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Effects of germination on antinutritional, colour, functional and physicochemical properties of millets

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Abstract
Germinated finger millet, pearl millet and foxtail millet flours were investigated for their antinutritional factors, functional properties, colour, mineral and nutritional composition. The results showed that tannin in finger millet was reduced after germination is 168 mg/100 g, whereas for foxtail millet and pearl millet it was 115 and 197 mg/100 g respectively. The germinated finger millet flour, foxtail millet flour and pearl millet flour showed decrease in bulk density *viz.* 540, 475 and 489 kg/m^3 respectively. The germinated finger millet, foxtail millet and pearl millet flour exhibited 124.04, 125.0 and 120.23 percent water absorption capacity respectively. Germinated finger millet flour, foxtail millet flour and pearl millet flour showed 111.21, 118.05 and 123.25% OAC respectively. The germinated millet flours reported 72.43, 61.70 and 68.24 percent carbohydrates respectively in finger millet, foxtail millet and pearl millet flours. Germinated millet flours showed an increase in the crude fibre 6.67, 8.68 and 6.21 percent respectively for finger millet, foxtail millet and pearl millet flours. Iron and zinc in all millets significantly improved after germination. The iron content in finger millet, foxtail millet and pearl millet flour were 3.12 mg, 3.15 mg and 12.13 mg/100 g respectively whereas zinc content was 1.25 mg, 1.16 mg and 11.42 mg/100 g respectively in the same order.

Keywords: Antinutritional, factors, functional properties, colour

1. Introduction
Millets are nutritionally better to other major cereals as millets are good in dietary fibres, resistant starches, vitamins, essential amino acids, storage proteins and other bioactive and phytochemical compounds (Amadou *et al*., 2013) [1]. These properties of millets have made them a crop of choice for farming in arid and semi-arid regions of the world.

Pearl millet is known to possess phyto-chemicals that lower cholesterol. It also contains folate, iron, magnesium, copper, zinc and vitamins E and B-complex. Pearl millet has a high energy content compared to other millets. It is also rich in calcium and unsaturated fats, which are good for the body.

Finger millet contains high amount of calcium, protein with well-balanced essential amino acids composition along with Vitamin A, Vitamin B and phosphorous. It also contains high amount of calcium (300-400 mg/100 g). Its high fibre content also checks constipation, high blood cholesterol and intestinal cancer. Protein content in finger millet is high, thereby making it an important factor in preventing malnutrition. It is an ideal food for diabetics as it has demonstrated the ability to control blood glucose levels and hyperglycaemia.

Foxtail millet has twice the quantity of protein content when compared to rice. Apart from controlling blood sugar and cholesterol, it increases disease resistant capacity and is recommended for people suffering from diabetes and gastric problem. It is rich in dietary fibre and minerals such as copper and iron that keep one's body strong and immune.

The presence of antinutritional factors in millets limits its nutritional availability for consumption. Hence, it is necessary to reduce these antinutritional factors by germination process. Many researchers observed reduction of antinutritional factors after germination. The present investigation refers to effects of germination on physicochemical properties and nutritional composition on finger, foxtail and pearl millet flours.

2. Materials and Methods
2.1 Functional properties of flours
2.1.1 Water and oil absorption capacity
One (1) gram FM flour was transferred into weighing 50 mL centrifuge tubes in triplicate to which 10 mL of distilled water/edible soybean oil was added, stirred homogeneously with a

glass rod and incubated in water bath at 30 °C for 30 min. The centrifuge tubes were centrifuged at 3000 rpm for 15 min using laboratory centrifuge. The supernatants were discarded, and the residues were weighed. (Sawant *et al.*, 2013) [14]

$$\text{Water/Oil absorption capacity (ml/g)} = \frac{V1-V2}{V2} \times 100$$

Where
V_1 = Initial volume of the liquid.
V_2 = Final volume of the liquid.

2.1.2 Foaming capacity and foaming stability

The foaming capacity and foaming stability was evaluated by method given by (Kaur and Singh 2005) [16]. The dispersion of flour samples in 50 ml of distilled water at the rate of 3% w/v was homogenized vigorously for 3-5 minutes at 4000 rpm with laboratory centrifuge. The blend is immediately transferred to a graduated cylinder and 10 ml of distilled water was added to it. The volume was recorded before (V_1) and after whipping (V_2) and measured as percent volume increase due to whipping. The foaming capacity was expressed as percentage of volume increase.

$$\text{Foaming capacity (\%)} = \frac{V_1}{\text{15 ml initial volume}} \text{x } 100$$

$$\text{Foam stability (\%)} = \frac{V_1\text{-}V_2}{V_1} \text{x } 100$$

2.1.3 Emulsion capacity and stability

Emulsification capacity (EC) was determined using the method of (Kaushal *et al.*, 2012). Two grams of the flour was blended with 25 ml distilled water at room temperature for 30 s. Thereafter, 10 ml of refined corn oil was added, and the blending continued for another 30 s before transferring into a centrifuging tube. Centrifugation was done at 3500 rpm for 5 min. The volume of oil separated from the sample after centrifuging was read directly from the tube. Emulsification capacity was expressed as the amount of oil emulsified and held per gram of sample.

$$\text{Emulsification capacity (\%)} = \frac{\text{Height of emulsified layer}}{\text{Height of whole solution in the centrifuge tube}} \text{x } 100$$

The remaining portion of the emulsion in the beaker was heated at 80 °C in a water bath for 30 min and then cooled to room temperature in another water bath for 15 min. The obtained emulsion was then transferred into two 50-mL centrifuge tubes (30 mL each), followed by centrifugation at 1,300 g for 5 min. The heights of emulsified layer and the entire emulsion were recorded, and ES was calculated below:

$$\text{Emulsion stability (\%)} = \frac{\text{Height of emulsified layer}}{\text{Height of whole solution in the centrifuge tube}} \text{x } 100$$

2.2 Proximate composition of raw materials and prepared products (cookies and vermicelli)

2.2.1 Moisture content

The moisture, fat, protein, ash, fibre and carbohydrate content (%) was determined with the method (AACC, 2000).

2.2.2 Determination of Tannins and Phytic Acid

Tannin and phytate was determined as per the method suggested by (Kamble *et al*., 2019a). For tannin estimation, about 0.1 ml of sample extract was transferred to a 100 ml volumetric flask containing 75 ml of distilled water. Folin-Denis reagent (5 ml) and Sodium carbonate solution (10 ml) were then added and the volume was adjusted to 100 ml with distilled water. The resulting solution was incubated for 30 min and then the absorbance was recorded against an experimental blank at 760 nm. The data was expressed as milligram tannic acid equivalent/100 g dry basis of flour weight (mg TAE/100 g).

For the phytate test, the powder sample (0.15 g) was combined with 10 ml of HCl (2.4%) and the extraction was performed using a shaking incubator (1 h/25-27 C). The resulting solution was centrifuged (3000 rpm/30 min) and filtered to obtain a pure phytate extract. Briefly, 1 ml of wade reagent (0.3% of sulfosalicyclic and 0.03% $FeCl_3.6H_2O$ acid in water) was mixed with sample extract (3 ml) and vortexed for 5s. The reading was immediately recorded at a wavelength of 500 nm and the results reported as mg/100 g dry basis of sample weight.

3. Results

3.1 Effect of germination on anti-nutritional factors in millets

Based on the review of literature for effective reduction of antinutritional factors in millets, germination was carried out and the obtained results are depicted in table 3.1.

Table 1: Antinutritional content in millet

Millet	Tannin (mg/100 g)		Phytic Acid (mg/100 g)	
	Raw	Germinated	Raw	Germinated
Finger Millet	301	168	425	270
Foxtail Millet	221	115	306	180
Pearl Millet	450	197	550	215

*Each value is average of three determinants

Among many different pre-treatments, germination process was mostly used for reducing tannin and phytic acid in millets. As germination continues, the reduction of antinutritional factors was observed in millets. From above table it can be seen that in all millet, significant reduction of tannins and phytic acid in germinated millets. In raw finger millet, foxtail millet and pearl millet, the antinutritional factors present were 301, 221 and 450 mg/100 g tannins and 425, 306 and 550 mg/100 g phytic acid respectively, whereas the germinated millet showed remarkable reduction in tannin and phytic acid all the millet. The tannin in finger millet was found to be after germination is 168 mg/100 g, whereas for foxtail millet and pearl millet it was 115 and 197 mg/100 g respectively. Decrease in tannins on germination may be attributed due to leaching of polyphenols in soaking water and increased enzymatic action during germination.

The pearl millet showed highest reduction in phytic acid 215 mg/100 g and followed by 180 mg/100 g foxtail millet and 270 mg/100 g finger millet. The reduction in phytic acid may be attributed due to leaching into soaking water under the concentration gradient. Another reason in decrease of phytic acid during the germination is attributed with the increase in the phytase enzyme activity which hydrolyze phytate to phosphate and myoinositol phosphates.

The obtained results are in agreement with the findings reported by (Handa., *et al*., 2017) [3] that 48 hrs germination reduced tannin content from 199.85 to 100.30 mg/100 g. (Masud., *et al*., 2016) also analyzed the effect of germination duration and found a linear reduction of phytic acid in kidney beans and mung bean and stated that germination is one the best way to reduce phytic acid up to 40%.

(Lakshmanaswamy and Narayanan 2015) worked on three biofortified pearl millet varieties Dhanshakti, ICMH 1201, and Proagro 9444, having 0.56, 0.58, and 0.58 g/100 g phytate content and 0.54, 0.42, and 0.59 g/100 g tannin content, respectively. After germination and drying, they reported 28.57, 31.03 and 60.3 percent reduction in phytate and 59.2, 19.04 and 52.54 percent in tannin levels in the above three varieties. As the germination significantly reduced the antinutritional factors in selected millets and hence in further studies germinated millet flours are used for preparation of cookies and vermicelli.

3.2 Physical properties of flour

Physical properties of germinated flours of millets were determined such as bulk density, true density and percent porosity. The physical properties are important factors for suitability of selection of packaging materials, mixing and design of process equipment which are showed in table 3.2.

Table 4.2: Physical properties of millet flour

Properties	Finger millet		Foxtail millet		Pearl millet	
	R	G	R	G	R	G
Bulk density (kg/m^3)	560	540	490	475	520	489
True density (kg/m^3)	1120	980	1280	1025	1480	1256
Porosity (%)	50	44.89	61.71	53.65	64.86	61.06

R=Raw; G=Germinated *Each value is mean of three determinations

Bulk densities of raw finger millet, foxtail millet and pearl millet flour were 560, 490 and 520 kg/m^3 respectively. Flours with higher bulk densities indicate that it can be used in food preparations. True density of raw finger millet flour was found to be 1120 kg/m^3 which is least among all flours whereas the raw foxtail millet flour and raw pearl millet flour had 1280 and 1480 kg/m^3 respectively.

The germinated finger millet flour, foxtail millet flour and pearl millet flour showed decrease in bulk density *viz.* 540, 475 and 489 kg/m^3 respectively. Similarly, the true density of germinated millet in all millet flours also decreased as bulk density decreased. Percent porosity of the raw and germinated millet flours were 50.00 and 44.89; 61.71 and 53.65; and 64.86 and 61.06 respectively for finger millet, foxtail millet and pearl millet flour. The decreased bulk density of the germinated millet flour indicates low porosity or air spacing in the flour.

The reduction in bulk density observed in germinated flour may be due to the breakdown of complex compounds such as starch as a result of its modification during germination (Ocheme *et al*., 2015) [12]. The values obtained were in good agreement with (Mercy and Kiruba 2021) [9] for raw and germinated millet flours.

3.3 Functional properties of flour

Millet flours were analysed for different functional properties such as water absorption capacity, oil absorption capacity, foaming capacity, foaming stability, emulsion capacity and emulsion stability which are given in table 3.3.

Table 2: Functional properties of flour

Property (%)	Finger millet flour		Foxtail millet flour		Pearl millet flour	
	R	G	R	G	R	G
Water Absorption Capacity	110.03	124.04	112.12	125.02	110.24	120.23
Oil Absorption Capacity	110.12	111.21	112.46	118.05	115.21	123.25
Foaming capacity	11.67	12.33	28.43	31.54	24.00	28.28
Foaming stability	51.00	51.67	52.54	53.12	52.45	53.86
Emulsion capacity	41.28	42.09	42.85	43.65	41.25	42.65
Emulsion stability	38.46	39.45	40.64	41.47	39.63	40.15

R=Raw; G=Germinated *each value is mean of three determinations

Among the millet flours, raw foxtail millet had highest water absorption capacity and finger millet had least. The higher WAC of foxtail millet is attributed to its high fibre content. The values for water absorption capacity were 110.03, 112.12 and 110.24 percent for finger millet, foxtail millet and pearl millet respectively, while the germinated finger millet, foxtail millet and pearl millet flour exhibited 124.04, 125.0 and 120.23 percent water absorption capacity respectively. The increase in WAC after the germination may be due to the increase in starch-protein interactions and increased fibre. The results of WAC were similar to findings of (Olapade *et al.*, 2014) [13].

Water absorption capacity is greatly influenced by polysaccharides which are hydrophilic in nature. (Khatoniar and Das 2020) [5] also observed the similar values for functional properties of millet grown in Assam region. Water absorption of finger millet flour, foxtail millet flour and refined wheat flour were 107.50, 189.70 and 120.66 ml/g, respectively. These results are in agreement with the values reported by (Tiwari and Srivastava 2017) [17]. High water absorption capacity indicates that millets may have starch and protein interactions containing hydrophilic parts that tend to absorb more water.

Oil absorption capacity of raw finger millet flour 110.12, foxtail millet flour 112.46 and 115.21 for pearl millet flour whereas germinated finger millet flour, foxtail millet flour and pearl millet flour showed 111.21, 118.05 and 123.25% OAC respectively. The oil absorption capacity of any food material relies mainly on its capacity to physically entrap oil by a complex capillary attraction. Oil absorption capacity is attributed mainly due to the physical entrapment of oils. It is an indication of the rate at which the protein binds to fat in food formulation. The increase in OAC after germination may be also due to strong hydrophilic interaction among protein and lipid molecules. Variation in oil absorption is occurred with the variation in protein concentration, degree of interaction with water and oil. The relatively high oil absorption capacity of sample suggests that it could be useful in food formulation where oil holding capacity is needed such as sausage and bakery products. Similar results were reported by (Singh *et al*., 2005) [16].

The foaming capacity of a protein refers to the amount of interfacial area that can be created by the protein and foam stability (FS) refers to the ability of protein to stabilize against gravitational and mechanical stresses. Foaming capacity and foaming stability for raw and germinated finger millet flour 11.67 and 51.00; 12.33 and 51.67; and for foxtail millet flour 28.43 and 52.54; 31.54 and 53.12; and for pearl millet flour were 24.00 and 52.45; 28.28 and 53.86 respectively. Both finger and pearl millet flour had low foaming stability as compared to foxtail millet flour may be due to low protein content in the respective flours.

It can be also seen from table that increase in foaming capacity after germination may be due to the strong protein interactions as protein content may increase after germination and proteins provide high foam capacity and stability.

Emulsion capacity and emulsion stability values for raw and germinated millet flours were 41.28 and 38.46; 42.09 and 39.45 for raw and germinated finger millet flour, 42.85 and 40.64; 43.65 and 41.47 percent for raw and germinated foxtail millet flour whereas raw and germinated pearl millet flour had 41. 25 and 39.63; 42.65 and 40.15 percent respectively.

3.4 Colour analysis of millet flours

The colour analysis of millet flours was compared with germinated millet flours and also that of refined wheat flour and the values are depicted in table 4.4.

Table 4.4: Colour values of millet flours

Flours		L*	a*	b*
Finger millet flour	Raw	71.65	3.62	8.45
	Germinated	72.23	3.65	8.48
Foxtail millet flour	Raw	81.53	2.08	22.13
	Germinated	81.54	2.10	22.16
Pearl millet flour	Raw	73.32	0.34	9.87
	Germinated	73.54	0.35	9.89
Refined wheat flour		88.72	0.54	10.92

*Each value is mean of three determinations

Among all flours refined wheat flour had the highest value for L* followed by foxtail millet flour, finger millet flour and pearl millet flour. The L* values for refined wheat flour and foxtail millet flour were 88.72 and 81.53 whereas for finger millet flour it was 71.65 and pearl millet showed 73.32. It can be seen that germination leads to increase in L* value in all millet flours highest for foxtail millet flour (81.54) followed by pearl millet (73.54) and lowest for finger millet flour (72.23). This might be due to leaching of colouring compounds in soaking water used for germination and also due to complex biochemical reactions that occurred during germination.

The a* value which indicates intensity of red colour were 3.62, 2.08, 0.34 and 0.54 respectively for finger millet flour, foxtail millet flour, pearl millet flour and refined wheat flour. The foxtail millet flour and refined wheat flour had low values for a*. Among all germinated millet flours there was not any significant change in the b* values *viz.* 8.48, 22.16 and 9.89 for finger millet, foxtail millet and pearl millet flour.

The b* values which indicates yellowness was reported highest by foxtail millet flour (22.13) followed by refined wheat flour (10.92), pearl millet flour (9.87) and finger millet flour (8.45). The germinated millet flours were at par with raw millet flours in terms change in b* values. The b* values for germinated finger millet flour, foxtail millet flour and pearl millet flour were 8.48, 22.16 and 9.89 respectively. Similar results were given by (Gaurav *et al.*, 2021) [2] and (Mercy and Kiruba 2021) [9].

The colour values particularly 'L*' value which indicates the whiteness are increased in flours and again slightly increased in germinated millet flours which makes them suitable for preparation of bakery products such as cookies and vermicelli.

3.5 Effect of germination on proximate composition of raw materials

The proximate composition of millet flours for the different parameters such as moisture, crude fat, crude protein, crude fibre and ash were analysed and also compared with refined wheat flour and wheat semolina as major ingredient used in preparation of cookies and vermicelli and results are depicted in table 4.5.

Table 4.5: Proximate composition of raw materials

Nutrient (%)	Finger millet flour		Foxtail millet flour		Pearl millet flour		Refined Wheat flour	Wheat Semolina
	R	G	R	G	R	G		
Moisture	8.55	7.23	8.65	7.25	8.54	6.58	11.27	11.20
Crude fat	1.86	1.52	3.25	2.48	4.50	2.18	0.76	0.74
Crude protein	7.18	8.61	12.29	14.86	11.48	13.03	10.37	11.38
Crude fibre	3.62	6.67	6.73	8.68	2.33	6.21	0.98	2.20
Ash	2.61	2.81	3.30	3.41	2.35	2.78	0.51	0.80
Carbohydrates	73.28	72.43	63.95	61.70	70.73	68.24	74.12	70.40

R=Raw; G=Germinated *Each value is mean of three determinations.

The refined wheat flour had highest amount of carbohydrates (74.12%) as compared to all millets whereas semolina had 70.40 percent fat which was less than refined wheat flour. The carbohydrates in raw millet flours were 73.28, 70.73 and 63.95 percent in finger millet, pearl millet and foxtail millet respectively. The values for fat, protein and ash for raw finger millet were 1.86, 7.18 and 2.6 percent respectively. The raw foxtail millet showed 3.25, 12.29 and 3.30 percent of fat, protein and ash respectively while for the same pearl millet showed 4.5, 11.48 and 2.35 percent respectively. The germinated millet flours reported 72.43, 61.70 and 68.24 percent carbohydrates respectively in finger millet, foxtail millet and pearl millet flours. The decrease in carbohydrates after germination may be due to consumption as a source of energy during the germination process. The reduction in carbohydrates content is an important for preparation of low energy, high fibre product and also having slightly lower GI in prepared product. Decrease in carbohydrate during germination was due to the use of carbohydrates by the sprouts.

The protein content of semolina was 11.38 percent which was quite higher than refined wheat flour. The raw foxtail millet flour reported highest protein content than all others which was found to be 12.29 percent while raw pearl millet had higher amount of protein than finger millet and refined wheat flour i.e., 11.48 percent. Among all millet flours protein was gradually increased after germination. The protein content in finger millet, foxtail millet and pearl millet flour were 8.61, 14.86 and 13.03 percent respectively. This increment in protein content may be attributed to losses in dry weight, particularly in carbohydrates through respiration during germination. The losses in dry weight can be accounted mainly by loss in sugars during respiration due to production of carbon dioxide and water which escaped from the seeds. Moreover, the protein content in germinated foxtail and pearl millet flours was found to be higher than refined wheat flour and semolina.

Refined wheat flour and semolina showed 0.76 and 0.74 percent fat respectively. The fat content in raw pearl millet was highest among all millets which was 4.5 percent while foxtail millet had 3.25 percent and finger millet had 1.86 percent respectively. The fat content in all millet flours was decreased significantly after germination *viz.* 1.52, 2.48 and 2.18 percent respectively for finger millet, foxtail and pearl millet flour. The decrease in the fat content may be due to loss of low molecular weight nitrogenous compounds during soaking and rinsing of the millet grains and hydrolysis of lipid and oxidation of fatty acids during malting. In addition to above, the decrease in fat content may be due to use of fat as an energy source in germination process which was used as the major source of carbon for seed growth as fatty acids are oxidized to carbon dioxide and water to generate energy for germination.

The crude fibre content of all flours was analysed, and it was found that the foxtail millet had highest amount of fibre as compared to finger millet and pearl millet flour. The values for crude fibre were 3.6, 6.7 and 2.3 percent respectively for finger millet, foxtail millet and pearl millet raw flour. Germinated millet flours showed an increase in the crude fibre 6.67, 8.68 and 6.21 percent respectively for finger millet, foxtail millet and pearl millet flours respectively. The gradual increase in crude fibre observed in malted millet may be due to the synthesis of structural carbohydrates such as cellulose and hemicellulose which are very beneficial in value added products prepared from refined wheat flour and semolina which reduces the health hazards occurred due to its consumption specifically constipation and colon cancer.

Ash content in all millets increased after germination the finger millet, foxtail millet and pearl millet showed 2.81, 3.41 and 2.78 percent of ash respectively after germination. The germinated pearl millet flour scored significantly higher fibre and ash content than germinated finger millet flour and foxtail millet flour while germinated finger millet flour was found to be significantly better as compared to foxtail millet flour in terms of fibre content.

Similar results were reported by (Maharishi *et al.*, 2021) [7] for pearl millet, (Nithyashree 2019) [11] for finger millet and (Kehong *et al.*, 2018) [4] for foxtail millet.

3.6 Mineral composition of raw materials

The data on mineral composition *viz.* Ca, Fe, Zn and P of raw and germinated millet flours is given in table 3.6.

The raw finger millet had high amount of calcium among all the flours. Calcium content in finger millet was 333.57 mg/100 g. The phosphorous content was 171.46 mg/100 g while iron and zinc in finger millet was reported to be 2.44 and 0.84 mg/100 g respectively. Pearl millet had high amount of zinc and iron as compared to all other millets. The amount of Fe and Zn in pearl millet were 7.68mg/100 g and 4.18 mg/100 g. Foxtail millet had 31.73 mg/100 g and 181.36 mg/10 g of Ca and P respectively whereas the iron and zinc were found to be 2.18 mg/100 g and 0.85mg/100 g. Refined wheat flour and semolina showed Ca (20.6 and 29.38), Fe (1.73 and 2.98), Zn (0.72 and 0.78) and P (75.43 and 80.40) mg/100 g.

Table 3.6: Mineral composition of raw materials

Flour	Finger millet flour		Foxtail millet flour		Pearl millet flour		Refined wheat flour	Wheat semolina
Minerals mg/100 g	R	G	R	G	R	G		
Ca	333.57	340.25	31.73	35.26	45	48.23	20.6	29.38
Fe	2.44	3.12	2.18	3.15	7.62	12.13	1.73	2.98
Zn	0.84	1.25	0.85	1.16	4.18	11.42	0.72	0.78
P	171.46	180.25	181.36	185.56	245.33	251.61	75.43	80.40

R=Raw; G= Germinated *Each value is mean of three determinations

Among all millets mineral profile was improved significantly after the germination. The calcium content in the germinated finger millet, foxtail millet and pearl millet flour were 340.25, 35.26 and 48.23 mg/100 g respectively whereas the similar trend was observed in the phosphorus content i.e., 180.25, 185.56 and 251.61 mg/100 g respectively.

Iron and zinc in all millets significantly improved after germination. The iron content in finger millet, foxtail millet and pearl millet flour were 3.12 mg, 3.15 mg and 12.13 mg/100 g respectively whereas zinc content was 1.25 mg, 1.16 mg and 11.42 mg/100 g respectively in the same order. The increase in minerals may be due to reduction of antinutritional factor present in millet after germination. Malting generally improves digestibility of foods and could be an appropriate food-based strategy to derive iron and other minerals maximally from food grains. Germinated pearl millet flour was significantly higher in all minerals as compared to finger millet flour and foxtail millet flour.

The incorporation of germinated millet flours improved mineral profile of the value-added products prepared as compared to the refined wheat flour-based products.

It can be also seen from table that millet contain high amount of micronutrient as compared to wheat. The results were in accordance with (Nakarani *et al.*, 2021) [10], (Nithyashree 2019) [11], (Shonisani *et al.*, 2019) [15] and (Kehong *et al.*, 2018) [4].

4. Conclusion

The results showed that tannin in finger millet was reduced after germination is 168 mg/100 g, whereas for foxtail millet and pearl millet it was 115 and 197 mg/100 g respectively. The germinated finger millet flour, foxtail millet flour and pearl millet flour showed decrease in bulk density *viz.* 540, 475 and 489 kg/m^3 respectively. The germinated finger millet, foxtail millet and pearl millet flour exhibited 124.04, 125.0 and 120.23 percent water absorption capacity respectively. Germinated finger millet flour, foxtail millet flour and pearl millet flour showed 111.21, 118.05 and 123.25% OAC respectively. The germinated millet flours reported 72.43, 61.70 and 68.24 percent carbohydrates respectively in finger millet, foxtail millet and pearl millet flours. Germinated millet flours showed an increase in the crude fibre 6.67, 8.68 and 6.21 percent respectively for finger millet, foxtail millet and pearl millet flours. Iron and zinc in all millets significantly improved after germination. The iron content in finger millet, foxtail millet and pearl millet flour were 3.12 mg, 3.15 mg and 12.13 mg/100 g respectively whereas zinc content was 1.25 mg, 1.16 mg and 11.42 mg/100 g respectively in the same order.

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