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Original Research Article

Effect of Germination on Proximate Composition of Three Grains from Sudan

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Abstract: The objective of the current research was to investigate effects of germination on proximate composition of wheat (*Triticum spp.*), millet (*Pennisetum glaucum L.*) and maize (*Zea Mays.*) grains for comparison. All the grains were cleaned, washed and germinated at temperature 35 ± 2 °C and relative humidity 95 ± 2% for 48 hours. After germination grains were dried till moisture content 12 ± 2%. Main quality parameters such as protein, moisture, fat, fiber, ash and carbohydrates were determined in grains during their germination. Non germinated grains were used as a control sample. In the present experiments significant ($P \leq 0.05$) reduction in protein content was observed in the analyzed three grains during their germination for 48 hours which have been attributed to their degradation by proteases. Moisture content of all studied cereals was increased significantly ($P \leq 0.05$) due to hydration. Ash was increased only in wheat after germination while decreased in millet and maize significantly ($P \leq 0.05$). Non-significant ($P \geq 0.05$) changes were obtained in fiber and carbohydrates content of wheat after germination process and fat content in maize and millet after germination. Study revealed that germination for 48h could be an effective way of improving the fiber content in foods. The discrepancies between these studies could be related to differences in germination time and different sources of grains used in the study. Finally it was recommended to introduce germinated flour in bakery industry because it is of high carbohydrates content. As well as in our daily life because it is easily to be prepared at home so we can save time and money.

Keyword: *Triticum spp.* Grains, foods, Ash.

1.1 INTRODUCTION

Cereals like Sorghum, Millets, Wheat, Maize and Rice are major staple foods of the most population. These cereals are grown over an area of 98.6 m ha producing 162 m tons in Africa (FAO, 2011). Whole grain cereals have been found to be a good source of nutritionally valuable substances, such as carbohydrates, proteins, minerals, sugars, starch and dietary fiber. The health benefits of cereals are primarily caused by their phytochemicals including phenolic acids, flavonoids, vitamins, fiber, and minerals, which act together to combat oxidative stress, inflammation, hyperglycaemia, and carcinogenesis (Poutanen, 2012; Wang *et al*., 2013). Cereals are largely consumed as inexpensive sources of energy, they prepared in many form like bread and to a lesser extent as cakes, crackers and breakfast cereals. Millet is the main staple foods in the rural areas of Northern Sudan, and usually is fermented at room temperature at domestic house after milling to produce table food such as Kisra and Asida .While wheat and broad beans are principally consumed in the urban areas (Abuelgasium, 2001). They consumed in other forms like boiled, crushed, or rolled, made into pasta. According to the FAO/Sudan Production and Food Security Assessment conducted in 2010, cereals-mainly sorghum, millet and wheat account for about 53% of the per capita per daily energy requirement of the population, In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and it remains the most important agricultural crop for over 70 million farm families worldwide.

Wheat is the primary cereal grain and bread wheat represents the most important wheat species worldwide to be used as food ingredient in human nutrition (Rosenfelder *et al*., 2013). Wheat is mainly appreciated as a source of carbohydrates and proteins (albeit poor in some essential amino acids, especially lysine), but contributes also a significant proportion of fiber, minerals, and antioxidant compounds to the human diet (Ward *et al*., 2008; Hidalgo *et al*., 2016).

Several methods have been generally adopted to improve the nutritional and organoleptic qualities of cereal-based foods. These include: genetic modification, amino-acid fortification, supplementation or complementation with protein-rich sources and processing techniques which include malting, milling and fermentation (Laxmi *et al*., 2015).

Malting is a biotechnological technique which involves the controlled germination of a cereal grain which aims at activating enzyme systems that catalyze the hydrolysis of polymerized reserved food materials (Laxmi *et al*., 2015). Germination and malting of cereals is a way not only to produce fermentable extract for industries, but can also is a way to produce ingredients enriched with health promoting compounds (Hübner and Arendt, 2013).

Chemical and structural changes in grains, has been identified as an inexpensive and effective technology for improving cereal quality. The germination process is characterized by the growth of the embryo of the grain, manifested by the rootlets growth and increase in length of the shoot (acrospire), with the concomitant modification of the contents of the endosperm (de Pinho Ferreira Guine & dos Reis Correia, 2013).

Germination of grain commences with the uptake of water. Once germination is initiated, the predominant endosperm reserves, starch, cell wall, and storage proteins, are mobilized by the action of hydrolytic enzymes, which are synthesized in the aleurone layer and in the scutellum and secreted into the starchy endosperm of germinating grains (Shaik *et al*., 2014). During germination, endogenous enzymes of cereal grains are activated, and some major substances such as starch and protein undergo degradation to small molecules.

The germination process improves the nutritional quality of cereal. During the process of germination, significant changes in the biochemical, nutritional, and sensory characteristics of cereals occur due to degradation of reserve materials as used for respiration and synthesis of new cell constituents for developing embryo in the seed (Danisova *et al*., 1995; Sharma *et al*., 2016). As compared to un-germinated seed, germinated seeds contain high protein, low unsaturated fatty acids, low carbohydrate, and mineral content (Narsih, 2012; Sharma *et al*., 2016).

Most of studies and researches locally were conducted to proximate composition of cereals while a little research conducted to the effect of germination in different Sudanese cereals as a way to produce ingredients enriched with health promoting compounds. So this study is an attempt to enhance the nutritive value of common cereals through germination as it is the most inexpensive traditional processing technique for the elimination of the nutritional impediments of cereals, and processed to be available at market as germinated milled wheat, maize and millet. In Sudan cereals are usually processed through milling and only available at market as milled wheat, sorghum and millet.

The general goal of the study is to evaluate the effect of germination on proximate composition of local varieties of wheat, maize and millet for 48hr under ambient temperature and relative humidity for comparison.

This study will provide valuable information on germinated millet, wheat and maize for the consumer and processor to use of as individual or composite cereal mixes for the processing in future.

MATERIALS AND METHODS

2.1 Sample Collection

Three cereal grains (wheat, *Triticum aestivum*), (millet, *Pennisetum glaucum L*.), and (maize, *Zea mays L.)* were selected randomly from local market of Bahri, in Autumn season. One kilo of each grain was chosen almost of the same size and shape, free of damage, insect and foreign materials. Cereals were purchased and stored in dry and clean plastic polyethylene bags and transported to the laboratory of Food Technology, University of Bahri till further analysis.

2.2 Samples preparation

The three cereal samples were prepared for germination process by cleaning form dirty and foreign particles, only health and fit seeds were chosen. Then they were homogenized, weighed and assigned for two groups, one for running germination process and labeled as GM (germinated millet), GW (germinated wheat) and GMA (germinated maize). The other part was homogenized, milled and used as raw for proximate composition without germination having the following label NGW (non germinate wheat, NGM (non germinated millet) and NGMA (non germinated maize). All samples were kept in deep freezer at -18 °C in polyethylene bags for analysis.

2.3 Germination Method

Germination of wheat, millet and maize was done according to the method of Inyang and Zakari, (2008). About 500g of cleaned seeds were washed three times in tap water, soaked for 12h in tap water (1:3 w/v) at room temperature (32±2°C). After soaking the grains were drained and uniformly spread on wet jute sacks or cotton cloth. The grains were covered with another cotton cloth and water was sprinkled on the top. Germination was carried out at room temperature (32±2°C) for 48h. The grains were devegetated, moldy seeds were removed by hand and the sprouted seeds washed with tap water before drying in hot air oven at 100°C (or sun dried) for 6 h to about 12% moisture content. The dried, germinated grains were dehulled by washing in tap water to remove the bran. The dehulled grains together were milled into flour using hammer mill. The flour from germinated grains was kept in plastic bags at freezer (-18 °C) for further analysis.

2.4 Proximate Composition Analysis

Proximate compositions of germinated and non geminated (wheat, millet and maize flour) were carried out according to the methods of AOAC, 2005.

2.5 Statistical Analysis

The analysis of data was carried out by using one-way analysis of variance (ANOVA). Tukey LSD (Least Significant Difference) test and Paired-sample T test were done to determine the significant difference at $P \leq 0.05$ level. The Software for statistical analysis SPSS version 20.0 (IBM-SPSS, Chicago, IL, USA) was used.

RESULTS AND DISCUSSION

3.1 Proximate composition of (wheat, millet and maize)

The chemical analysis is important because it provides useful information to the nutritionist who are concerned with readily available sources of high in protein food as well as to the food scientist who are interested in developing them into high protein foods safety for consumers (Farhat and Chaudhry, 2011). Additionally, chemical composition could influence the storage and could assist in determining the suitability of different species to specific processing and storage techniques Therefore, processors have direct interest in the proximate composition of cereals in order to know the nature of the raw material before germination (Opstvedt, 2000).

3.1.1 Proximate composition of wheat *(Triticum ssp)*

Table1. Illustrate the (moisture, protein, fat, ash, fiber, and carbohydrates) of wheat before and after germination. Results indicate that moisture, fat and ash contents were increased significantly ($P \leq 0.05$) as a result of germination from (8.26 - 9.78%) - (2.60 - 2.81%) - (1.61- 1.76%), respectively. This result is within the finding of (Osman, 2011). Germination process decreased the protein of wheat significantly ($P \leq 0.05$) from (11.63-10.26%). Effect of germination on protein seems to be conflicting. Protein has been reported to increase upon germination depending on type of grains/seed (Laxmi *et al*., 2015). However, other scholars (Bhathal & Kaur, 2015) have reported a reduction in total proteins. Protein losses during germination have been attributed to their degradation by proteases. This result of protein reduction is within the finding of Onyango *et al*., (2013) who found reduction in total protein of wheat after germination.

Table 1: Proximate composition of germinated (G) and non germinated (NG) wheat as %(dry weight basis)

	Moisture	**Protein**	**Ash**	**Fiber**	**Fat**	**CHO**
NG	8.26	11.63	1.61	1.39	2.60	74.56
G	9.78	10.26	1.76	1.59	2.81	74.18
T calculated	27.338	6.084	43.00	1.579	7.810	2.526
P value	0.01	0.026	0.01	0.255	0.016	0.127
Sig.	**	**	**	Ns	**	Ns

N=3

T table 0.05 = 2.776

T table 0.01 = 4.604

T.test. The significance level was set at the probability level ($p \leq 0.050$).

There was a reduction after the germination process but insignificant ($P \geq 0.05$) in carbohydrates (74.56-74.18%). Reduction of wheat carbohydrates after germination is within the results of Osman (2011). The effect of germination on carbohydrates is largely dependent on activation of hydrolytic and amylolytic enzymes which results into decrease in starch and increase in simple sugars in a time-dependent manner.

Germination and malting facilitate the enzymatic breakdown of carbohydrates into simple sugars through activation of endogenous enzymes such as α-amylase thereby improving digestibility (Oghbaei & Prakash, 2016) as a result of degradation of starch to provide energy for the seed development (Zhang *et al*., 2015).

For fiber, there was insignificant ($P \geq 0.05$) increase of wheat fiber content from (1.39 -1.59%). Megat *et al*., (2016) reported increase in dietary fiber of different cereals for six hours.

4.1.2 Proximate composition of millet (*Pennisetum glaucum L*)

Table 2 exhibits the proximate composition of millet before and after germination as % on dry weight basis. There was significant increase ($P \leq 0.05$) in moisture (8.03-8.23%), fiber (1.34-2.17%) and carbohydrate (68.99-71.82%), while the protein and ash were significantly ($P \leq 0.05$) decreased (14.38-10.89, 1.84-1.68%), respectively. The increase of moisture was attributed to the increasing number of cells within the seed becoming hydrated (Nonogaki *et al.,* 2010). The increase in carbohydrates and fiber agreed with the results of the study of Megat *et al.,* (2016) who revealed an increase in total dietary fiber from 29% to 73% in different cereals.

Table 2: proximate composition of non germinated (NG) and germinated (G) of millet as % (dry weight basis)

	Moisture	Protein	Ash	Fiber	Fat	CHO
NG	8.03	14.38	1.84	1.34	5.40	68.99
G	8.23	10.89	1.68	2.17	5.36	71.82
T calculated	4.588	18.78	8.801	143.76	0.439	84.8
P value	0.044	0.033	0.013	0.000	0.704	0.00
Sig.	*	**	**	**	Ns	**

N=3
T table 0.05 = 2.776
T table 0.01 = 4.604
T.test. The significance level was set at the probability level ($p \leq 0.050$).

From the results of Table 2, germination could be an effective way of improving the fiber content in foods (Jan *et al*, 2017). Results of millet also showed relation between fiber and carbohydrates content, the higher carbohydrates content the higher crude fiber, the results of increasing of moisture, fiber and carbohydrate were within the results of (Ahmed *et al.*, 2018).

For fat content of millet after germination there was insignificant ($P \geq 0.05$) reduction(5.40-5.36) which was in the line of the study of Jan *et al*., (2017); who proved that lipid content of cereals slightly increases during the steeping stage of malting but later declines during the germination phase (Traore *et al*., 2004) as lipids are used for respiration process.

Protein of millet was reduced by germination process which is go through with study of Bhathal & Kaur, (2015) who reported, total protein reduction during germination due to their degradation by proteases which lead to protein losses.

Ash after germination was reduced, which is agreed with the result of Abiose and Ikujenlola (2014). The discrepancies between these studies could be related to differences in germination time and different sources of cereals used in the study.

4.1.3 The proximate composition of maize (*Zea mays L***)**

The ranges of moisture (8.18-9.72%), protein (8.73-6.02%) and fiber (1.59-1.93%) of maize showed the same trend of wheat and millet (Table 1 and 2) since there was significant ($P \leq 0.05$) increased in moisture and fiber while decreased in protein.

Table 3: proximate composition of non germinated (NG) and germinated (G) maize as % (dry weight basis)

	Moisture	Protein	Ash	Fiber	Fat	CHO
NG	8.18	8.73	1.71	1.59	4.35	75.41
G	9.72	6.02	1.57	1.93	4.36	76.36
T calculated	82.798	31.086	21.500	8.068	0.406	11.88
P value	0.00	0.001	0.002	0.015	0.724	0.007
Sig.	**	**	**	**	Ns	**

N=3
T table 0.05 = 2.776
T table 0.01 = 4.604
T.test. The significance level was set at the probability level ($p \leq 0.050$).

For fat content, maize showed the trend of millet, after germination there was insignificant ($P \geq 0.05$) increase (4.35-4.36%) which was in the line of the study of Ototu *et al*., (2014).

Carbohydrate of maize shows the same trend of millet but not wheat. It increased significantly ($P \leq 0.05$) from (75.41-76.36%). Desai *et al*., (2010); Laxmi *et al.,* (2015) reported increase in carbohydrate after germination of millet, wheat and chickpea.

Ash of maize decreased (1.71-1.57%) significantly ($P \leq 0.05$) to show the same trend of millet. Results of maize also showed relationship between increasing carbohydrates and fiber.

Germinated flour of the three cereals showed high fiber content which is might be useful to prevent the constipation and improving digestibility as a result of degradation of starch to provide energy through activation of endogenous enzymes such as α-amylase.

CONCLUSION

The main target of this study is evaluating the impact of germination on the proximate composition of three popular grains from Sudan (wheat, *Triticum ssp*), (millet, *Pennisetum glaucum L)* and (maize, *Zea mays L*) for 84hours.

The study revealed that germination had significant ($P \leq 0.05$) differences on moisture and protein. The discrepancies between parameters could be related to differences in germination time and different sources of cereals used in the study.

The results obtained from this study confirmed that germination as a processing technique can be used to effectively enhance the nutritional values of millet, wheat, and maize. Germinated grains might offer an alternative for allergic or malapsorption patients to gluten.

Finally it is recommended that germinated cereals should use in bakery industry because it is of high carbohydrates content and should be introduced in our daily life because it is easily to be prepared at home so we can save time and money.

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