

The Impact of Soaking and Germination on Chemical Composition, Carbohydrate Fractions, Digestibility, Antinutritional Factors and Minerals Content of Some Legumes and Cereals Grain Seeds

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ABSTRACT

Germination of legumes and cereals seed causes some important changes in the biochemical and a nutritional characteristic of the legumes that may be beneficial to human's health and nutritional status. This study evaluated the effects of soaking for 6 and 12 hr and germination for 2 and 4 days with or without light on the chemical composition, carbohydrate fractions (starch, total sugars, reducing sugars and total carbohydrates), in vitro starch and protein digestibility, antinutritional factors, minerals content (macro and micro elements, ppm) of some legume (peas, lentils, chickpea and faba bean) and cereal grains (oats and wheat). The proximate composition in studied seeds was affected by soaking and germination. In germinated samples, moisture and protein and total dietary fiber contents increased while carbohydrate, and fat were decreased. Germination caused increase in vitro starch and protein digestibility contents of all the legume and cereal samples. Phytic acid and trypsin inhibitors contents were decreased in germinated legumes and cereals. The decreased in phytic acid and trypsin inhibitors contents were due to enzymatic changes during soaking and germination period in seeds. The presence or absence of light during the germination process did not affect the results achieved.

It can be concluded that soaking and sprouting improved the nutritional worth of the selected legumes and cereals in terms of higher concentration of nutrients, reduced phytic acid, trypsin inhibitors and improved protein content and ascorbic acid. Germinated legumes and cereals can be incorporated with wheat-based food product such as bread or pasta to improve nutrition content.

Key words: Soaking, germination, legumes, cereals, chemical composition, carbohydrate fractions, in vitro starch and protein digestibility, antinutritional factors, mineral contents

INTRODUCTION

Legumes play an important role in the agriculture and diet of many developing countries and are a major source of dietary nutrients for many people (Ghavidel and Prakash, 2007). They are a good and inexpensive source of energy, dietary proteins, carbohydrates,

vitamins and minerals. However, their role appears to be limited because of several factors including low protein and starch digestibility (Negi, *et al.*, 2001), poor mineral bioavailability (Kamchan *et al.*, 2004), and high amounts of antinutritional factors (i.e. trypsin inhibitors, alpha -galactosides, inositol phosphates) in the raw seeds that need to be reduced by processing before consumption (Augustin *et al.*, 1989; Kaushik *et al.*, 2010).

Cereals, particularly wheat, are important components of the daily diet, providing carbohydrates, proteins, dietary fibers and vitamins to less privilege in many countries. Wheat is one of the most consumed cereal grains worldwide and makes up a substantial part of the human diet (Punder and Pruijboom, 2013). Native oat is known as a health promoting cereal with high content of soluble dietary fiber, beneficial fatty acid content and a large selection of vitamins, minerals, sterols and antioxidants (Tian *et al.*, 2010), the studies of germinated /malted oat are few. In recent years, Oats have attracted research and commercial attention mainly due to their high contents of β -glucan and phenolic compounds with high antioxidant activities (Malkki *et al.*, 2004).

Soaking is the first step in water penetration, which transforms the inactive tissue into living tissue. In this step, the grain's metabolism is activated in preparation for germination (Maisont and Narkrugsa, 2010). Soaking and germination of cereal and legumes were also found to reduce trypsin inhibitor activity level and flatulence causing oligosaccharides (namely stachyose and raffinose), thereby increasing protein digestibility and improving sensory properties (Zanabria *et al.*, 2006; Osman, 2007).

Germination is an inexpensive and effective technology for improving nutrients availability and diminishing anti-nutritional factors in present in legume and cereal grains and maximizes the levels of some of the utilizable nutrients (Inyang and Zakare, 2008; Maisont and Narkrugsa, 2010). Gupta and Sehgal

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(1991) reported a decrease in phytic acid content of cereal grain used for preparation of weaning foods as results of soaking and germination. Germinated seeds are good source of ascorbic acid, riboflavin, choline, thiamine, tocopheroles and pantothenic acid (Sangronis and Machado, 2007).

In recent years, germinated seeds have gained a lot of popularity and widely accepted as a functional food because of its nutritious and health benefits in several aspects (Moongngarm, 2011). The practice of sprouting of cereal grains has become popular in the western world. They can be used in many different foods including breakfast items, salads, soups, casseroles, pasta and baked products (Lorenz, 1980).

The presence of light advances the metabolic changes that take place during the different stages of germination, and so it is necessary to evaluate how these changes influence the bioavailability of essential nutrients (Urbano *et al.*, 2005).

There have been very few comparative studies in which the same seeds were exposed to light germination or germinated entirely in darkness while holding other germination conditions constant (Kuo *et al.*, 2004; Vidal-Valverde *et al.*, 2002).

Therefore, the purpose of the current experiment was to study the effect of some domestic traditional processes, such as soaking and germination process in presence or absence of light on the chemical composition, carbohydrate fractions, digestibility of starch and protein, antinutritional factors, mineral contents in some legumes (peas, lentils, chickpea and faba bean) and cereal grains (oats and wheat).

MATERIALS AND METHODS

Materials:

Three whole legumes and two cereal grains, namely pea (*Pisum sativum*), lentils (*Lens esculenta*), chickpea (*Cicer arietinum*), faba bean (*Vicia faba*), oats (*Avena sativa*) and wheat (*Triticum vulgare*) were obtained from El – Behira governorate, and used for the germination experiments. Samples were washed and cleaned with tap water before soaked.

Methods:

1- Technological methods :

Soaking: -

Legumes and cereal seeds were first cleaned manually to remove broken seeds, dust and other extraneous materials and then soaked in 2500 ml of 0.07% sodium hypochlorite solution for 30 min at room temperature. Seeds were then drained and washed to neutral pH and then soaked in distilled water for 6 and 12 h at ambient temperature. A seed to water ratio of

1:10 (w/v) was used. The unimbibed water was discarded. The soaked seeds were rinsed twice in distilled water and then dried at 55-60°C (Vidal-Valverde *et al.*, 2002).

Germination:-

The soaked seeds were allowed to germinate under a wet muslin cloth for 0, 2 and 4d with or without light (G0, G2DL, G2DD, G4DL and G4DD) at 37 °C and 99% relative humidity, with frequent watering as described by Obizoba and Atii (1994). Ungerminated seeds served as control. The sprouts were rinsed in distilled water and dried at 60 °C for 12 h using an oven until constant weight was achieved. The dried samples of raw, soaked and germinated seeds were ground to fine powder in an electric grinder and then stored in plastic containers for further use.

Chemical methods:

Proximate analyses:

Proximate compositions of the food sample were determined in triplicate using the standard procedures of Association of Official Analytical Chemists (AOAC, 2005). Moisture content, crude protein (Kjeldahl method), crude fat (solvent extraction), crude fiber and ash were determined using standard methods (AOAC, 2005).

Carbohydrate fractions:

Starch was determined as glucose after hydrolyzation by HCL (AOAC, 2005). The total carbohydrate content was determined by difference, that is addition of moisture, fat, crude protein, ash and crude fiber, which was subtracted from 100%. This gave the amount of nitrogen free extract otherwise known as carbohydrate.

$$\% \text{Carbohydrate} = 100 - (\% \text{Moisture} + \% \text{Fat} + \% \text{Ash} + \% \text{Crude fiber} + \% \text{Crude protein}).$$

Total sugar determination:

Total sugar was determined according to the method of Dubois *et al.*, (1956), with slight modification. Samples were thoroughly mixed with ethanol and diluted with water appropriately and filtered prior to addition of phenol and concentrated sulphuric acid and the absorbance read at 490 nm after 10 min. Sugar content was calculated using a standard curve prepared using 0 – 100 µg glucose.

Reducing sugars:

Reducing sugars contents were colorimetrically determined according to the method of Miller (1959). Five grams of sample was extracted with 50 ml of 70% ethanol and incubated in water bath at 70°C for 3 hours. Then, the solution was filtered. The filtrate was made up to 100 ml with distilled water. Five ml of the filtrate was

pipetted in test tube and 2 ml of 3,5- dinitrosalicylic acid were added in test tube, shake well, heated exactly for 10 min in water bath at 100°C and cooled under stream of tap water. The color intensities measured at 550 nm. Standard curve was made by using different concentrations of pure glucose solution.

Ascorbic acid determination:

Ascorbic acid was determined according to AOAC (2005) procedure using 2,6 - dichlorophenol indophenol dye.

Nutritional methods:

Phytic acid determination:

Phytic acid was extracted from each 3 g flour sample with 3% trichloroacetic acid by shaking at room temperature followed by high speed centrifugation as described by Wheeler and Ferrel (1971). This method depends on an iron to phosphorus ratio of 4:6. Five grams of the test sample was extracted with 3% trichloroacetic acid. The phytate was precipitated as ferric phytate and converted to ferric hydroxide and soluble sodium phytate by adding sodium hydroxide. The precipitate was dissolved in hot 3.2 N HNO and the colour read immediately at 480 nm. The standard solution was prepared from Fe(NO₃)₃ and the iron content was extrapolated from Fe(NO₃)₃ standard curve. The phytate concentration was calculated from the iron results assuming a 4: 6 iron: phosphorus molecular ratio. The phytic acid was estimated by multiplying the amount of phytate-phosphorus by the factor 3.55 based on the empirical formula C₆P₆O₂₄H₁₈.

Trypsin inhibition activity determination:

The trypsin inhibition activity was assayed in terms of the extent to which an extract of the defatted flour inhibited the action of bovine trypsin on the substrate benzoyl-DL-arginine-p-nitranilide hydrochloric (Kakade *et al.*, 1969).

Starch digestibility:

In vitro starch digestibility was assessed by employing pancreatic amylase and incubating at 37°C for 2h. Liberated maltose was measured colorimetrically by using dinitrosalicylic acid reagent (Singh *et al.*, 1982).

Protein digestibility:

In vitro protein digestibility was assessed by employing pepsin and pancreatin (Akeson and Stahmann, 1964). The nitrogen contents of the sample and undigested residue were determined by the microkjeldahl method (AOAC, 2005). The digested protein of the sample was calculated by subtracting residual protein from total protein of the sample.

Protein digestibility (%)= Digested protein / Total protein × 100

Mineral analysis:

The standard method described by Association of Official Chemists was used for mineral content analysis of the samples (AOAC, 2005). Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Iron (Fe), Manganese (Mn) and Zinc (Zn) were determined using Atomic Absorption Spectrophotometer (PERKIN – ELMER, 2380). All values were expressed in ppm.

Statistical analyses:

The data obtained were subjected to analysis of variance according to SPSS, (1997). Significant differences among individual means were analyzed by Duncan , s multiple range test (Duncan,1955).

RESULTS AND DISCUSSION

Effect soaking and germination on proximate composition of some legumes and cereals:

The effect of germination on the proximate composition of peas, lentils, chickpea, faba bean, oats and wheat seeds, both raw, soaked (6 and 12 h) and after germination for periods of 0, 2, or 4 day in presence of light and in darkness are given in Table (1). The moisture and protein contents were increased after soaking and germination in both legume and cereal samples, while their crude lipids, total carbohydrate and ash contents decreased. The moisture content increased for example, from 18% in raw peas to 78% after 12h soaking and 4 day germination. It is clear that oats contain more crude lipids than other seed samples. These results are in agreement with Saastamoinen *et al.*, (1989) who reported that oats contain lipids, normally 5-9%. As germination proceeds, legumes took up water from the surrounding in order for the metabolic process to commence. Dry legumes absorb water rapidly, influenced by the structure of the legume. The increase in water uptake with time is due to the increasing number of cells within the seed becoming hydrated (Nonogaki *et al.*, 2010). Many researchers observed significant increase in protein content of cereal and legumes (Traore *et al.*, 2004; Oloyo, 2004; Alonso *et al.*, 2000).

Reports on changes in total protein content during germination show either an increase, a decrease or indifference. Total protein content was found to increase significantly during germination in wheat, triticale, barley, rice, rye and oat (Miller 1978, Nielsen *et al.*, 1978).

Soaking was found to cause slightly change in fat content of seed samples, whereas, germination caused significant decrease in fat content.

Table 1. Effect of soaking period and germination conditions on the proximate composition of some legumes and cereals

Samples	Moistur %		Protein %		Lipids %		Ash %		Crude fiber %	
	Soaking periods (h)									
	6	12	6	12	6	12	6	12	6	12
Peas										
Raw	18.93±.01	-	27.86±.12	-	2.23±.08	-	3.18±.11	-	4.53±.38	-
G0	58.66±.21	64.22±.02	27.63±.07	27.22±.10	2.13±.11	2.16±.05	3.00±.09	2.96±.12	5.19±.12	5.66±.13
G2DL	65.16±.03	68.12±.15	28.56±.11	28.43±.11	2.08±.09	2.12±.11	2.74±.12	2.70±.22	7.33±.09	7.94±.07
G4DL	76.43±.11	78.30±.17	28.66±.12	28.46±.12	1.96±.32	1.88±.12	2.43±.07	2.28±.04	9.86±.11	10.33±.12
G2DD	65.15±.20	68.15±.03	28.73±.11	28.54±.09	2.12±.11	2.13±.21	2.33±.17	2.21±.07	7.30±.07	8.06±.56
G4DD	76.39±.13	78.23±.11	29.01±.05	28.95±.12	2.00±.12	1.79±.43	2.16±.22	2.11±.33	10.02±.11	10.30±.04
Lentils										
Raw	12.2±.12	-	25.33±.11	-	2.18±.01	-	4.26±.11	-	7.57±.12	-
G0	57.33±.07	59.16±.11	25.12±.01	25.09±.11	1.86±.09	1.88±.03	3.53±.12	3.50±.01	8.33±.04	9.16±.07
G2DL	59.42±.11	61.52±.08	25.65±.09	25.44±.01	2.09±.10	2.04±.07	3.18±.07	3.11±.10	10.65±.08	11.36±.12
G4DL	62.19±.12	66.83±.12	25.87±.11	25.63±.21	2.01±.05	2.00±.10	2.86±.08	2.83±.003	12.74±.11	12.42±.01
G2DD	59.38±.06	61.36±.03	26.16±.01	26.02±.01	2.11±.12	1.98±.11	3.12±.01	3.00±.11	10.62±.08	11.37±.11
G4DD	62.14±.11	66.78±.11	26.23±.15	26.12±.31	2.00±.11	2.00±.11	2.77±.11	2.52±.10	12.77±.03	12.40±.08
Chickpea										
Raw	14.22±.10	-	30.41±.06	-	6.46±.03	-	3.72±.02	-	5.62±.10	-
G0	62.19±.11	64.32±.11	29.63±.01	29.21±.01	5.45±.08	5.43±.32	3.14±.11	3.12±.10	7.36±.11	7.92±.12
G2DL	63.67±.08	68.46±.03	31.30±.21	31.09±.12	5.33±.12	5.26±.11	3.02±.01	2.98±.21	9.47±.07	10.36±.11
G4DL	71.43±.10	73.23±.11	32.12±.40	32.22±.09	5.21±.10	5.15±.06	3.09±.05	2.88±.12	11.52±.04	12.48±.04
G2DD	63.62±.09	68.32±.07	31.16±.11	32.13±.01	4.36±.05	4.28±.11	3.00±.10	2.98±.06	9.44±.31	10.33±.23
G4DD	72.11±.07	73.06±.03	32.34±.04	32.24±.12	4.32±.41	4.14±.60	2.98±.16	2.77±.09	11.50±.18	12.42±.05
Beans										
Raw	10.46±.11	-	31.35±.06	-	1.89±.01	-	12.38±.90	-	4.88±.06	-
G0	60.52±.03	62.33±.07	31.11±.01	31.09±.08	1.83±.00	1.81±.03	10.25±.02	10.16±.21	6.73±.03	7.82±.12
G2DL	63.43±.21	65.26±.11	32.45±.12	32.67±.21	2.15±.12	1.89±.11	9.58±.11	9.42±.06	7.48±.11	8.67±.03
G4DL	70.18±.05	73.44±.03	32.66±.13	32.77±.11	2.11±.02	2.11±.04	9.26±.04	9.15±.11	8.76±.02	10.77±.11
G2DD	63.54±.11	65.24±.21	32.33±.41	32.45±.31	2.01±.21	2.13±.21	9.54±.22	9.33±.04	7.44±.15	8.60±.03
G4DD	70.20±.09	72.96±.02	32.54±.03	32.68±.00	2.12±.30	2.14±.04	9.12±.08	9.09±.12	9.09±.02	10.78±.23
Oats										
Raw	12.76±.05	-	18.89±.12	-	8.46±.06	-	2.78±.04	-	6.75±.06	-
G0	59.18±.03	60.88±.06	19.55±.04	19.61±.11	7.74±.09	7.43±.12	2.44±.08	2.31±.12	7.23±.12	8.31±.03
G2DL	61.32±.12	62.52±.12	21.76±.09	21.78±.12	7.52±.11	7.41±.06	2.22±.11	2.13±.05	8.34±.11	10.38±.08
G4DL	66.43±.04	68.87±.03	24.33±.41	24.41±.04	7.24±.03	7.11±.11	2.18±.05	2.00±.11	10.56±.06	12.61±.12
G2DD	61.30±.11	62.51±.12	22.79±.12	22.82±.18	7.41±.12	7.32±.11	2.18±.12	2.09±.07	8.42±.06	10.46±.01
G4DD	66.22±.08	69.06±.23	24.41±.07	24.43±.06	7.00±.12	7.13±.05	2.15±.11	2.11±.12	10.62±.11	12.66±.10
Wheat										
Raw	13.23±.12	-	10.86±.02	-	1.97±.22	-	1.98±.19	-	9.46±.12	-
G0	60.13±.06	62.15±.12	10.34±.09	10.30±.18	1.56±.12	1.49±.31	1.94±.07	1.92±.11	12.78±.03	12.88±.00
G2DL	64.28±.03	65.33±.05	13.65±.12	13.60±.12	1.42±.09	1.40±.11	1.91±.11	1.88±.09	13.86±.12	13.92±.12
G4DL	69.45±.06	70.72±.11	13.76±.08	13.65±.06	1.12±.02	1.10±.03	1.84±.10	1.82±.21	15.96±.11	16.98±.11
G2DD	64.21±.12	65.18±.09	13.81±.12	14.00±.02	1.33±.12	1.26±.09	1.92±.003	1.84±.11	13.84±.12	13.91±.02
G4DD	69.06±.17	70.36±.13	14.06±.01	14.04±.11	1.10±.03	1.00±.18	1.83±.12	1.80±.01	15.97±.08	16.98±.07

Each value is expressed as mean of triplicates ± standard deviations.

G0= ungerminated, G2DL= 2day germinated in light, G4DL= 4day germinated in light, G2DD= 2day germinated in dark, G4DD= 4day germinated in dark

These results agree with Inyang and Idoko (2006) who reported reduction in fat content in malted millet during production. The decrease in fat content could be attributed to increase in lipolytic enzymes during germination or due to break down of fat by β -oxidation for energy purpose in embryo development. Increase in protein content was also noted by Camacho *et al.*, (1992) during germination of beans, lentils, chick pea and pea's seeds. Ohtsubo *et al.*, (2005) found an increment in crude protein of germinated brown rice. The increase in protein content could be attributed to a net synthesis of enzymic protein (e.g. proteases) by germinating seeds (Nzeribe and Nwasike, 1995). Other researchers have attributed the increase to the degradation of stored protein and synthesis of new protein and other materials while stated that the increase in protein on germination of corn was due to mobilization of storage nitrogen producing the nutritionally high quality protein which the young plant needs for its development.

Fat content was decreased in all germinated samples with significant decrease found in germinated peas, lentils, chickpea, faba bean, oats and wheat. Similar results occurred in study by El-Adawy *et al.* (2004), Ghavidel and Prakash (2007) and Hahm *et al.* (2008) where the fat content decrease with increase in the time of germination. This is because fat was used as the major source of carbon for seed growth (Bau *et al.*, 1997). Hahm *et al.* (2008) also suggested that fatty acids are oxidized to carbon dioxide and water to generate energy for germination.

Ash content was significantly decreased in all germinated samples (Table 1). This reduction could be due to leaching of solid matter in soaking water (Ghavidel and Prakash, 2007). Wang *et al.*, (1997) reported that the differences in ash content after soaking for a specific time was due to decreased ash content. The decrease in ash content represents loss in minerals due to rootlet and washing of the rice in water to reduce the sour smell during the period of germination (Tatsadjieu *et al.*, 2004).

Study by Azizah and Zainon (1997) demonstrated that total dietary fibre was decreased in soaked wheat, barley, peanut and mung bean, but conversely increased in soaked rice and soy bean. This indicates that germination process affect the level of total dietary fibre during the period of soaking before the actual phase of germination (Megat Rusy *et al.*, 2011). In a similar study conducted on soybean, Jimenez *et al.*, (1985) also noted an increase in the fiber and protein content of soybean seeds during sprouting.

The decreased carbohydrate levels of the germinated seeds might be due to increase in α -amylase activity (Lasekan, 1996). α -Amylase breaks down complex carbohydrates to simpler and more absorbable sugars which are utilized by the growing seedling during early stages of germination.

Germination meanwhile, altered the biochemical composition of legumes. Decrease of carbohydrate level is beneficial to diabetes mellitus patients. In addition, increase of total dietary fiber and decrease of fat content can give benefit to people with cardiovascular disease and hypercholesterolemia (Megat Rusy *et al.*, 2011).

Finally, germination did affect the proximate composition of the seeds of the plants, but though differently. Fat content of control seeds ranged from 0.89 g/100 g in lentil to 5.45 g/100 g in chickpea. On germination, there was a statistically significant decrease of fat content, which could be due to total solid loss during soaking prior to germination (Wang *et al.*, 1997) or use of fat as an energy source in sprouting process.

El-Adawy *et al.*, (2003) reported significant increase in ash content during sprouting in mungbean, pea and lentil seed. The decrease in crude fat and carbohydrate contents during sprouting may have led to the apparent increase observed in ash and other chemical components. Several studies on the effect of germination on legumes found that germination can increase protein content and dietary fiber, reduce tannin and phytic acid content and increase mineral bioavailability (Hussein and Ghanem, 1999; Ghavidel and Prakash, 2006).

Effect of soaking and germination on carbohydrate fractions and ascorbic acid content:

Table 2 shows the carbohydrate fractions and vitamin C content of raw, soaked (for 6 and 12h) and germinated (2 and 4 days) some legume and cereal seeds in presence or absence light.

The decrease in the starch content of germinated seeds was found after germination was taken placed for 2-4 days due to the starch was broken down by amylase and resulting in increasing the concentration of simple sugars (Table,2). In this study, reducing sugar was found to increase with soaking and germination time, due to the hydrolysis of starch. The maximum content was observed at soaking for 12 hour and germination for 4 days. Starch in cotyledon was broken down into smaller molecules such as glucose and fructose to provide energy for cell division while the seeds mature and grow (Vidal-Valverde *et al.*, 2002; Nonogaki *et al.*, 2010). Ohtsubo *et al.*, (2005) explained that carbohydrate breakdown in which α -amylase activities were found to

Table 2. Effect of soaking period and germination conditions on starch, total sugars, reducing sugars, total carbohydrates and ascorbic acid of legumes and cereals

Samples	Starch %		Total sugars %		Reducing sugars %		*Total carbohydrates %		Ascorbic acid (mg/100g)	
	Soaking periods (h)									
	6	12	6	12	6	12	6	12	6	12
Peas										
Raw	45.40±.01	-	6.80±.12	-	.85±.02	-	62.22±.22	-	.96±.17	-
G0	42.38±.11	40.87±.11	4.94±.23	6.54±.13	.55±.13	.49±.31	62.05±.07	60.00±.12	1.38±.11	1.94±.22
G2DL	40.72±.07	38.16±.07	6.21±.11	18.33±.11	3.09±.11	5.66±.12	59.28±.01	58.80±.09	2.49±.06	3.35±.12
G4DL	38.86±.13	35.42±.12	10.68±.01	19.84±.01	4.66±.13	7.48±.08	57.09±.11	57.05±.11	4.58±.16	5.62±.06
G2DD	40.33±.09	37.36±.09	6.15±.11	18.28±.13	3.11±.11	6.88±.11	59.52±.32	59.06±.02	2.44±.04	3.33±.18
G4DD	38.45±.11	36.17±.31	11.43±.20	19.56±.11	4.58±.05	7.44±.06	56.75±.06	56.85±.62	4.69±.11	6.35±.04
Lentils										
Raw	39.62±.07	-	10.82±.13	-	0.65±.05	-	60.66±.80	-	1.64±.32	-
G0	38.19±.04	36.53±.12	8.92±.03	7.17±.12	0.48±.12	0.36±.12	61.16±.12	60.37±.07	1.96±.22	1.99±.53
G2DL	32.61±.11	30.46±.08	12.15±.22	12.66±.11	2.66±.21	3.05±.31	58.43±.05	58.05±.23	2.55±.18	3.18±.32
G4DL	28.33±.13	27.33±.23	16.18±.18	15.45±.06	4.13±.06	5.72±.11	56.52±.11	57.12±.11	5.17±.11	5.33±.12
G2DD	32.42±.09	31.41±.07	13.22±.10	12.60±.11	2.62±.17	3.01±.07	57.99±.32	57.64±.08	2.57±.13	3.22±.11
G4DD	27.87±.11	27.14±.11	16.18±.11	14.98±.03	4.22±.11	6.11±.11	56.23±.23	56.96±.44	5.21±.11	6.08±.05
Chickpea										
Raw	42.36±.13	-	11.35±.32	-	0.97±.43	-	53.79±.67	-	1.36±.12	-
G0	40.13±.07	40.11±.05	10.44±.17	9.77±.1.11	0.66±.11	0.53±.11	54.43±.08	54.32±.16	2.75±.09	2.89±.21
G2DL	39.28±.11	38.62±.08	11.98±.07	12.78±.73	3.75±.21	4.16±.43	50.88±.31	50.31±.03	4.66±.44	5.34±.08
G4DL	37.53±.12	35.47±.11	15.38±.12	16.48±.32	6.18±.32	7.34±.22	48.06±.22	47.27±.42	6.33±.23	7.29±.12
G2DD	39.06±.11	37.66±.12	12.06±.11	12.73±.12	8i3.66±.11	4.10±.12	52.04±.09	50.33±.12	4.68±.12	5.36±.11
G4DD	37.14±.09	35.73±.11	15.22±.09	16.26±.11	6.32±.04	7.32±.08	48.87±.31	48.43±.53	6.36±.17	8.14±.08
Beans										
Raw	48.53±.11	-	13.72±.52	-	0.77±.1.11	-	49.50±.45	-	15.89±.36	-
G0	46.64±.03	46.18±.12	10.53±.33	9.16±.1.11	0.55±.87	0.43±.55	50.08±.02	49.12±.08	33.67±.28	34.54±.1.1
G2DL	38.09±.11	36.22±.08	13.16±.21	13.89±.37	3.18±.22	4.56±.23	48.34±.12	47.35±.14	33.89±.22	34.89±.84
G4DL	34.52±.09	32.43±.11	18.32±.30	19.76±.33	7.33±.12	6.88±.08	47.21±.35	45.20±.01	36.46±.19	38.66±.32
G2DD	38.19±.12	37.11±.06	13.22±.23	13.87±.26	3.15±.20	4.67±.12	48.68±.01	47.52±.25	34.55±.30	35.17±.22
G4DD	34.56±.08	33.12±.12	18.27±.14	19.72±.03	8.06±.11	7.32±.05	47.13±.25	45.34±.36	38.68±.11	39.36±.08
Oats										
Raw	59.86±.12	-	18.66±.32	-	3.75±.55	-	63.12±.22	-	.64±.21	-
G0	54.13±.06	52.66±.32	15.73±.12	13.83±.16	3.22±.14	3.11±.09	63.04±.12	62.34±.08	.71±.04	.88±.06
G2DL	53.26±.11	51.54±.11	17.48±.09	16.88±.05	4.56±.09	5.63±.11	60.16±.07	58.30±.23	.98±.12	1.34±.19
G4DL	51.34±.09	49.76±.09	20.55±.12	19.76±.13	6.87±.11	7.87±.05	55.69±.45	53.87±.20	1.56±.11	2.48±.08
G2DD	53.21±.12	50.81±.01	17.39±.04	17.34±.08	3.93±.33	5.66±.04	59.21±.01	57.31±.11	.93±.02	1.54±.12
G4DD	50.66±.03	49.88±.13	20.52±.01	19.65±.33	6.85±.06	7.73±.11	55.82±.00	53.67±.03	1.64±.17	2.43±.30
Wheat										
Raw	68.42±.12	-	20.33±.22	-	2.13±.21	-	75.73±.10	-	.93±.04	-
G0	57.68±.11	54.65±.12	18.61±.05	17.32±.1.1	5.66±.05	7.22±.05	73.38±.03	73.41±.26	1.44±.01	1.87±.26
G2DL	48.87±.09	45.74±.10	19.56±.11	19.84±.09	7.32±.11	9.16±.12	69.16±.33	69.2±.00	1.78±.23	2.55±.21
G4DL	45.49±.06	42.56±.11	22.74±.08	23.65±.23	10.66±.02	12.72±.01	67.32±.19	66.45±.11	2.65±.00	3.45±.00
G2DD	48.44±.11	45.54±.09	20.32±.11	19.92±.12	7.30±.22	9.14±.11	69.10±.70	68.99±.20	1.67±.12	2.67±.01
G4DD	45.11±.05	42.44±.01	23.22±.03	23.44±.41	10.48±.19	12.76±.52	67.04±.14	66.18±.21	2.78±.00	3.52±.11

Each value is expressed as mean of triplicates ± standard deviations.

G0= ungerminated, G2DL= 2day germinated in light, G4DL= 4day germinated in light, G2DD= 2day germinated in dark, G4DD= 4day germinated in dark

*Carbohydrates was calculated by difference

parallel with the pattern of starch breakdown. Increase in α -amylase activity during germination (Uriyo, 2001) could be a possible explanation of the total starch loss and appreciable improvement in percent glucose released.

From the tabulated data, it could be noticed that all the sugar contents decreased on soaking for 6 and 12 h. Losses of sugars during soaking could be from simple diffusion of sugars after being solubilized. Soaking has been known to reduce the level of sugars in various pulses (Jood *et al.*, 1998) whereas, germination caused increase in the content of sugars for 2 and 4 day. The increase in sugar content of soaked seeds during germination may be because of mobilization and hydrolysis of seed polysaccharides, leading to more available sugars.

The increase in total and reducing sugar contents after germination is mostly from the hydrolyzed starch by amylases. Therefore, the higher concentration of sugars was observed in germinated seeds that soaked and germinated for the longer times.

Germination resulted in increased ascorbic acid contents in all studied seeds during the course of germination (as shown in Table, 2).

Germination of grains and seeds is known to increase the content of certain vitamins, such as ascorbic acid (Riddoch *et al.*, 1998). Khalil *et al.*, (2007) reported increase in ascorbic acid during chickpea germination, Yang *et al.*, (2001) also noted similar changes in the concentration of vitamin C in wheat seed with germination.

Germinated cereals and legumes might be a useful source of ascorbic acid in developing countries where fruits and vegetables rich in ascorbic acid are often unavailable and/or too expensive to be added to the diet (Egli, 2001). Also, Sangronis and Machado, (2007) reported that germinated seeds are good source of ascorbic acid, riboflavin, choline, thiamine, tocopheroles and pantothenic acid. Riddoch *et al.* (1998) reported that many species of pulses produced significant quantities of vitamin C up to five days following germination in both light and dark although cooking caused a marked loss of ascorbate.

Effect of soaking and germination on in vitro starch and protein digestibility and antinutritional of seed samples:

Germination increased the in vitro starch and protein digestibility of all the samples as compared to control samples (Table 3), which is supported by the findings of Negi *et al.*, (2001) and Archana *et al.*, (2001). Germination may mobilize starch, seed proteins are

metabolized and antimetabolites are catabolized, thereby resulting in improved digestibility of starch and protein of pulses. Sprouting causes mobilization of protein with the help of protease leading to the formation of peptides, oligopeptides and free amino acid (Jood *et al.* 1988).

Soaking could be one of the processes to remove soluble antinutritional factors, which can be eliminated with the discarded soaking solution (Akande and Fabiyi, 2010).

Table (3) presents the antinutritional factors of soaked and germinated some legume and cereal flours. Out of four legumes and two cereals analysed, control samples contained considerable amounts of phytic acid (0.38 – 0.783 g/100g). From the tabulated data, it clear that soaking for 12 hr in water reduced phytic acid content more than 6 hr. This could be due to the fact that phytic acid in dried legumes and cereals exists wholly as a water soluble salt (probably potassium phytate) (Crean and Haisman, 1963). Decrease in phytic acid content during germination could be due to increase in phytase activity as reported by several authors in faba bean (Eskin and Wiebe, 1983), broad bean, chickpea and lentil (Egli *et al.*, 2002) and several other legumes (Kyriakidis *et al.*, 1998).

Soaking and germination treatments at room temperature for different times affected the trypsin inhibitors of studied seeds. There were slightly differences among germination with or without light. However, some metabolic reactions can take place during soaking which will affect some of the constituent compounds (Vidal-Valverde *et al.*, 1992). Our results are in accordance with those of Vidal-Valverde *et al.*, (1994) who found that soaking of lentils in water for 9h at room temperature caused 11% reduction in trypsin inhibitors activity. Alaa *et al.*, (1982) reported that the inhibitory activity of broad bean, chickpea, black eyed pea, lentil and mung bean decreased in most seeds after soaking in water at room temperature for 24h. Similar results were obtained by Osman, (2007) and Sangronis and Machado, (2007). From the tabulated data, it could be noticed that soaked and germinated oats had the highest phytic acid content compared to other studied seeds. Fretzdorff (1992) noticed that the degradation of phytate during germination was significantly lower in oat than in other cereals.

Gupta and Sehgal (1991) observed that decrease in phytic acid contents of cereal grains used for preparing weaning foods as a result of soaking and germination. The decrease in the level of phytic acid during soaking may be attributed to leaching out into soaking water under the concentration gradient (Abdullah *et al.*, 1984).

Table 3. Effect of soaking period and germination conditions on antinutritional factors, in vitro starch and protein digestibility of some legumes and cereals flours

Samples	In vitro Starch digestibility %		In vitro protein digestibility %		Phytic acid (mg/100g)		Trypsin inhibitor (TIU/mg protein)	
	Soaking periods (h)							
	6	12	6	12	6	12	6	12
Peas								
Raw	54.82±1.2	-	81.66±.82	-	.488±.46	-	7.98±.12	-
G0	56.36±.90	51.61±.23	86.37±.35	86.78±1.3	.453±.31	.443±.26	7.33±.05	7.12±.16
G2DL	58.27±.46	49.43±1.11	88.31±.16	88.45±.82	.422±.18	.419±.41	6.84±.14	6.76±.10
G4DL	48.31±.43	45.28±.21	90.42±.27	92.33±.54	.414±.26	.400±.46	5.77±.07	5.22±.07
G2DD	50.22±.16	49.42±.17	88.52±.23	88.18±.13	.403±.09	.388±.35	6.68±.23	6.62±.13
G4DD	49.17±.27	45.16±.36s	89.27±.42	91.01±.42	.309±.36	.344±.51	5.73±.11	5.05±.42
Lentils								
Raw	38.66±.36	-	66.18±.60	-	.783±.16	-	29.18±.82	-
G0	36.41±.82	35.37±.42	68.13±.18	69.11±.22	.771±.22	.732±.81	27.33±.09	22.47±.30
G2DL	34.38±.42	33.24±.09	70.26±.21	72.24±.36	.723±.26	.706±.54	23.46±.15	20.16±.16
G4DL	30.35±1.3	29.33±1.31	74.33±.09	76.18±.19	.661±.07	.624±.08	19.34±.11	15.23±.23
G2DD	34.16±.90	33.16±.62	71.32±.31	73.66±.01	.711±.40	.698±.31	23.34±.44	20.21±.34
G4DD	31.03±.12	28.21±.42	74.16±.16	76.32±.33	.642±.36	.611±.25	19.07±.40	15.22±.11
Chickpea								
Raw	42.90±1.0	-	64.67±.16	-	.566±.42	-	18.45±.02	-
G0	38.78±.81	36.88±.24	73.38±.22	74.55±.35	.546±.31	.532±.36	16.21±.51	14.56±.18
G2DL	36.26±.92	34.19±.18	75.23±.18	76.43±.16	.522±.26	.518±.71	14.09±.01	13.66±.09
G4DL	33.45±.24	32.47±.61	78.17±.09	79.78±.30	.482±.08	.467±.46	12.33±.33	12.28±.11
G2DD	36.18±.36	34.23±.52	75.29±1.3	77.35±.42	.526±.24	.509±.77	14.02±.37	13.49±.51
G4DD	34.02±.11	33.17±.09	78.26±.32	80.07±.53	.477±.36	.435±.44	12.18±.13	12.00±.01
Beans								
Raw	44.16±.42	-	62.85±.67	-	.479±.42	-	26.18±.01	-
G0	43.32±.36	42.45±.61	64.33±.46	64.89±.34	.360±.33	.346±.05	24.36±.32	23.11±.08
G2DL	42.51±1.2	41.33±.36	66.26±.34	68.45±.21	.315±.21	.324±.12	22.36±.20	20.31±.31
G4DL	35.24±.07	34.17±.42	69.43±.52	70.55±.32	.309±.09	.311±.06	20.26±.11	18.78±.23
G2DD	42.16±.46	40.62±.05	66.52±.16	69.32±.11	.301±.11	.302±.12	22.43±.03	20.52±.02
G4DD	36.72±.23	32.57±.16	68.37±.08	73.22±.26	.304±.05	.284±.03	20.12±.00	18.72±.14
Oats								
Raw	34.55±.02	-	65.16±.15	-	2.38±.71	-	.513±.09	-
G0	36.19±1.1	37.34±.33	67.44±.20	68.42±.00	1.58±.45	1.28±.1.0	.453±.01	.412±.21
G2DL	38.34±.22	39.12±.05	70.43±.11	72.23±.23	.86±.09	.76±.17	.383±.13	.322±.11
G4DL	45.16±.07	48.44±.24	75.27±.42	77.42±.07	.28±.11	.23±.07	.216±.11	.201±.09
G2DD	38.54±.15	39.04±.12	70.41±.22	72.41±.21	.80±.03	.75±.11	.340±.06	.321±.00
G4DD	45.18±.03	49.02±.09	75.24±.11	77.33±.31	.27±.23	.21±.08	.280±.33	.198±.21
Wheat								
Raw	32.78±.11	-	63.18±.23	-	.597±1.0	-	.980±.19	-
G0	35.71±.23	36.54±.04	64.39±.12	65.16±.11	.422±.92	.378±.12	.707±.03	.667±.52
G2DL	37.43±.07	38.87±.11	65.88±.09	67.33±.43	.412±.23	.345±.33	.645±.12	.583±.33
G4DL	42.77±.20	44.77±.08	68.34±.11	70.23±.07	.388±.12	.312±.06	.487±.09	.388±.07
G2DD	37.39±.11	38.66±.32	65.76±.07	67.30±.23	.377±.22	.287±.12	.632±.11	.578±.11
G4DD	42.65±.17	44.65±.09	68.12±.00	70.21±.12	.278±.39	.3.05±.03	.499±.08	.391±.13

Each value is expressed as mean of triplicates ± standard deviations.

G0= ungerminated, G2DL= 2day germinated in light, G4DL= 4day germinated in light, G2DD= 2day germinated in dark, G4DD= 4day germinated in dark

Table 4. Effect of soaking period and germination conditions on macro-elements (ppm) of selected legumes and cereals

Samples	(Ca)		(K)		(Mg)		(Na)	
	Soaking periods (h)							
	6	12	6	12	6	12	6	12
Peas								
Raw	690.0	-	687.40	-	115.43	-	200.34	-
G0	4880.0	4890.0	1048.0	1052.0	142.90	172.61	430.67	446.78
G2DL	1410.0	1403.0	400.0	388.0	135.62	157.33	140.33	135.66
G4DL	1490.0	1377.0	300.0	295.11	130.33	160.32	80.23	100.96
G2DD	1412.0	1398.0	400.0	364.09	135.45	158.11	140.00	136.77
G4DD	1478.0	1378.0	300.0	296.42	129.87	160.22	140.00	102.34
Lentils								
Raw	77.0	-	873.0	-	13.31	-	140.78	-
G0	163.88	161.92	600.22	562.09	39.60	45.67	115.44	100.23
G2DL	161.72	160.34	553.23	523.11	20.55	45.89	100.23	95.46
G4DL	155.0	153.10	508.12	449.13	16.12	30.34	93.45	90.78
G2DD	161.0	157.5	516.71	522.43	34.77	42.99	100.28	93.33
G4DD	154.0	150.3	500.89	428.65	33.89	25.88	91.79	91.27
Chickpea								
Raw	34.40	-	1127.22	-	130.67	-	360.33	-
G0	189.0	1880.0	518.98	1061.11	160.34	170.11	140.89	138.67
G2DL	133.2	196.0	505.23	980.78	150.33	160.32	290.45	270.44
G4DL	140.8	177.0	400.99	700.89	140.78	150.33	200.79	200.66
G2DD	110.6	195.0	400.67	840.55	150.12	166.12	140.45	126.76
G4DD	140.2	176.0	300.88	680.98	140.66	146.27	140.99	130.34
Beans								
Raw	40.27	-	500.76	-	125.44	-	140.34	-
G0	136.88	134.15	1377.12	1487.23	100.12	95.82	200.00	140.33
G2DL	141.75	139.54	1365.45	1409.78	98.33	92.74	290.12	200.23
G4DL	143.36	142.71	1370.09	1403.11	85.16	80.42	290.89	275.67
G2DD	141.63	139.43	1366.45	1400.89	93.45	92.56	200.41	290.12
G4DD	143.21	141.88	1372.78	1402.33	85.01	78.57	200.67	230.22
Oats								
Raw	68.50	-	400.43	-	128.22	-	140.22	-
G0	2110.0	1170.0	480.77	457.34	185.23	180.67	290.34	280.23
G2DL	121.80	120.60	300.00	280.23	180.76	175.66	140.34	130.78
G4DL	129.90	125.11	200.00	250.26	170.88	160.56	140.67	125.44
G2DD	116.30	115.00	400.00	400.00	176.56	172.98	200.23	140.73
G4DD	125.00	121.70	200.00	200.00	165.89	155.78	140.34	130.87
Wheat								
Raw	7.10	-	448.23	-	13.89	-	140.00	-
G0	1860.0	1190.0	450.12	455.22	289.23	284.34	150.12	160.34
G2DL	110.90	160.50	200.98	400.78	25.56	10.89	100.56	95.56
G4DL	112.30	144.00	100.23	279.55	30.35	12.45	80.45	76.99
G2DD	118.90	157.00	300.45	400.00	28.33	11.98	100.98	96.55
G4DD	138.00	143.70	100.34	280.12	31.63	14.67	80.23	77.58

Each value is expressed as mean of triplicates \pm standard deviations.

G0= ungerminated, G2DL= 2day germinated in light, G4DL= 4day germinated in light, G2DD= 2day germinated in dark , G4DD= 4day germinated in dark

Table 5. Effect of soaking period and germination conditions on micro-elements (ppm) of selected legumes and cereals

Samples	(Fe)		(Zn)		(Mn)	
	Soaking periods (h)					
Lentils						
Raw	8.63	-	4.46	-	1.69	-
G0	6.74	5.34	3.36	3.22	1.23	1.44
G2DL	8.88	7.89	4.33	4.12	1.53	1.73
G4DL	10.87	11.34	6.55	5.88	1.81	2.11
G2DD	8.78	7.66	4.31	4.32	1.55	1.68
G4DD	10.65	11.43	6.46	5.75	2.06	2.13
Chickpea						
Raw	5.45	-	4.41	-	3.95	-
G0	4.67	4.33	3.88	3.27	3.24	3.11
G2DL	5.88	6.22	4.47	4.97	3.85	4.32
G4DL	7.67	8.56	6.11	7.12	4.44	6.52
G2DD	5.67	6.12	4.33	4.87	3.82	4.22
G4DD	7.54	8.33	6.03	7.34	4.29	5.98
Beans						
Raw	10.55	-	2.625	-	1.479	-
G0	9.06	8.78	2.432	2.512	1.425	1.233
G2DL	11.23	10.77	2.750	2.978	1.559	1.457
G4DL	13.54	12.89	3.234	3.664	2.354	1.987
G2DD	11.61	10.65	2.674	3.012	1.522	1.522
G4DD	13.33	12.57	3.312	3.965	2.277	2.010
Oats						
Raw	4.73	4.09	3.645	-	4.454	-
G0	3.22	2.89	3.022	2.898	4.211	4.104
G2DL	5.66	4.99	3.586	3.885	4.887	4.644
G4DL	7.23	7.11	5.223	5.264	6.642	5.887
G2DD	5.56	5.12	3.522	3.921	4.769	4.567
G4DD	7.11	7.03	5.211	5.370	6.445	5.875
Wheat						
Raw	0.58	-	0.324	-	4.055	-
G0	0.33	0.31	0.142	0.132	3.876	3.117
G2DL	1.56	1.22	0.288	0.189	4.121	3.889
G4DL	2.27	3.29	0.443	0.387	4.987	4.874
G2DD	1.67	1.24	0.341	0.211	4.119	4.237
G4DD	2.33	3.18	0.430	0.367	5.012	4.883

Each value is expressed as mean of triplicates \pm standard deviations.

G0= ungerminated, G2DL= 2day germinated in light, G4DL= 4day germinated in light, G2DD= 2day germinated in dark, G4DD= 4day germinated in dark

Agte and Sandhana (1997) reported that soaking of wheat batter is beneficial because it reduces phytic acid by 40%.

Effect of soaking and germination on mineral contents of some legumes and cereals :

Macro- elements:

Minerals play a vital role in the maintenance of human health. Cereals and legumes are rich in minerals but the bioavailability of these minerals is usually low

due to the presence of antinutritional factors such as phytate, trypsin inhibitor and polyphenoles (Nadeem *et al.*, 2010).

Table (4) shows the macro- elements composition (ppm) such as calcium (Ca), potassium (K), magnesium (Mg) and sodium (Na) of ungerminated, soaked and germinated some legumes and cereal seeds in presence that light or dark (with or without light). Data in this Table indicate soaking process (at 6 and 12 h) increased macro element, this may be due to that soaking

improved the availability of all the minerals. These results disagree with those reported by Marton *et al.*, (2010) who reported that soaking prior to the germination is responsible for the loss of Mg and Zn that continuously emptying from the seed during the sprouting. From the tabulated data, it could be noticed that germination had varied effects on the mineral composition. On the other hand, prolonging germination to 4 day cause more decrease as compared with 2 day or soaked samples. In comparison, the mineral composition of soaked and germinated legume and cereal samples was higher in calcium than raw samples. It was observed in this study that germination process technique improved the mineral composition of the selected samples than that of raw legumes and cereals samples. This observation could be attributed to biosynthesis and activities of enzymes during germination process (Gabriel and Akharaiyi, 2007; Bau *et al.*, 1997).

This finding indicates that the selected legume and cereal samples would serve as good sources calcium which are considered essential for bone and teeth formation and development in children. A decrease found in potassium, magnesium and sodium contents on germination comparing with raw and soaked samples (Table 4), is well documented by other authors (Enujiugha *et al.*, 2003). This is easily observable in the lower ash contents obtained in the germinated samples. Soaking process (at 6 or 12h) on the seeds was found to cause increase changes in minerals contents of studied legumes and cereals. Presence or absence light had slightly effect or no effect on changes in minerals contents.

Absence or presence of light did not affect in the four days old pea sprouts the Zn and Mg content during the sprouting, at the same time sprouting for two and four days improved the biological availability of Zn Mg (Urbano *et al.*, 2006).

Micro-elements :

El-Adawy *et al.*, (2003) reported significant increase in ash content during sprouting in mungbean, pea and lentil seed. The decrease in crude fat and carbohydrate contents during sprouting may have led to the apparent increase observed in ash and other chemical components.

There are wide applications of germinated food products besides as ingredient in normal food preparation. Some of the identified uses of germinated legumes and cereals include flour (Giami, 2004; Charoenthaikij *et al.*, 2010), beverage (Tonella and Berry, 1987) and weaning food (Marero *et al.*, 1988). Bread made using germinated products has increased nutritive value (Charoenthaikij *et al.*, 2009) compared to control bread without germination. Tonella and Berry (1987) also found that

chocolate beverage made from germinated chickpeas, sugar, cocoa, salt, vegetable oil and water showed reduced viscosity and improved consistency when compared with control formulated using nongerminated chickpeas (Megat Rusydi *et al.*, 2011).

CONCLUSIONS

As shown in this study, soaking (for 6 and 12 hr) and germination at 2 and 4 day affected the chemical composition, antinutritional factors and nutritional quality of selected legume and cereal seeds. However, soaking processes caused smaller losses in minerals. All processes improved the in vitro starch and protein digestibility of seeds. Therefore, soaking and germination are recommended for legume and cereal seeds preparation in households and restaurants for improving the nutritional quality. Therefore, the use of processed legume and cereal flours can be exploited in functional and nutritional foods as well as a therapeutic agent in various bakery products. Since germination is cheap and more effective in improving nutritional value, it is hoped that this can contribute to nutrition of people.

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الملخص العربي

تأثير عمليات النقع والانبات على التركيب الكيماوى، مكونات الكربوهيدرات، المواد المضادة للتغذية، الهضمية ومحتوى المعادن لبعض بذور البقوليات والحبوب

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الكربوهيدرات والدهن. يؤدي النقع والانبات لزيادة الهضمية العملية لكل من النشا والبروتين وإنخفاض محتويات كل من حمض الفيتيك ومثبطات التربسين، والإنخفاض في حمض الفيتيك ومثبطات التربسين يكون بسبب التغيرات الإنزيمية خلال فترة النقع والانبات. وتشير النتائج عدم وجود تأثير (أو تأثير طفيف) للضوء خلال عملية الانبات على المكونات المختلفة. ويمكن أستنتاج أن عمليات النقع والانبات تحسم من الحالة الغذائية للبقوليات والحبوب موضع الدراسة من حيث ارتفاع تركيز المغذيات وخفض حمض الفيتيك ومثبطات التربسين وتحسين البروتين وحمض الأسكوربيك. يمكن إدخال الحبوب والبقول المنبتة في الأغذية التي تعتمد في تصنيعها على القمح مثل الخبز والمكرونات لرفع قيمتها الغذائية.

تؤدي عمليات النقع والانبات لبذور البقوليات والحبوب إلى بعض التغيرات في الخصائص الكيموحيوية والغذائية للبقوليات والتي لها فوائد على صحة الإنسان، وكذلك الحالة الغذائية. في هذه الدراسة تم تقييم عمليات النقع لمدة 6، 12 ساعة الانبات لمدة 2، 4 يوم بدون أو في وجود الضوء(الظلام) على التركيب الكيماوى- مكونات الكربوهيدرات(النشا- السكريات الكلية- السكريات المختزلة- الكربوهيدرات الكلية بالفرق)، وعلى هضمية كل من النشا والبروتين، وكذلك دراسة العوامل المضادة للتغذية ومحتويات المعادن(الكبرى والصغرى) لبعض البقوليات (البسلة- العدس- الحمص- الفول البلدى) والحبوب (الشوفان-القمح). أوضحت النتائج حدوث زيادة في محتويات الرطوبة والبروتين في العينات المنبتة في حين انخفضت محتويات