Plant Archives Vol. 21, Supplement 1, 2021 pp. 789-797 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.119

THE EFFECT OF WHEAT GERMINATION PROCESSES ON THE NUTRITIONAL PARAMETERS OF WHEAT FLOUR

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ABSTRACT

The study conducted to show the effects of germination process on chemical composition of wheat flour (*Triticum aestivium*). The germination process included several stages, the wheat grains were soaked for period of (24) hours, followed by the germination phase for a period of (48) hours, drying at a temperature of (30)°C for a period of (18-22) hours and then milling to obtain Whole wheat flour. The chemical of non-sprouted and sprouted wheat flour had been estimated, which include Moisture, Protein, Fat, Fiber, Ash and Carbohydrate. The results of the Chemical Analysis showed a decrease in the percentage of Moisture, an increase in the percentage of Protein in wheat flour after germination as it, a decrease in the percentage of Oil, an increase in the percentage of Fibers. The results of the study showed an increase in the concentration of total phenolic compounds in wheat flour after germination, as it was (7.53) mg/gm and for sprouted wheat flour was (12.36) mg/gm, reduction in concentration of Phytic acid in wheat flour after germination, as it was (25.9) mg/gm, and for sprouted wheat flour was (6.3) mg/100 g. An increase Zinc, Iron, Copper, Magnesium, Chromium content after germination as they were (12.21, 6.59, 1.15, 110, 2.06, 0.81, 3700) mg/100 g and for sprouted wheat flour was (13.05, 7.1, 1.36,140, 2.38, 0.9, 4100) mg/gm, also the results showed a decrease in the concentration of essential Amino acids (Lysine, Isoleucine, Valine, Threonine as it were (3.748, 4.384, 17.938, 9.480) mg/100gm and for sprouted wheat flour were (1.962, 1.266, 3.596, 4.275) mg/100gm,a decrease in concentration of non-essential amino acid (Glysine, Glutamic acid, Serine, Arginine) as they were (8.512, 26.277, 10.515, 55.123) mg / 100 gm and for sprouted wheat flour were (3.730, 0.818, 9.202, 5.837) mg / 100 gm. Essential Amino acids (Leucine, Methionine) were not recorded before germination, but they were recorded after germination, non-essential amino acid (Alanine, Tyrosine) were not recorded before germination, but they were recorded after germination as they were recorded after germination as they were (2.469, 6.407) mg/100gm. The essential Amino acids (Phenylalanine, Histidine) were recorded before germination as they were (0.412, 2,630) mg/100 gm, but they were not recorded in sprouted wheat flour. The results of the study showed an increase in the concentration of non-essential Amino acids (Aspartic acid) after germination as it was (0.407) mg/100gm and for sprouted wheat flour as it was (1.233) mg/100gm, an increase in concentration of essential amino acid (Cystine) after germination, as it was (0.329) mg /100 gm and for sprouted wheat flour was (5.386) mg/100 g.

Keywords: Wheat germination processes, Nutritional parameters, wheat flour

Introduction

Wheat (*Triticum aestivium*) is one of the major cereal crops in the world in terms of production and area (FAO; 2018), which is an important food that provides food to 40% world's population due to the possibility of preparing many food products (Shiferaw *et al.;* 2013). It is second only to rice among other cereal crops (Zampieri *et al.,* 2017). Wheat is grown on an area of about 210 million hectares of land in the world, with an annual production of about 700 million tons of which (~20%) of the food that the world's population needs (Thungo *et al.,* 2020). Estimates and statistics indicate that the continuous increase in the world's population and the increased need and demand for food require an increase of about (50)% in total wheat production by 2030 (Gahlaut *et al.;* 2017). Wheat has the advantage of being a good source of nutrients such as proteins, vitamins, including vitamin (B), mineral elements, dietary fibers and others, which makes it a good and healthy food, so it is widely used in the manufacture of baking products, such as bread because it contains a high-quality of protein (Gluten) (Ledaskar *et al.;*2018). Wheat flour products, such as bread are preferred food because it is asource rich in protein (Gluten), which has an important role for giving unique visco-elasticity characteristic, which allows the retention CO_2 gas during the fermentation and baking stages (Johnston *et al.,* 2019). Germination is a natural process and suitable for increasing the health benefits of seeds (Shafqat, 2013). The demand for sprouted grains has started to increase in super market since 2006, and sales of sprouted cereals in United States reached 30 million dollar in 2015, reached 250 million dollar in 2018 (Crawford, 2017). There are several technologies for the purpose of processing cereals and legumes to increase the bioavailability of mineral elements and other nutrients, such as Fermentation and Germination, and some of these techniques are applied in some regions of the world and some are global techniques, for example fermentation and Malting a common practice in developing countries (Africa and South America), fermentation and germination are widely used for cereal and legumes crops, as they represent the largest portion of the food diets of developing countries and enhance the nutritional value and a bioavailability of mineral elements (Nkhata *et al.,* 2018). More recently, research has proved that

sprouted grains are more nutritional benefits, and the reason for its containers many minerals, vitamins and phenolic compounds and that their bioavailability is more than their non-germinated counterparts, and their energy storage is readily available in its active form (Hung *et al.,* 2011). (Ozturk *et al.,* 2012) indicated that the content of sprouted wheat from calcium, magnesium, iron, sodium, potassium and phosphorus has increased (2-3) times more than in un sprouted wheat flour. (Tian *et al.,* 2019) studied the effect of germination of early stages on the activity of antioxidants and the chemical composition of sprouted wheat as they demonstrated that germination increased the nutritional value of whole sprouted wheat flour. Simple phenolic compounds are one of the most important phytochemical compounds in wheat that are usually considered as an important source of antioxidants (Hung, 2016). Antioxidants have many benefits, including free radicals and mineral chelation (Battin and Brumaghim, 2009). Several research has focused on changes taking place in sprouted grains, in particular the improvement of metabolism of complex polymers such as starch, and has studied significant changes in the content of most cereal crops of carbohydrates (Gujjaiah and Kumari; 2013). Germination increases the activity of amylase enzymes that break down starch, amylose and amylopectin into simple sugars, including glucose, maltose, and a small percentage of sucrose (Aoki *et al.,* 2006). As a result of the increased activity of these enzymes, increased digestion of starch and simple sugars in the gut occurs when consuming the germinated grains (You *et al.,* 2016). (Desai *et al.*2010) concluded that germination is an suitable and convenient method for producing food for newborns babies. Studies have shown that there is an increase in the protein percentage of sprouted wheat flour, and the reason is due to the increase in free nitrogen due to the increase in the activity of proteolytic enzymes after germination (Steve .; 2012). The percentage of protein increase in quantity and quality during germination as a result of increased proteins degradation enzymes (Ledaskar *et al.,* 2018). Therefore, the nutritional value of sprouted wheat flour improves due to the conversion of complex compounds in to relatively simpler compounds of higher nutritional value, for example the enzymes reduce the viscosity of food elements and improves digestion and absorption, as well as is a rich source of nutrients (Sharif *et al.,* 2013). Therefore, sprouted wheat flour extensively can be used and gives many benefits for preparing breakfast foods rich in protein for children of a great weakness (Hussain and Uddin, 2012). The aim of the study were to show the improvement of nutrient in sprouted wheat.

Materials and Methods

Germination process

Wheat (*Triticum aestivium*), cultivar (Rasheed) was obtained from Ministry of Agriculture/Agriculture Resarch office, Harvest 2019 (Iraq). It was followed the method mentioned by (Ariyama and Khan, 1990). With some modification carried out by the researcher, which amounted to (48) hours, the grain sample was purified from damaged and broken grains and impurity, then washed with regular water for several times under a temperature (10)°C, then washed with Sodium hypochlorite solution Concentration (2.0)% for (15) minutes on room temperature, after that it washed with distilled water several times for (20) minutes until the grain moisture percentage reached (40)%, where the grains were placed in transparent plastic bottles that were closed with airtight cover and left for soaking stage (24) hours at a temperature (24-25) °C and relative humidity (100) %. Then the grains were spread in to plastic trays in the form of one single layer after the trays were spread with four layers of cloth (acrylic) and the grains were covered with four layers from the aforementioned material. The germination process was carried out in the incubator at a temperature (25)°C under dark, the grains were sprayed with distilled water every (24) hours, and to prevent molds growth the grains stirred three times every day, after the end of suitable period of germination (48) hours, grains dried with sprouts parts in (Oven) at a temperature (30)°C for (18-22) hours to receipt the grain moisture percentage to (10-11) % and to imparting the palatable smell, and the germination process continued as long as sprout growth does not exceed kernel length (AACC, 2018).

Laboratory milling and preparing the sample of wheat flour:

Determination the percentage of moisture in wheat grains:

The moisture was estimated using the standard method of American Association of Cereal Chemists (AACC, 2010) for wheat grains, and a German Device (Measure 1200D) was used with accreditation on tables.

Milling of sprouted and nun sprouted wheat flour

The grains were milled by laboratory mill after the process of tempering the grains for purpose adjusting the moisture content of 10 % in order to obtain flour with moisture percentage of 14 % which is required and suitable percentage of flour by adding the necessary amount of tap water (ml) for moistening, was calculated according to the following equation:

The amount of added water (ml) = ((100-sample moisture)/(100-required moisture))-1 × the sample weight.

The grains were left for the purpose of tempering to get flour with extraction rate 80 %. Wheat grains were milled by laboratory mill from Sweeden Buhler company according to the mention in (AACC, 2010).

sprouted wheat grains were milled after dried at a temperature (30)°C for period (18-22) hours to reach the moisture percentage (10) %, as the current study and previous studies indicate that the moisture content of grain after germination and prepared for milling ranges between (8-11) %, flour has been obtained with extraction rate (80) %, after that the bran was mixed with dry growing part (Radical, Seminal roots, coleoptile) with flour resulting from milling process. The result flour was kept in the polyethylene in the refrigerator at a temperature of (4-5)°C until further laboratory tests.

Analytical Methods:

Proximate analysis:

The proximate composition was determined according to the standard method of American association of Cereal Chemists (AACC, 2010). Moisture percentage was determined by use the oven at a temperature (135)°C until the weight stability. Crude protein by Kjeldahl method, and digestion the sample by use Sulfuric Acid acid (H_2SO_4) and calculate protein percentage as nitrogen percentage, then the result (%Nitrogen) is multiplied by a factor (5.7). Ash

percentage was determined by weighted (2) gm from sample, then it was placed in Oven at a temperature (550)°C for (24) hours. Fat percentage was determined by use Soxhlet method and use Hexane solvent. Crude fiber was determined by digestion (2) gm of the sample (That fat was removed) with H_2SO_4 of 1.25 % and NaOH of 1.25 %. The carbohydrate percentage was determined by difference, that is addition of moisture, fat, crude protein, ash and crude fiber, which was subtracted from 100 %.

% carbohydrate = 100-(% Moisture + % fat + % Ash + % Crude fiber + % Crude protein).

Determination of total phenolic compounds content:

Extraction and sample preparation:

The method of extraction was summarized by weight a sample of (5) gm of flour and put it in the soxhlet apparatus and extracted with (300) ml of ethanol under a temperature of (50-55)°C for a period of (3-4) hours, then extraction was filtered by using whatman no.1 filter paper, the extraction was concentrated by using a rotary evaporator apparatus under low pressure at a temperature of (40)°C, after that weighted of (2.6) gm from the extraction and it was stored at a temperature of (40)°C until analysis is performed.

Determination of total phenolic compounds by standard curve of Gallic acid:

The total phenolic compounds of sprouted and non-sprouted wheat flour extract was determined using Folin-Ciocalteu reagent according to the method mentioned in (Zare *et al.,* 2014), which states that taking (150) µl of alcohol extraction with (500)µl of Folin-Ciocalteu reagent and added (1.5)ml of sodium carbonate (20)%, mixes well and complete the final volume to (10)ml. After two hours of interaction, the absorption was recorded at the wavelength of 765 nm. The concentration of total phenolic compound was calculated for calibration curve of gallic acid in units (mg/gm) based on dry weight.

Determination of phytic acid content:

The phytic acid content of sprouted and non-sprouted wheat flour was determined by HPLC according to the method mentioned by (Lehrfeld, 1989), analysis condition: (The carrier phase of methanol: formic acid 5 % with a ratio of (77:23) respectively, flow rate of 1.2 ml/min, and column dimensions (25cm*4.5mm)(C18-OSD), and use the UV-2010nm detector

Extraction process of sample:

The sample (0.5)gm of flour was weighted with (10)ml of (0.5) M of HCl and mixed for a period of (1-3) minutes, then the suspension was centrifuged at a speed of (1500) cycles/minutes for (15) minutes, the supernatant was removed and diluted with (20)ml of H2O and poured onto column, then the column was washed with (10)ml of (0.05) M HCl and injected into HPLC, and the column contain inositol solution (IP3, IP4, IP5, IP6), then were eluted with (2) ml of (2) M HCl. Portion of the inositol was removed by drying with a rotary evaporator at a temperature of (40)°C, then the inositol was removed by taking (1)ml and centrifuged it at a speed of (14000) cycles/minutes for (3) minutes. Supernatant was separated and injected into the HPLC unit, personification process of the concentration of phytic acid in sprouted and non-sprouted wheat flour was determined by compared retention time of standard material with the nearest time conformity in sample.

The phytic acid concentration was calculated as P.P.M units for the samples by the following equation:

Phytic acid Concentration= (Concentration of standard material× sample area /standard area) × (dilution/Weight of the sample).

Analysis of mineral elements:

The material elements of sprouted and non-sprouted wheat flour was determined according to the method mentioned by (Isaac and Kerber, 1971), by using Atomic Absorption and Flame Photometry apparatus (Shimadzue Model AA 7000).

The digestion of sample:

Weigh (2) gm of sample and placed in to beaker and added (40) ml of HNO_3 and cover with a watch glass and digest with heating at a temperature (105)°C and Added (3) ml of $HClO_3$. Reheating until drying and the sample was cooled, added (2) ml of $HClO_3$ and (3) ml of distilled water. Reheating at a low temperature (60)°C, the sample was cooled and transferred into (25)ml-volumetric flask.

Standard curve preparation:

Prepared (4) of standard solution from base solution, it is usually concentrated (1000) p.p.p. Using general dilution equation (C1×V1=C2×V2), the dilution that necessary to prepare four standard solution as a concentration (5, 10, 15.20, 25)p.p.m. The blank solution was prepared that it is usually is being deionized water. After setting the apparatus and selecting all the data for the element, the absorption of four standard solutions are read and get the calibration curve. Then read unknown samples to obtain the concentration. The concentration of mineral elements were estimated according to the following equation :

Con*. of element= (con*. Of standard solution× ABS**. of sample)/ ABS**. of standard solution .

*Concentration. **Absorption.

Determination of amino acid content:

Amino acids content of non-sprouted and sprouted wheat flour was determined by HPLC model (2100 Solvent Dilivery System) from Germany Sykam company to identify flour samples quantity and quality content from amino acid according to the following:

The flour sample was analyzed acidically by heating (0.2) gm from sample in (0.2) ml of (6) N of hydrochloric acid in closed and vacuumed tube, placed in the oven at a temperature of (110)°C for a period of (24) hours. The samples were ruling out from the oven after completion of the appropriate time, then it was filtered through filter paper (0.8)µm and washed with (50) ml of deionized water. The result portion that washed is concentrated by drying in rotary evaporator at (50)°C, adding (10) ml of deionized water and evaporator again at (50)°C, then adding (3) ml of (0.02) M HCl again. Then it was injected in amino acid analyzer, the column dimention were (4.6mm*150mm) with OPA reagent (Orthophthalialdehyde Reagent) from Japan Shimadzu company. Flow rate of (2) ml/minutes.

Results and Discussion

Proximate composition

The proximate composition of wheat flour samples is presented in Table 1. We notice from Table (1) a decrease in the percentage of moisture after germination as it was (13.1)% and for sprouted wheat for was (11.3)%. (Massood *et al.,* 2014) indicated the reason is due to the drying process that are taking place after ending germination process, which is one of the main and important stages to finished the germination process. In addition, it is important to increase storage period because it works to reduce the percentage of moisture in it, which reduces the growth of microorganisms (Dziki and Gawlik-Dziki, 2019). The results of this study less than result by (Steve, 2012), who indicated the percentage of moisture in un-sprouted wheat flour was (13.20) %. The results were higher than result by (Liu *et al,* 2017), as the percentage of moisture in non-sprouted wheat flour was (8.70) % and for enrichment wheat flour with sprouted wheat at ratio (25, 50, 75, 100)% was (9.02, 9.48, 9.76, 10.12)% respectively. Al-Mahyawi (2018) indicated that the moisture content of wheat flour for local cultivars (Iba 99, Rasheed, Tamus, Abu Ghraib) was (11.4, 12.4, 13.5, 12.7) % respectively. Table (1) shows that the percentage of protein in non-sprouted was (11.23) % and for sprouted wheat flour (which contains all component of grain which are endosperm, germ, bran, semi roots, redicle and coleoptile) was (14.97) %, table (1) showed that there is an increase in the percentage of protein in flour after germination at a ratio (1.87) %. Aborus *et al.* (2018) explained an increase the percentage of protein after germination due to the increased effectiveness of proteolytic enzymes. Also, the reason for increasing the protein percentage after germination may be due to loss in the percentage of amino acid, fats and carbohydrate during the seed respiration stages and synthesized of new amino acids during the germination stages (Jan *et al.,* 2017). So there are new proteins that are synthesize more than the proteins that are degraded, and it attributes on determining the actual protein content with the breakdown and synthesis protein (Nkhata *et al.,* 2018). The results of the study were less than by Hung *et al.* (2012), as the percentage of protein in non-sprouted wheat flour was (15.4) % and for sprouted wheat flour was (15.7) %. The results were higher than result by (Steve, 2012), indicated as the percentage of protein in non-germinated wheat flour was (10.77) % and after germination was (13.50) %. (Grassi *et al.,* 2018) indicated that the percentage of protein in whole wheat flour before germination was (12.9) % and after germination was (13.2) %, and the percentage of protein in refined flour before germination was (13.9) % and after germination was (12.8) %, and attribute the reason for an increase in percentage of proteins in whole wheat flour after germination to the activity of proteases and the loss of a percentage of carbohydrate and dry matter.

Table (1) shows that the percentage of Lipid in non-sprouted wheat flour was (1.91) %, and for sprouted wheat flour was (1.59) %. The table shows a decrease in the percentage of Lipid in flour after germination by (0.16) %. Poudel *et al.* (2019) explained an increase activity of lipase and lipoxygenase after germination, as they indicated an increase in activity of lipase at a temperature of (40)°C by (3) times than it was before germination, so activity of lipase was increased under temperature of (40)°C more compared under (60)°C for (72) hours. Poudel and Rose (2018) attributed that the reason of lipase was affected by heat more than lipoxygenase, due to difference in their activity with difference of drying temperature that it is take place to end the germination process. The result of this study were less than results by Hnilička *et al.* (2017), indicated that the percentage of oil in wheat flour before germination was (6.6)%, and for wheat flour germinated for (48) hours under a temperature of (22)° C was (3.9)%, and attribute the reason that there is a need for more energy and intermediate metabolic products that are required to complete the germination process, attributed Kaukovirta-Norja *et al.* (1998) a decrease in the percentage of oil after germination due to the decomposition of triglycerides by the activity of lipolytic enzymes such as lipase and which its activity increases after Germination. The results were less than result was shown by Donkor *et al.* (2012), as the percentage of oil in the non-germinated wheat flour was (1.95)% and for germinated wheat flour was (1.81)%. The results of this study was similar with the results indicated by Steve (2012), as the percentage of oil in wheat flour before germination was (1.93)% and after germination was (1.53)%. Hung *et al.* (2012) was showed that the percentage of oil in wheat flour before germination was (1.83)% and after germination was (1.82)%.

Table (1) shows the percentage of fibers in non-sprouted wheat flour was (1.42) % and for sprouted wheat flour was (2.39)%. Table (1) shows an increase in percentage of fibers in flour after germination, and the reason may be to an increase in the extraction ratio because the sprouted wheat flour represent whole extraction flour (Germ, bran, endosperm) with seminal roots, coleoptile and radical. And because the fibers available in bran, this leads to high percentage of fiber in sprouted wheat flour. The results of this study were lower than the results by Leghari *et al.* (2020) as the percentage of fiber in non-germinated wheat flour was (2.79) % and for whole germinated wheat flour was (5.98) %. Steve (2012) showed that the percentage of fiber in non-germinated wheat flour was (1.70) % and for germinated wheat flour was (1.93)%.

Table (1) shows that the percentage of ash in non-sprouted wheat flour was (1.26) %, and for sprouted wheat flour was (1.61)%. Table (1) shows that there is an increase in the percentage of ash in flour after germination by (0.18)%. The reason for the high percentage of ash after germination is due to the increase in the extraction rate, as Al-Mahyawi (2018) attributed the high ash content in whole wheat flour to the local wheat varieties (Ibaa 99, Al-Rashid, Tammuz, Abu Ghraib) due to the increase in the ratio of extraction of flour, also mentioned Yaqoob *et al.* (2018) The ash content of flour is an indication of the concentration of mineral elements in it. That is, the increase in mineral elements (An increase in the activity of the phytase enzyme that led to a decrease in the percentage of phytic acid in wheat flour after germination) is an indication of an increase in the ash content in the flour. The results of this study were less than the results obtained by Hung *et al.* (2012), as the ash content in wheat flour before germination was (1.80)% and for germination wheat flour for 48 hours was (1.94)%, also less than the results indicated by Donkor *et al.* (2012), as the percentage of ash in non-germinated wheat flour was (1.85)%, and for germinated wheat flour was (2.18)%. The results were higher than the results shown by Leghari *et al.*

(2020), as the percentage of ash in whole wheat flour was (1.15%), and wheat germinated flour was (1.20)%.

Table (1) shows that the percentage of carbohydrates in non-sprouted wheat flour was (71.03)% and for sprouted wheat flour was (68.14)%. Table (1) shows that there is a decrease in the percentage of carbohydrates in wheat flour after germination by (1.4)% . The reason may be due to the activity of enzymes such as the alpha-amylase, which its activity increases after germination. Nkhata *et al.* (2018) explained that germination lead to degradation of carbohydrates due to the alpha-amylase, which results in a decrease in the proporation of starch and increase in the proportion of sugars that depend on the period of germination. The results of this study were less than the results obtained by Steve (2012) the percentage of carbohydrates in non-germinated wheat flour was (84.63)%, and for germinated wheat flour was (82.13)%, and a reduction of the percentage of carbohydrates in the germinated wheat flour compared to the control sample was due the consumption of seeds for fats and carbohydrates required for biochemical activities to complete the germination process (Wang *et al .,* 1997). Dhillon *et al.* (2020) indicated that the percentage of carbohydrates decreased after germination as the percentage in whole wheat flour was (69.74)% and for whole germinated wheat flour was (69.17), and attributed the reason to the use of seeds for carbohydrates to biochemical activities to complete the germination stages.

Table 1: Proximate composition of non-sprouted and sprouted wheat flour.

Nutrient/sample	Non-sprouted wheat flour	Sprouted wheat flour
Moisture (%)	13.1	11.3
Protein (%)	11.23	14.97
Fat (%)	1.91	1.59
Fiber (%)	1.42	2.39
Ash (%)	1.26	1.61
Carbohydrate (%)	71.08	68.14

Amino acid determination:

Table (2) shows the percentages of amino acids in non-sprouted and sprouted wheat flour cultivar (Rasheed). As it was observed that there are (12) amino acid in non-sprouted wheat flour cultivar (Rasheed), including (6) essential amino acids (Lysine, Isoleucine, Phenylalanine, Valine, Threonine, Histidine). The essential amino acids (Valine, Threonine) were recorded the highest amounts reaching (17.938, 9.480) mg/100gm respectively, while the amounts were not recorded for essential amino acids (Leucine, Methionine), also non-essential amino acids (Alanine, Tyrosine) were not recorded before germination, but its amount in sprouted wheat flour were (10.644, 6.407) mg/100gm, and the reason may be due to its ratios were little before germination. Fourteen amino acids were recorded in sprouted wheat flour cultivar (Rasheed), including seven essential amino acids Lysine, Isoleucine, Valine, Threonine, Leucine, Methionine and Cystine. Essential amino acids (Valine, Threonine, Cystine) were recorded highest values by (3.596, 4.275, 5.386) mg/100gm, essential amino acids (Leucine, Methionine) were not recorded before germination but their amounts in sprouted wheat flour were (0.753, 10.644) mg/100 gm. The percentage of essential amino acids (Histidine) before germination was (2.630) mg/100 gm, but it was not recorded in sprouted wheat flour, the reason may be to its ratio was slight percentage after germination. Non-essential amino acids (Alanine, Tyrosine) were not recorded before germination but they were recorded in sprouted wheat flour as it were (10.644, 6.407). Assenova *et al.* (2019) attributed an increasing in some amino acids to the increasing in solubility of protein complexes, while a decrease in others due to the biological changes that occur as result of germination processes that influence on the proteolytic enzymes, results in peptide chains and amino acids. Johnston *et al.* (2019) concluded that there is an increasing in proteolytic enzymes activity of flour produced from sprouted wheat flour, as results in amino acids, peptide chains and others, which results in increase in some amino acids.

Table 2 : Amino acids content in wheat flour before germination and after germination at (mg/100gm) units.

Amino acid	Content, mg/100gm	
	Before germination	After germination
Essential		
Lysine	3.748	1.962
Isoleucine	4.384	1.266
Phenylalanine	0.412	----
Valine	17.938	3.596
Threonine	9.480	4.275
Leucine	----	0.753
Methionine	----	10.644
Histidine	2.630	----
Cystine	0.329	5.386
Non-essential		
Glycine	8.512	3.730
Aspartic acid	0.407	1.233
Glutamic acid	26.277	0.818
Serine	10.515	9.202
Arginine	55.123	5.837
Alanine	----	10.644
Tyrosine	----	6.407

Mineral elements determination

Table (3) shows sprouted and non-sprouted wheat flour cultivar (Rasheed) content of mineral elements which they are zinc, iron, copper, magnesium, chromium, selenium and calcium in a different concentration, as it reached (12.21, 6.59, 1.15, 110, 2.06, 0.81, 3700) mg/ 100gm respectively before germination, and increased after germination to (13.05, 7.1, 1.36, 140, 2.38, 0.9, 4100) mg/100 gm respectively. The results of this study were higher than results indicated by Assenova *et al.* (2019) in their study on effect of germination on mineral elements content in soft wheat flour, as it was (52, 5.2, 0.455, 2.75, 106) mg/ 100 gm of calcium, iron, copper, zinc and magnesium, and selenium as it was (0.027)µgm/100gm, and after germination they were (100, 7.5, 0.375, 1.55, 112) mg/100gm calcium, iron, copper, zinc and magnesium, and selenium as it was (0.027) µgm/100gm. (Lemmens *et al.,* 2018) indicated the reason of increase in mineral elements after germination is due to phytase which leads to degrade and reduce of phytic acid, it is considered one of chelating agent as it chews divalent and trivalent cations of mineral elements such as iron, zinc, calcium, magnesium, copper and manganese. (Bewley *et al.,* 2013) explained increase mineral elements bioavailability due to phytase activity that begins during early stages of elicitation, then its activity increase after germination . The differences in the bioavailability of minerals in cereals and legumes after germination for different periods may be to the differences in their phytate content, as well as the difference in phytase activity and the extent of minerals are bound to complexes. Luo *et al.* (2014) showed that minerals content in hard wheat after germination (3.31, 2.21, 0.82, 39.64) mg/gm for zinc, iron, cooper and calcium respectively.

Table 3 : Mineral elements content in wheat flour before germination and after germination at (mg/100gm) units.

Mineral	mg/100gm	
	Before germination	After germination
Zinc	12.21	13.05
Iron	6.59	7.1
Copper	1.15	1.36
Magnesium	110	140
Chromium	2.06	2.38
Selenium	0.81	0.9
Calcium	3700	4100

Determination of phytic acid content in flour

Table (4) shows the amounts of phytic acid in sprouted and non-sprouted wheat flour. Notes from the table that percentage of phytic acid in wheat flour cultivar (Rasheed) was (25.9) mg/100gm, which is higher than the results indicated by Al-Mahawi (2018) when his studying whole wheat flour content of phytic acid of local wheat cultivar, as it reached by (12.90) mg/100gm, the reason of difference due to environmental condition, soil type and fertilizer use (Muhamad *et al.,* 2010). Also notes from the same table that the percentage of phytic acid in sprouted wheat flour cultivar (Rasheed) was decreased to (6.3) mg/100gm, the reason of the decreasing after germination to increase in phytase activity which is degradation and reduction of phytic acid content. Rakhi and Puni (2013) indicated that the percentage of phytic acid in varieties studied were (206.71, 240.10) mg/100gm, and a decreased after germination to (33.21, 38.27) mg/100gm respectively. Parmar and Dahiya (2015) showed that phytic acid content were (234.15, 238.06, 253.9) mg/100gm in bread wheat cultivars and decrease to (167.18, 183.48, 205.11) mg/100gm after germination.

Table 4 : Phytic acid and total phenolic compounds in sprouted and non-sprouted wheat flour.

Cultivars	Phytic acid (mg/100gm), units	Total phenolic compounds (mg/gm), units
Non-sprouted wheat flour cultivar (Rasheed)	25.9	7.53
Sprouted wheat flour cultivar (Rasheed)	6.3	12.36

Total phenolic compounds determination:

Total phenolic compounds were estimated for sprouted and non-sprouted wheat flour cultivar (Rasheed) by extraction method and obtaining on standard curve of gallic acid. Table (4) shows that the concentration of total phenolic compounds in wheat flour was (7.53) mg/gm and after germination as its ratio was (12.36)mg/gm which an approach to results by Gawlik-Dziki *et al.* (2016) when they were studied the effect of enrichment wheat flour with sprouted wheat flour and studying its content of antioxidants and total phenolic compounds to identified their suitability for bread making, as total phenolic compounds were estimated for non-germinated and supplemented with germinated wheat flour at ratio at (10)% reaching (9.199, 11.645) mg/gm respectively. Ramadan *et al.;*(2012) mentioned that the germination of wheat led to a decrease in its content from total phenolic compounds, as it is a decreased from (3.81) to (2.24) mg/gm, they were attributed to increase in polyphenol oxidase activity and other enzymes that are motivated as result of germination for wheat. The results of this study were less than results by Swieca and Dziki (2015) when they were studied the enhancement of functional properties of sprouted wheat flour and its influenced by elicitation, temperature and germination period, as total phenolic compounds of sprouted wheat flour were recorded increased in sprouted wheat flour content of total phenolic compounds compared to control treatment when germination process at (20)°C for period of (2) days, as increased from (6.03) mg/gm to (7.17) mg/gm for control and sprouted sample respectively, the reason may be due to enzymes activity, as well germination conditions as temperature, germination period, as depends on the enzymes

activity that motivated as result of germination and controlling condition such as period, illumination added to elicitation which it is influence by several biotic and abiotic factors. Liu *et al. (*2011) mentioned that during the early stage of sprouting, bound phenolic compounds can be released from cell wall complex due to the degradation of their conjugators in cell wall such as carbohydrates and proteins.

Conclusions

From the results of this study, it was confirmed that the germination process was enhance the nutritional value of wheat flour. Approximate composition, mineral elements, total phenolic compounds contents and amino acids concentration were significantly influenced by the germination process. Increasing in protein, fiber, ash contents, mineral elements, total phenolic compounds, essential amino acids like leucine, methionine and cystine were increased by the germination process. Phytic acid concentration was decreased by the germination process.

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