	+1.36
5	Phenol (mg)	1572 ± 4.26	1625 ± 2.40	14.020**	+53.00

Note. Values represent mean of triplicate ± standard deviation. *significant at 5% level of significance, **significant at 1% level of significance

Conclusion

The study concluded that malting influences the nutritional composition of finger millet grains by reducing the tannin, phytate, saponin and other anti-nutritional factors present in it. Through malting process the bioavailability, digestibility and absorption of proteins and minerals like calcium, magnesium, iron and zinc increased due to the combined effect of during soaking, germination and roasting. Through hydrolysis, enzymatic activation and break down and leaching, the concentration of these anti-nutrients decrease and facilitates the optimum utilization of the nutrients. Hence, malting can be considered as an effective pre-treatment to enhance the nutrient bioavailability of millet grains. Finger millet malt can be used as a nutrient dense source of infant food as well as a good source of diet for adults.

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Conflict of Interest

The authors declare no conflicts of interest. They bear sole responsibility for the content and composition of the paper.

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