Nutritional Assessment of Barley, Talbina and Their Germinated Products

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Abstract Talbina is a food product with high potential applications as a functional food. Talbina was prepared from two barley varieties namely: Giza126 and Giza130 by adding whole barley flour to water (1:10 w/v) and (1:5 w/v) for germinated barley then heating at 80 °C for 5 minutes with continuous stirring until reaching a porridge like texture. The present investigation was carried out in an attempt to clearly the nutritional assessment of talbina as a functional food. The study included the determination of gross chemical composition, caloric value, mineral composition, vitamins composition and the amino acids composition. Meanwhile, computation of the chemical scores (CS) and A/E ratios were carried out for raw, germinated barley, talbina, germinated talbina and commercial talbina. The data revealed that protein content of the all raw studied and processing treatments ranged from 8.75 -18.34g/100g on dry weight basis. Besides, the all treatments recorded rather slight decrease in crude fat content.

Keywords Barley, Talbina, Germination, Minerals, Vitamins, Amino Acids

1. Introduction

World production of barley was approximately 9.4% of the total world area under cereal production and ranks fifth in the world (30). There are two main distinguished types of barley, two rowed and six rowed barleys (10). The principal uses of barley are as feed for animals, in the form of barley meal, and as grain for malting and brewing in the manufacture of beer and whisky (42, 25). However, the barley crop may be considered relatively underutilized with regard to its potential use as an ingredient in processed human foods (40, 58). Whole barley grain consisted of about 65–68% starch, 10–17% protein, 4–9% β-glucan, 2–3% free lipids and 1.5–2.5% minerals (34, 50). β-glucans the major fiber constituents in barley, had been shown to lower plasma cholesterol, reduce glycemic index and reduce the risk of colon cancer (15).

Vitamin E is generally assigned a function as a radical scavenger in lipophilic environments and hence as a protector of the polyunsaturated fatty acids in membrane lipid (52). Moreover thiamin (B1) readily soluble in water, in thiamin deficiency the metabolism of sugar is incomplete and pyruvic acid accumulates in the tissues; also in nature riboflavin (B2) may exist as riboflavin phosphate, or as a constituent of specific flavoproteins, the latter functioning as important enzymes in tissue respiration, with a deficiency of riboflavin a definite reduction in tissue concentration of the enzyme had been shown; while pyridoxine (B6) was recognized through its ability to prevent dermatitis in rats which was observed during attempts to produce experimental pellagra in rats (53). Vitamin B12 (cyanocobalamin) has an important function in human physiology (62, 11). Vitamin B12 deficiency in humans is manifested by an anemia and a neuropathy (41).

Moreover niacin is incorporated as nicotinamide adenine di nucleotides, to form the prosthetic group of some enzymes, involving in the electron transfer reactions of the respiratory chain and oxidative phosphorylation (16). Whereas folic acid had been recently finalized regulations mandating by The United States Food and Drug Administration (FDA) to fortification of enriched cereal-grain products with it and this action was taken to assist women in increasing their folate intake to reduce their risk of having a pregnancy affected by a neural tube birth defect (31, 32, 33). Peter and Shewry determined the protein nutritional quality by the proportions of essential amino acids, which cannot be synthesized by animals and hence must be provided in the diet (47).

The wife of the prophet Mohammed peace be upon him “Aisha”, used to recommend talbina for the sick and for one who is grieving over a dead person. She used to say, "I heard the Messenger (Salla Allah alayhi wa sallam) saying, "The Talbina gives rest to the heart of the patient and makes it active and relieves some of his sorrow and grief” (4). Talbina is an Arabic word made of the word laban which means milk, this may also designate in the case of barley grains when they...
reach the milky stage, so the inside of these grains is white and liquid resembling milk (1).

The main objectives of this investigation are the utilization of whole barley flours and germinated barley flour to make talbina. In the present study the gross chemical composition, minerals, vitamins composition, and amino acids compositions were determined in two Egyptian raw barley varieties and their germinated forms as well as the talbina made from both, in an attempt to assess their nutritive value.

2. Materials And Methods

2.1. Materials

Ten kilograms of each varieties of Egyptian barley grains (Hordeum Vulgare): Giza126 (hulled barley), and Giza130 (hull-less barley) were procured from Agricultural Research Center, Giza. 100g Commercial talbina (Giza132) was obtained from local market in Assiut Governorate. All samples were obtained in 8/1/2008.

2.2. Methods

2.2.1. Preparation of Talbina

Talbina was prepared by adding whole barley flour to water (1:10 w/v) according to (64); and (1:5 w/v) for germinated barley then the mix was heated at 80°C for five minutes with continuous stirring until reaching a porridge like texture as described in figure (1).

![Flow sheet for the preparation of talbina products](image)
2.2.2. Preparation of Germinated Barley

2.2.2.1. Soaking

Seeds were freed from broken seeds, dust and other foreign materials, and then soaked in water (1:5 w/v) for 12 h at 25±5°C.

2.2.2.2. Germination

The pre-soaked (12 h) seeds were spread on wet cotton in aluminium baskets. The temperature ranged from 10°C (during the first 144 h) to 25±5°C (in the last 24 h of sprouting). The germinated seeds were dried at 55°C for 24 h then at 71°C for the same period (63).

2.2.3. Determination of Gross Chemical Composition

Moisture, protein, crude fibers and ash contents were determined according to the methods described in the A.O.A.C. (8). Crude fat content was determined as the ether extract (9). Total carbohydrate was calculated by difference according to pellet and Sossy (44). All determinations were performed in triplicates and the means were reported. The caloric value was calculated using values of 4k.cal. / g of protein, 4k.cal. / g of carbohydrates and 9 k.cal./g of fat according to (38).

2.2.4. Determination of Minerals Content

To extract Na, K, Mg, P, Ca, Zn, Cu, Mn and Fe, samples were dried, ashed then the ash was dissolved in hydrochloric acid (35). Sodium and potassium were determined by the flame photometric procedure (Corning instrument model 400) (18). Determination of phosphorus was preceded according to the procedure for phosphorus analysis by the sulfomolybdo-phosphate blue colour method (54). Calcium and magnesium were determined by titration with version 0.0156 N according to (35). Iron, zinc, copper and manganese were determined using a GBC Atomic Absorption 909 AA (8).

2.2.5. Determination of Vitamins

Vitamin E was colorimetrically estimated (48); whereas HPLC technique as described by Batifoulier (12) was used for the separation and quantification of thiamine, folic acid, Pyridoxine, nicotinic acid, riboflavin and B12 by a new reversed-phase chromatographic method.

2.2.6. Determination of Amino Acids Composition

Amino acids were determined according to the method described by Pellet and Young (45) by using Beckman Amino acid Analyzer Model 119 CL.

2.2.6.1. Determination of Tryptophan

Tryptophan was determined using spectrophotometer (51).

2.2.6.2. Computation of Chemical Score

The chemical score (CS) was defined as follows:

\[
CS = \frac{\text{mg of essential amino acid in 1 gm test protein} \times 100}{\text{mg of essential amino acid in 1 gm reference protein}}
\]

according to Bhanu (13).

2.2.6.3. Computation of A/E Ratio

It was calculated according to F.A.O (28) as follows:

\[
A/E \text{ ratio} = \frac{\text{mg of the individual essential amino acid}}{\text{gm of total essential amino acids}}
\]

2.2.7. Statistical Analysis

The data were analyzed for variance (ANOVA) procedures using the MSTAT-C statistical software package (7).

3. Results And Discussion

3.1. Gross Chemical Composition of Samples

The gross chemical composition as well as caloric values of raw barleys, germinated barleys, talbina, germinated talbina and commercial talbina is presented in Table (1).

3.1.1. Moisture

The data represented in Table (1) indicated that the moisture of raw barleys, germinated barleys, talbina, germinated talbina and commercial talbina content ranged from 4.4-11.9%. The moisture (g/100g) in barley from Jordan, Morocco and the FAO was 4.5, 7.8 and 10.1%; respectively (26). Moreover rather similar results were previously reported by Erkan (27), who found that moisture in hulled barley flour ranged between 10.7-11.8%, whereas it was 11.9% in hull-less barley flour. It could be seen from the results given in table (1) that, the highest percentage of moisture was recorded for whole barley flour 126 (11.9%). On the contrary, germ inated barley flour 126 recorded the lowest percentage of moisture content (4.4%). Such results showed that moisture contents of germinated, talbina and germinated talbina were decreased after all the studied processing treatments.

3.1.2. Crude Protein

The data represented in Table (1) indicated that the moisture of raw barleys, germinated barleys, talbina, germinated talbina and commercial talbina content ranged from 4.4-11.9%. The moisture (g/100g) in barley from Jordan, Morocco and the FAO was 4.5, 7.8 and 10.1%; respectively (26). Moreover rather similar results were previously reported by Erkan (27), who found that moisture in hulled barley flour ranged between 10.7-11.8%, whereas it was 11.9% in hull-less barley flour. It could be seen from the results given in table (1) that, the highest percentage of moisture was recorded for whole barley flour 126 (11.9%). On the contrary, germinated barley flour 126 recorded the lowest percentage of moisture content (4.4%). Such results showed that moisture contents of germinated, talbina and germinated talbina were decreased after all the studied processing treatments.
carbohydrates as energy sources for the developing sprouts. Similar results were recorded by (27), who showed that protein content in hulled barley flour ranged between 8-10%, whereas in hull-less barley it recorded the highest percent (13.4%). Likewise, the whole kernels protein content was significantly higher in hull-less barley (12.9-16.7%) than in hulled barley (10.3-13.6%) (50). Moreover (23) showed that the protein content of normal malting barley ranged from 9 to 11%.

3.1.3. Crude Fat

Data represented in Table (1) showed that crude fat content ranged from 1.5-2.9%. The crude fat content in the same table indicated that raw barley (Giza130) had the highest content, while commercial talbina had the lowest crude fat content on dry weight basis. Likewise it could be seen from the same table that treatments including germinated barley, talbina and germinated talbina recorded rather slight decrease in crude fat content. The decrease of crude oil might be due to the increase activity of lipases during soaking and germination (36). Moreover, the crude fat content was 1.5-2.2 % (26). Whereas fat content ranged between 1.62-1.92% in hulled barley and 1.9% in hull-less barley (27). Similar results were shown by (61), who found that oil content ranged from 1.9 -4.1% and represented positive correlation with protein content.

3.1.4. Fiber, Ash and Carbohydrates

Crude fiber, ash and carbohydrates recorded 3-4.2%, 2.4-2.8% and 75.7-87.2%; in barley from Jordan, morocco and the FAO; respectively (26). While in the present study it ranged between 3.83-4.37%, 2.29-2.86% and 73.40-82.66%; respectively. The crude fiber content was higher in the hulled barley (3.7%), while it was 1.9% in the dehulled barley; as well as hull-less barleys had more digestible energy than the hulled cultivars (59). Likewise, in agreement with the present study data, (50) reported that ash content of whole kernels was significantly higher in hulled barley (2.24-2.55%) than in hull-less barley (1.49-1.87%); on the other hand (27), showed that ash content was higher in hull-less barley (1.31%) than hulled barley (0.86-1.03%). There was a negative relationship between carbohydrates and protein content of barley grain (39). Such relationship appeared in the present study especially in commercial talbina which had lowest percentage of carbohydrate (73.40%) and highest percentage of protein (18.34%).

3.2. Mineral Composition of Samples

The minerals (mg/100g) content in barley grown in Jordan, Morocco and by the FAO namely Ca, P, Mg, K, Na, Fe, Zn, Cu and Mn; were as follows, 69.3-69.9, 179-350, 92.7-135, 573-612, 6.5-20.3, 3.5-19.9, 2.2-2.8 ,2.29-3.5 and 0.8-1.94; respectively (26). Likewise, in the present study the same minerals ranged as follow, 120-160, 300-510, 130-180, 240-320, 15.17-47.35, 5.75-13.85, 3.27-39.9, 0.550-0.985 and 1.02-2.67 (mg/100g); respectively. In general, the results are shown in Table (2) revealed that iron, manganese, copper and zinc contents decreased with germination treatment, and increased after making talbina especially zinc, which recorded the highest value with talbina treatment. On the contrary Ca and P were increased with germination treatment. Likewise, it could be seen from table (3) that sodium was decreased after all studied treatments and recorded the lowest value in germinated talbina126 (15.17).

3.3. Vitamins

Vitamin E is a major biological antioxidant quenches free radicals and acts as a terminator of lipid per oxidation, particularly in membranes that contain highly unsaturated fatty acids (17). There was a role of both genotype and location in determining tocols homologue contents of barley varieties, further more the total tocols concentration of six barley genotypes averaged over locations ranged from 51.0 to 61.4 mg/kg with a mean value of 54.5 mg/kg (20). It could be seen from Table (3) that, germination process increased the amount of vitamin E, and germinated130 had recorded the highest amount of vitamin E (622.33 IU/100g or 416.9 mg of α-tocopherol /100g). Likewise, (46) found that tocols in barley products resulted from milling, malting and mashing were 56.70, 52 and 152 mg/kg, while the tocotrienols were 77.50, 76.40 and 83.40 mg/kg; respectively. In barley, the content of tocopherols and tocotrienols were 13.5 and 15.58 μg/g (on dry basis), and vitamin E was 9.3 IU/Kg (65). Moreover, (43) reported that tocopherol amount was (11.1 -21.5 mg/kg) on dry weight, and α-tocopherol ranged between7.8 to 12.7 mg/kg. While total tocols (which, including tocopherol and tocotrienols) ranged from 50.3 to 88.6 mg/kg on dry weight.

Data represented in Table (3) showed that germinated talbina130 recorded the highest amounts of vitamins B2, Nicotinic acid, B6 and folic acid, where germinated 130 had the highest amount of thiamin (B1). Vitamins B1, B2, B6 and niacin contents in barley were 0.356, 0.136, 0.262 and 4.07 mg/100g; respectively (37).
Phenylalanine was the highest essential amino acid, followed by leucine. Moreover germinated126 had the highest value of leucine and lysine, whereas methionine and phenylalanine recorded the highest value in talbina130. Table (4) illustrated the essential amino acids patterns suggested by F.A.O./W.H.O. (29) for school child and adult amino acids requirements.

In general all studied treatments recorded higher content of all essential amino acids than that suggested by the FAO.

3.4. Essential Amino Acids

The essential amino acids determination was carried out on the studied processed barley grain products under investigation because of their importance from the nutritional point of view. The essential amino acids of raw, germinated barley and talbina products are tabulated in Table (4). Phenylalanine was the highest essential amino acid,
reference protein except of methionine, which had a low value in all studied treatments, with the exception of talbina 130 treatment, which recorded higher value than that suggested by the FAO reference Protein.

It could be seen from Table (4) that there was a trend to increase the content of isoleucine, leucine, lysine, methionine, phenylalanine, and tryptophan in germinated 126 samples, which increased by 55.4%, 56.16%, 58.14%, 3.18%, 76.7% and 15.5%; respectively; whereas in germinated 130 the content of leucine, isoleucine, methionine, phenylalanine, threonine, tryptophan and valine increased by 0.2%, 12.8%, 38.3%, 21.5%, 5.53%, 74.57% and 14.28%. Similar results were previously reported by (55), increased by 0.2%, 12.8%, 38.3%, 21.5%, 5.53%, 74.57% methionine, phenylalanine, threonine, tryptophan and valine in germinated 130 the content of leucine, isoleucine, methionine, phenylalanine, threonine, tryptophan and valine increased by 0.2%, 12.8%, 38.3%, 21.5%, 5.53%, 74.57% and 14.28%. Similar results were previously reported by (55), who found that germination might offer a method for converting nutritionally poor-quality plant protein to a high quality for human consumption. The contents of isoleucine presented continuous increase since germinated for 24 h., and the lysine content of germinated oats was always higher than that of raw oats (56). There an increase in lysine content expressed as per cent of dry weight of oat seeds during germination (22).

The increase in the amino acids by germination might be due to an increase in proteolytic activity during sprouting desirable for nutritional improvement of cereals because it leads to hydrolysis of prolamins and the liberated amino acids such as glutamic and proline are converted to limiting amino acids such as lysine (19).

It could be seen from Table (4) that talbina treatment (cooked barley flour) resulted in a noticeable increase in the most of the essential amino acids including isoleucine, leucine, lysine, methionine, phenylalanine and tryptophan, which increased by 93.45% & 121%, 8.22% & 115.4%, 9.3% & 72.1, 378.3% & 271.6%, 151.2% & 258.4% and 25.8% & 31.6% in talbina 126 & talbina 130; respectively. Besides, (57) reported that Leucine was the highest essential amino acid and methionine was the second limiting amino acid and histidine was the second. Moreover, in raw barleys, valine was the second limiting amino acid when egg protein was used as the reference protein, whereas lysine was the second when human milk was used as the reference protein. Besides, threonine was the first limiting amino acid in talbina (made from Giza 126 and Giza 130) and lysine was the second when human milk was used as a reference protein. Besides, threonine was the first limiting amino acid in talbina (made from Giza 126 and Giza 130) and lysine was the second when human milk was used as a reference protein. Table (5) indicated that talbina treatment (Giza 126 and Giza 130) recorded high chemical score in phenylalanine when both egg and human milk were used as the reference protein especially when comparing with the raw varieties. Likewise it could be seen from the table that phenylalanine had the highest chemical score in talbina 130. Besides, (57) reported that Leucine was the highest essential amino acid in barley grains, while tryptophan was the first limiting amino acid and methionie was the second limiting amino acid.

Data given in Table (6) represented A/E ratio between individual essential amino acid content (ng) and total essential amino acid content (g) of raw barleys and processed as compared with FAO requirement patterns of school child (10-12 yr) and adult (1985). It could be seen from Table (6) that talbina and germinated talbina were considered as a rich source of isoleucine, (which recorded 172.6 & 172.5 in Giza 126 and 148.6, 158.6 in Giza 130), phenylalanine (254.7, 204.5 and 313.1, 295.4) and tryptophan (62.6, 265.0 and 60.9, 171.7); respectively, when compared with FAO requirement patterns.

On the contrary threonine was decreased after all studied treatments, as well as lysine, which decreased except in the case of germinated 126. Besides, phenylalanine recorded highest value in talbina 130 (313.1).

Data given in Table (5) outlined the chemical score of all studied treatments and revealed that, the first limiting amino acid was methionine in raw, germinated barleys and germinated talbina 126; while valine was the second limiting amino acid in germinated barleys when both egg and human milk were used as the reference protein. Similar results were represented by (24), who found that Leucine was the highest essential amino acid, whereas methionine was the first limiting amino acid and histidine was the second. Moreover, in raw barleys, valine was the second limiting amino acid when egg protein was used as the reference protein, whereas lysine was the second when human milk was used as the reference protein.

### Table (4). Essential amino acids content of raw, germinated barley and, talbina products

<table>
<thead>
<tr>
<th>Essential amino acids (g.A.A/100 g protein)</th>
<th><strong>Treatments</strong></th>
<th>FAO/ WHO (1985) g A.A/100 g protein.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Giza-126</td>
<td>Giza-130</td>
</tr>
<tr>
<td></td>
<td>Raw G T G.T</td>
<td>Raw G T G.T</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>3.82 5.94 7.39 2.85</td>
<td>2.57 2.90 5.68 2.90</td>
</tr>
<tr>
<td>Leucine</td>
<td>7.30 11.40 7.90 4.05</td>
<td>4.92 4.93 10.60 5.58</td>
</tr>
<tr>
<td>Lysine</td>
<td>4.30 6.80 4.70 1.7</td>
<td>2.69 2.26 4.63 1.11</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.345 0.356 1.65 0.166</td>
<td>0.154 0.213 2.87 0.097</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>4.34 7.67 10.9 3.38</td>
<td>3.34 4.06 11.97 5.40</td>
</tr>
<tr>
<td>Threonine</td>
<td>3.79 ND 2.73 ND</td>
<td>2.53 2.67 0.148 0.055</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>2.13 2.46 2.68 4.38</td>
<td>1.77 3.09 2.33 3.14</td>
</tr>
<tr>
<td>Valine</td>
<td>5.10 1.72 4.85 ND</td>
<td>2.73 3.12 ND ND ND</td>
</tr>
<tr>
<td>Total E.A.A</td>
<td>31.13 36.35 42.80 16.53</td>
<td>20.70 23.24 38.23 18.28</td>
</tr>
</tbody>
</table>

*ND= not detected ** G=Germinated T=Talbina G.T=Germinated talbina C.T=Commercial talbina. (n=3)
<table>
<thead>
<tr>
<th>Essential amino acids:</th>
<th>Whole egg (E)***</th>
<th>Human milk (M)***</th>
<th>Giza-126</th>
<th>Giza-130</th>
<th>Treatments**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw G T G.T Raw G T G.T</td>
<td>Raw G T G.T Raw G T G.T</td>
<td>CT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 P/E 100 P/M</td>
<td>100 P/E 100 P/M</td>
<td>100 P/E 100 P/M</td>
<td>100 P/E 100 P/M</td>
<td>100 P/E 100 P/M</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>80</td>
<td>73.3</td>
<td>106.1</td>
<td>142</td>
<td>131.9</td>
</tr>
<tr>
<td>Leucine</td>
<td>96</td>
<td>880</td>
<td>1373</td>
<td>119.7</td>
<td>95.2</td>
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<tr>
<td>Lysine</td>
<td>69</td>
<td>68.3</td>
<td>87.9</td>
<td>98.5</td>
<td>74.6</td>
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<tr>
<td>Methionine</td>
<td>16</td>
<td>9.0</td>
<td>18.0</td>
<td>11.1</td>
<td>223</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>35</td>
<td>85.1</td>
<td>124.0</td>
<td>150.4</td>
<td>219</td>
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<tr>
<td>Threonine</td>
<td>46</td>
<td>74.3</td>
<td>82.4</td>
<td>ND*</td>
<td>ND</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>17</td>
<td>118.3</td>
<td>125.3</td>
<td>136.6</td>
<td>144.7</td>
</tr>
<tr>
<td>Valine</td>
<td>60</td>
<td>67.1</td>
<td>85.0</td>
<td>22.6</td>
<td>28.6</td>
</tr>
<tr>
<td>First limiting AA</td>
<td>Met</td>
<td>Met</td>
<td>Met</td>
<td>Met</td>
<td>Met</td>
</tr>
<tr>
<td>Second limiting AA</td>
<td>Val</td>
<td>Lys</td>
<td>Val</td>
<td>Val</td>
<td>Thr</td>
</tr>
</tbody>
</table>

*ND= not detected ** G=Germinated T=Talbina G.T=Germinated talbina CT=Commercial talbina

Moreover, the present study indicated that the nutritional quality of cereal grains (2). These results are in accordance with that of Wang and Fields, (60), who found that germinated cereal grains had increased relative nutritive values (RNV) and increased levels of lysine, methionine and tryptophan when compared to ungerminated seeds. In addition, germination improved the nutritional quality of cereal grains (2).

### 4. Conclusions

In the light of the above – mentioned data, barley talbina proved to have high levels of the nine studied minerals, especially zinc, which recorded higher value than that recommended daily. Furthermore, germinated talbina13 recorded the highest amounts of vitamins B3, Nicotinic acid, B6 and folic acid. Moreover, the present study indicated that there were good balanced essential amino acids composition required for human nutrition, besides phenylalanine was the highest essential amino acid, followed by leucine.

Table (6). Computation of A/E ratio of raw, germinated barley and, talbina products

<table>
<thead>
<tr>
<th>Essential amino acids</th>
<th>Giza-126</th>
<th>Giza-130</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw G</td>
<td>T</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>122.7</td>
<td>163.4</td>
</tr>
<tr>
<td>Leucine</td>
<td>235.0</td>
<td>313.6</td>
</tr>
<tr>
<td>Lysine</td>
<td>138.4</td>
<td>187.1</td>
</tr>
<tr>
<td>Methionine</td>
<td>9.3</td>
<td>9.8</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>139.7</td>
<td>211.0</td>
</tr>
<tr>
<td>Threonine</td>
<td>122.0 ND*</td>
<td>63.8</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>68.6</td>
<td>67.7</td>
</tr>
<tr>
<td>Valine</td>
<td>164.2</td>
<td>47.3</td>
</tr>
</tbody>
</table>

These results are in accordance with that of Wang and Fields, (60), who found that germinated cereal grains had increased relative nutritive values (RNV) and increased levels of lysine, methionine and tryptophan when compared to ungerminated seeds. In addition, germination improved the nutritional quality of cereal grains (2).

### REFERENCES


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