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OPTIMIZATION OF PROCESSING TECHNIQUES FOR PRODUCTION OF OAT AND BARLEY MILKS

Salama, Fatma M. M.[*] ; M. A. Azzam[*] ; M. A. Abdl-Rahman[**] ; M. M. Abo-El Naga[***] and M.S. Abdl-Hameed[*]

[*] Dairy Sci. Dept., Fac. Agric. Cairo Univ., Giza, Egypt.

[**] Physiology Dept., Fac. Vet. Med., Cairo Univ., Giza, Egypt.

[***] Food Tech. Res. Institute, Agric. ReS. Center, Giza, Egypt.

ABSTRACT

Three trials have been carried out to prepare oat and barley milks with acceptable organoleptic properties and are free of unhealthy and harmful substances. These trails were (A) boiling of intact oat and barley grains after soaking but before disruption, (B) wet toasting of soaked grains before disruption, (C) disruption of soaked grains without heating. Effect of processing conditions (soaking, soaking + heating and soaking + toasting) and the ratio of grains to extracting medium on phytic acid content, % milk and % recovery of solids and protein in the resultant milk was studied. Some chemical and physical properties of the resultant milks were compared with that of cow milk (control). The results showed that process B has low yield of oat milk but higher recoveries of solids and protein in comparison with processes A and C whereas; process A was preferable to produce barley milk. Using sweet whey as an extracting medium instead of tap water caused an increase in total solids and protein contents and improved of organoleptic properties of resultant milks. About 13% on average of phytic acid was lost during the soaking of oat and barley grains. This reduction was increased to 16.56% after toasting of soaked oat grains while reached 21.73% after heating of soaked barley grains. Chemical analysis of oat, barley and cow milks showed that cow milk had higher fat and Ca contents than both oat and barley milks while, oat and barley milks contain more carbohydrates, phosphorus, potassium, iron and Zinc than dose cow milk. Cow milk and oat milk contain nearly identical amounts of protein and fiber is a big plus, dairy has none. With respect to the amino acid composition, isoleucine, methionine, threonine and tyrosin occurred at slightly lower levels in proteins of oat and barley milks than those of the FAO/WHO reference protein. Cow milk protein had slightly higher essential amino acids content than those in proteins of oat and barley milks. Both oat milk and barley milk exhibited higher viscosity and lower heat stability than those of cow milk whereas, titrable acidity and specific gravity values of these milks were approached those of cow milk.. Consequently, oat milk or barley milk can be a healthy choice for many peoples especially who are allergic to milk protein.

Keywords—soaking, heating, phytic, oat milk, barley milk, cow milk, comparison**.**

INTRODUCTION

Cereal foods such as vegetarian milks, their remoteness circulated in the last two decades because of abundant their health benefits such as reduction of plasma cholesterol and postprandial glycaemic response, which decrease the risk of cancer, heart disease, hypertension and obesity in the long term. These milks have no cholesterol or casein, therefore can be used as alternatives to cattle milks ,especially, for some individuals who are allergic to milk protein, and when milk may be either too expensive or unavailable.

Although, these milks contain useful human nutrients such as well-balanced protein, soluble fiber, carbohydrate, oil and several vitamins and minerals (Peterson 1992 and Welch 1995), but some of these nutrients will not be available because of presence of anti-nutritional factors in the origin material employed. Therefore, it becomes necessary to define appropriate conditions of minimizing anti-nutritional factors and of maximizing protein extraction during processing and/or preparation of these products.

A study of the literature on preparation of cereal or vegetarian milks showed that there are many variables in the processing of these milks influence on recovery of protein and on elimination of anti-nutritional factors such as phytate, which is known to reduce the bioavailability of major minerals such as Ca and P and trace ones such as Zn, Fe, Cu and Mn (Hallberg *et al*., 1989 and Hurrell *et al*., 2000). Therefore, decreasing of phytic acid is very advantageous. Milling, soaking, germination and fermentation are important traditional methods used to reduce phytic acid and could thus improve bioavailability of minerals in cereal and legume products as reported by Gibson *et al*., (2000). Liang,*et al*., 2007 found that milling of cereal grains leads to considerable losses of phytic acid (minerals inhibitor).Soaking of millet, soya bean, maize, sorghum, and mungbean at 30ºC for 24 h decreased the contents of phytic acid by 4–51% (Lestienne, *et al*., 2005a,b,c), whereas soaking of pounded maize for 1 h at room temperature already led to a reduction of phytic acid by 51% (Hotz, *et al*., 2001).Larsson and Sandberg (1995) found that soaking of oat whole grains, dried at 80ºC and stored at 4ºC, overnight at room temperature, followed by 6 h at 37.8ºC reduced the phytate content by 79%.Germination of sorghum for 4 d reduced phytic acid by 68–87% (Mahgoub and Elhag, 1998). Badau, *et al*., (2005) reported that with longer germination times, HCl-extractability of calcium, iron and zinc in pearl millet was increased by 2–16%, 15–45% and 12–25%, respectively. Egounly and Aworh (2003) reported that fermentation with *Rhizopus oligosporus* enhanced the nutritional value of some grain legumes by causing significant changes in chemical composition and reduction of phytic acid by 30.7, 32.6 and 29.1% respectively in soybean, cowpea, and groundbean at the harvesting time.

Also, the heating is one of the most interesting variables in the processing of cereal milks because of its influence on recovery of protein and anti-nutrient constituents. Lindahl, *et al*., (1997) have made use of a process in which oat grains were toasted by steam before disruption. Such a process has the dual advantage of maximizing protein extraction. Phillippy *et al*., (1987) reported 81% reduction of phytic acid in autoclaved sodium phytate at pH 4.0. Servi *et al*., (2008) reported that autoclaving for 2 h at the pH levels of 5.0, 4.5, 4.0 and 3.5 resulted in 89.4, 95.6, 96.8 and 96.6% reduction, respectively, in the phytic acid contents of the wheat bran.

The present study was carried out to evaluate the effect of three processes (boiling of soaked grains in tap water for 30 min., wet toasting of soaked grains for 15 min. and soaking without heating) on phytic acid content of grains, yields of oat and barley milks and their content of solids and protein. Some chemical and physical properties of oat and barley milks were also evaluated and compared with those of cow milk.

MATERIALS AND METHODS

Oat (Avena sativa) and barley (Hordeum vulgare) grains were purchased at stores of the experimental farm of Agriculture Research Center, Giza, Egypt and stored at 4ºC to minimize changes in composition. Fresh cows' milk was obtained from the herd of Faculty of Agriculture Cairo University.

Three different processes for the preparation of oat and barley milks were investigated and outlined in Table 1. Process A is unique in heating the grains at 100ºC for 30 min before grinding; process B is unique in toasting the grains by steam for 15 min before grinding, and process C is unique in applying no heat to the grains. The soaking was done in tap water 3x the weight of the grains. After soaking and after blanching, the grains were rinsed twice and drained. The grinding was done (Blender mill, Moulinex®, France) in tap water at differed ratios of grains to water.

Water adsorption by grains was measured by suspending a 50g sample in excess water at 20 - 25±1ºC. The grains were contained in a bag made from a single layer of cheesecloth, and excessive surface moisture was removed before weighing.

As a way of evaluating the three processes for their effect on the recovery of grain solids and constituents of the solids in the resultant milks, several analyses were made on a weight basis. Using the analytical data and the following equations as reported by Ali *et al.* (1992), we were able to compare yields for the different processes:

% oat or barley milk =
wt of oat or barley milk (after clarification) / wt of oat or barley slurry (before clarification)

% solids or protein in oat or barley milk =
wt of solids or protein in oat or barley milk / wt of oat or barley milk

% solids or protein in oat or barley slurry =
wt of solids or protein in oat or barley slurry / wt of oat or barley slurry

% yield of solids or protein =
wt of solids or protein in oat or barley milk / wt of solids or protein in slurry that yielded the oat or barley milk

Whole un-deformed oat and barley grains were selected and milled (Standard electric grinder, Moulinex®, France) prior to analysis. The chemical analysis of the milled grains for dry matter according to Egli *et al*. 2002 while, lipids, total fiber and ash were performed using standard methods outlined in AOAC (2000). The nitrogen content in samples was determined by kjeldahl's method as described in AOAC (2000), and a conversion factor of 5.83 was used for calculating the protein content. Total carbohydrates were determined colorimetrically according to Duboies *et al*. (1956).The minerals (Ca, K, Fe and Zn) were analyzed using an inductively coupled plasma optical emission

spectrometer, (ICP-AES) Varian- Vista- MPX, (Varian, Inc.) according to Horwitz (2000). Total phosphorus content was estimated using colorimetrically method as described by Okalebo *et al.* (2002). Phytic acid in pulverized grains was determined according to Wheeler and Ferrel (1971). All determinations were expressed on a dry matter basis.

Table (1): Outline of processes used in the preparation of oat and barley milks

Process A	Process B	Process C
Soak grains in tap water for 18 hr	Soak grains in tap water for 18 hr	Soak grains in tap water for 18 hr
Drain	Drain	Drain
Rinse twice with tap water	Rinse twice with tap water	Rinse twice with tap water
Blanch 30 min at 100ºC in tap water	Preheat grains 15 min. by steam	
Grind with tap water at 20 - 25ºC	Grind with tap water at 20 - 25ºC	Grind with tap water at 20 - 25ºC
Filter slurries through cheese cloth	Filter slurries through cheese cloth	Filter slurries through cheese cloth
Heat the resultant milks at 72ºC/1min., then cool	Heat the resultant milks at 72ºC/1min., then cool	Heat the resultant milks at 72ºC/1min., then cool

The procedure was done in triplicate for each process.

Total solids, ash, fat, fiber and protein for Oat and barley milks and cow milk were determined as described in AOAC (2000). Total carbohydrate content was calculated by difference according to Pearson (1976). The minerals were determined according to Horwitz (2000), while, total phosphorus content was estimated according to Okalebo *et al.* (2002).

The amino acid composition was determined according to the method described by Block *et al.* (1958) using Automatic amino acid analyzer (Model AAA 400 INGOS Ltd.). Tryptophan was lost during hydrolysis, therefore, tryptophan values are not reported. The essential amino acid contents of oat, barley, and cow milks protein were compared with the FAO/WHO (1993) reference protein.

Titratable acidity and specific gravity of oat, barley, and cow milks were determined as described in AOAC (2000), whereas , heat stability was determined according to Basheer (2011). Viscosity was measured using a Brookefield viscometer (Brookefield Engineering Laboratories Inc., Middleboro, Mass., U.S.A.) and expressed in centipoise (cP). Measurements were made for 30 s at 200 rpm and at 21± 2°C.

Statistical analysis for the obtained data was carried out using 2 × 3 factorial design. Duncan's test was used to make the multiple comparisons, (Steel *et al.* 1996). Significant differences were determined at $P < 0.05$.

RESULTS AND DISCUSSION

Three factors have contributed in preparing the oat and barley milks under this investigation were studied. These factors included the chemical composition of grains, processing conditions, and extracting medium. Some chemical and physical properties of the resultant milks were evaluated as compared to those of cow milk.

The chemical composition of the used oat and barley grains are illustrated in Table (2).Significantly higher contents of crude fiber and total lipids, and lower contents of carbohydrates were determined in oat grains .While, no significant difference were found between oat and barley grains in the dry matter, crude protein, ash and phytic acid.

As for minerals composition,, the whole grains usually contain high levels of minerals. This is due to the presence of the outer kernel layers where minerals are concentrated as reported by Ragaee *et al.* (2006). Barley grains had the highest levels of calcium, phosphorus, iron and zinc, and followed by oat in potassium content (Table 2).

All values reported in Table (2) are within the ranges indicated in theliterature by Hidvegi and Lasztity (2002);Grausgruber *et al*. (2004); Ragaee *et al*. (2006) and But *et al*. (2008).

The relation between soaking period and water absorption by raw grains of oat and barley is shown in Fig. 1. Two water absorption curves of the two kinds have a similar pattern. Barley grains absorbed 75% of their weight in water after14 hr and reached a peak at 18 hr, while a maximum rate of water uptake by oat grains was 65% only after approximately 18 hr of soaking period.

The moisture content in both barley and oat grains increased rapidly during the initial stages of hydration then decelerated. This effect was also observed during water soaking of soybean (Deshpande *et al.*, 1994); amaranth grains (Calzetta Resio *et al.* 2003) and rice grain (Bello *et al.* 2004), and is attributed to capillary of the outermost layers of the pericarp that would accelerate the water uptake, moreover, the water sorbed in the void space between hull and the kernel of grain.

Table 2: Chemical composition (%)[1] of oat and barley grains.

Component	Oat	Barley
Dry matter	91.98[a]	91.76[a]
Crude protein (*N* × 5.83)	10.72[a]	10.80[a]
Lipids	3.86[a]	2.34[b]
Crude fiber	18.45[a]	4.02[b]
Carbohydrates	63.17[b]	79.30[a]
Ash	2.74[a]	2.69[a]
Phytic acid (mg/100g)	960[a]	948[a]
Calcium (mg/100g)	58.49[b]	74.67[a]
Phosphorus (mg/100g)	360.11[b]	490[a]
Potassium (mg/100g)	562.98[a]	492.14[b]
Iron (mg/100g)	3.34[b]	9.14[a]
Zinc (mg/100g)	3.29[a]	6.41[b]

[1] **Dry matter basis**

Superscripts a,b: the same letters in the row means that the results are not significantly different ($p < 0.05$).

Soaking the grains for 18 h reduced the phytic acid content by 12.50% in oat and by 13.92% in barley (Table 3).Similar results have been reported earlier in rice, pounded maize, millet, soybean, cowpea, kidney bean, and pea (Hotz *et al*., 2001; Egli *et al*., 2002; Lestienne *et al*., 2005d; and Khattab and Arntfield, 2009), and with a significant reduction of 12 – 71%, compared to its raw cereals. This could be due to the fact that phytic

acid in dried grains exists wholly as a water-soluble salt (probably potassium phytate) (Crean and Haisman, 1963). Other studies have proposed that the activity of endogenous phytase was the main factor leading to a reduction of phytic acid during soaking (Lestienne *et al*., 2005a and Lestienne *et al*., 2005b).

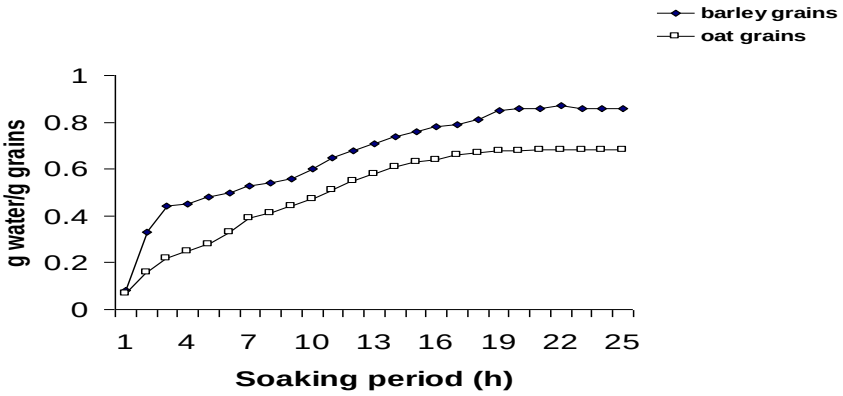

Fig (1): water absorption of oat and barley grains during soaking in tap water at 25 ± 1°C.

Of course, with sizable quantities of grains, some will be hard shells and not fully hydration. Therefore, utility of blanching grains before disruption may to be softer and thus easier to disrupt, moreover, increase the porosity of cellular membranes; hence, the water absorption rate is increased. This is supported by the earlier finding of Akinyele (1989) and Saikia *et al*., (1999), who reported also that heat –denaturation of grain protein increased the water-imbibing capacity.

Table (3): Effect of processing conditions on phytic acid content of oat and barley (mg/100g dry matter basis)[*]

Treatment	Oat	Barley
Raw grains	960[a]	948[a]
Soaking	840[b] (- 12.50)[**]	816[b] (- 13.92)
Soaking and blanching	762[d] (- 20.63)	742[d] (- 21.73)
Soaking and toasting	801[c] (- 16.56)	775[c] (- 18.25)
LSD value at 0.05	16.71	10.02

[*] **Mean value of three replicates.**
[**] **Values in parentheses indicate the percentage reduction.**
Superscripts a,b: the same letters in the column means that the results are not significantly different (p < 0.05).

Results given in Tables (4&5) indicated that the percentage of oat and barley milks was the highest when blanching grains (process A) but was the lowest in toasting treatment (process B). However, the percentage of oat and barley solids in resultant milk was greatest for toasting treatment (process B) and un-heating treatment (process C), respectively, and least for blanching treatment (process A). This is due to that the increase in moisture content of blanched grains was high and had a dilution effect on all solids.While,

toasting process lead to retract of shell and loss of a little of absorbed water. Similar findings of decrease in nutrient contents with blanching were reported by many workers in lentils and rice (Shakib *et al*., 1985 for crude fiber); chick pea and black gram (Jood *et al*., 1988 for starch); rice bean (Saikia *et al*., 1999 for crude protein); soybean, cowpea, and groundbean (Egounlety and Aworh, 2003 for carbohydrates) and taro (Lewu *et al*., 2010 for minerals).

With regard to recovered solids in the resultant milk, data in Tables (4&5) show different effects on both blanching and toasting procedures on recovered solids and proteins from the grains. Blanching procedure (process A) gave the highest recovered total solids (68.61%) and protein (75.77%) in obtained barley milk after grinding grains, especially, at the ratio of grains to water 1:3 (Table 5). Toasting procedure (process B) was the best for recovery of the total solids and protein from oat grains at the ratio 1:3 (65.94% and 79.44%, respectively). This means that process A is poor process for recovery of oat protein, even though it is a good process for yield (80.16% vs.76.07%,Table 4).The plausible reason for poor recovery of oat protein in process A is denaturation of protein while, in process B, loss of a little of absorbed water (and consequent increase of solids) during the toasting procedure lead to increment protein recovered in oat milk indicating that the content of protein in the resultant milk at ratio 1 toasted grains : 3 water was the highest (1.56%) compared with those for other two processes at the same ratio (Table 4).

Table(4): Effect of processing conditions and the ratio of oat grains to water during grinding upon the yield, solids and protein contents of oat milk.

Proce.	Ratio by wet oat:water	% Oat milk*	% Solids of oat milk	% recovery of solids+	% Protein** of oat milk	% recovery of protein+
A	**1 : 1**	54.43^{f}	16.49^{c}	42.59^{hi}	1.99^{c}	50.43^{de}
	1 : 3	80.16^{d}	8.07^{f}	62.62^{ab}	0.93^{ef}	71.68^{ab}
	1 : 5	85.05^{c}	4.52^{i}	54.89^{de}	0.57^{g}	68.43^{b}
	1 : 7	89.15^{b}	2.89^{k}	50.03^{efg}	0.36^{h}	61.51^{bc}
	1 : 9	91.25^{a}	2.11^{l}	46.57^{fgh}	0.18^{j}	39.14^{fg}
B	**1 : 1**	50.18^{g}	27.15^{a}	46.23^{gh}	3.20^{a}	53.78^{cd}
	1 : 3	76.07^{e}	12.77^{d}	65.94^{a}	1.56^{d}	79.44^{a}
	1 : 5	81.13^{d}	7.16^{g}	59.55^{bcd}	0.86^{f}	70.48^{ab}
	1 : 7	86.85^{bc}	4.83^{j}	57.25^{cd}	0.55^{g}	64.28^{b}
	1 : 9	87.60^{abc}	3.62^{j}	54.66^{de}	0.29^{hi}	43.15^{efg}
C	**1 : 1**	52.85^{fg}	22.10^{b}	41.87^{hi}	2.69^{b}	49.46^{de}
	1 : 3	77.39^{de}	10.96^{e}	60.44^{bc}	0.99^{e}	53.70^{cd}
	1 : 5	85.10^{c}	5.68^{h}	51.39^{ef}	0.52^{g}	46.25^{defg}
	1 : 7	87.54^{abc}	3.59^{j}	44.69^{hi}	0.33^{hi}	40.24^{efg}
	1 : 9	89.62^{ab}	2.57^{kl}	40.76^{i}	0.23^{ij}	35.97^{g}
LSD		3.85	0.473	5.034	0.101	10.38

*** % oat milk = wt of oat milk / wt of oat slurry**

+ % Recovery of solids or protein from crude oat grain = wt of solids or protein in oat milk / wt of solids or protein in slurry

**** Protein = N × 5.83**

Superscripts a,b,c….etc: the same letters in the column means that the results are not significantly different (p < 0.05).

The combined effect of soaking and blanching procedure (process A) resulted ingreater reduction in the level of phytic acid than soaking alone (20.63% vs. 12.50% and 21.73% vs. 13.92% in oat and barely, respectively), while, effect of toasting after soaking (process B) on the phytic acid content was lower than its previous like (Table 3). The observed reduction in phytic acid content of seeds during heat treatments may be partly due to the heat-labile nature of phytic acid and the formation of insoluble complexes between phytate and other components (Undensi *et al*., 2007).

Table (5): Effect of processing conditions and the ratio of barley grains to water during grinding upon the yield and solids and protein contents of barley

Proc.	Ratio by wet. barley : water	% Barley milk*	% Solids of barley milk	% recovery of solids+	% Protein** of barley milk	% recovery of protein+
A	1 : 1	61.31^{h}	14.91^{c}	49.56^{d}	1.74^{c}	52.95^{d}
	1 : 3	85.34^{b}	7.40^{e}	68.61^{a}	0.89^{f}	75.77^{a}
	1 : 5	90.93^{a}	4.23^{g}	63.23^{b}	0.53^{h}	72.69^{a}
	1 : 7	91.56^{a}	2.66^{i}	55.52^{c}	0.34^{i}	65.67^{b}
	1 : 9	93.02^{a}	1.89^{j}	49.27^{d}	0.19^{j}	45.35^{ef}
B	1 : 1	42.00^{j}	17.34^{b}	23.82^{j}	2.11^{b}	26.56^{i}
	1 : 3	69.10^{g}	9.69^{d}	44.17^{ef}	1.10^{d}	45.79^{ef}
	1 : 5	73.04^{f}	5.60^{f}	40.42^{gh}	0.63^{g}	41.63^{fg}
	1 : 7	77.05^{e}	3.81^{gh}	38.76^{h}	0.40^{i}	37.58^{g}
	1 : 9	80.42^{d}	2.60^{i}	34.27^{i}	0.26^{j}	31.48^{h}
C	1 : 1	53.91^{i}	19.85^{a}	41.79^{fgh}	2.59^{a}	49.99^{de}
	1 : 3	82.74^{c}	9.57^{d}	62.00^{b}	1.00^{e}	59.38^{c}
	1 : 5	85.21^{bc}	5.40^{f}	53.81^{c}	0.56^{gh}	51.14^{d}
	1 : 7	88.52^{ab}	3.35^{h}	46.09^{de}	0.41^{i}	51.31^{d}
	1 : 9	91.06^{a}	2.41^{i}	42.65^{efg}	0.23^{j}	37.28^{g}
LSD		4.656	0.501	3.687	0.078	4.751

*** % barley milk = wt of barley milk / wt of barley slurry**
+ % Recovery of solids or protein from crude barley grains = wt of solids or protein in oat milk / wt of solids or protein in slurry
**** Protein = N × 5.83**
Superscripts a,b,c,d,……etc : the same letters in the column means that the results are not significantly different (p < 0.05).

As shown in Table (6), using sweet whey as an extracting medium instead of tap water in processes A and B resulted in an increase in total solids and protein content and improved the organoleptic properties of the resultant milks. This improvement might be attributed to the lactose content of whey; hence the sweet whey masked the starchy flavor of resultant milks. Similar results were reported by Ali *et al*., (1992), who found that use the sweet whey in preparation of soymilk improved composition and acceptability of resultant milk.

Based on the statistical analyses for the previous data, we recognized that the processes A and B were preferable to produce barley and oat milks, respectively, especially, at the ratio 1 grains: 3 sweet whey as an extracting medium instead of tap water.

Table (6): Effect of extracting media as sweet whey on % solids, % protein and flavor of milk prepared from oat and barley grains.

Process	% Solids	% Protein	Criticism
Oat × whey*	15.08[a]	3.70[a]	More acceptable flavor
Oat × water	12.77[b]	1.56[c]	Slight starchy flavor
Barley × whey*	14.67[a]	2.95[b]	Acceptable flavor with slightly starchy flavor
Barley × water	7.40[c]	0.89[d]	Very starchy flavor
LSD at 0.05	0.54	0.14	

Superscripts a,b,c,d: the same letters in the column means that the results are not significantly different ($p < 0.05$).

*** Protein = N × [(1/4 × 5.83) + (3/4 ×6.38)] = N × 6.24**

Results obtained from chemical analysis of both oat milk and barley milk compared to cow milk (Table 7) showed that oat milk had higher total solids (15.08%), crude protein (3.7%), total carbohydrates (9.1%), phosphorus (160.11 mg%), potassium (240.2 mg%), iron (1.56 mg %), and zinc (1.23 mg%) but low fat (0.6%) and calcium (34.52 mg %) contents than cow milk. Barley milk had more total carbohydrates (9.91%), phosphorus (301.19 mg %), iron (2.31 mg %) and zinc (2.44 mg %) than cow milk and oat milk but the lowest in protein (2.9%) and fat (0.47%) contents. Oat milk had higher dietary fiber (1.14%) than that of barley milk (0.57%). All samples were similar in titrable acidity values (on average 0.14%).

Both oat milk and barley milk had higher viscosity (2.03 and 1.83 centipoise, cP respectively) than that of cow milk (1.71 cP) (Table 7). This could be attributed to nature of their proteins and their content of starch. Whereas, specific gravity values of these milks were approached those of cow milk. With respect to the heat stability, cow milk exhibited higher heat stability (15.43 min. at 140°C) than both oat milk (2.53 min.) and barley milk (2.46 min.) (Table 7). This may be due to protein denaturation and salt balance defect in the resultant milks as a result of high heat treatment of grains during preparation of these milks (Ali *et al*., 1992).

The amino acid composition of oat, barley and cow milks is presented in Table (8). All the essential amino acids occurred at higher levels in cow milk than those of the FAO/WHO reference protein (FAO, 1993), while, isoleucine, methionine, threonine and tyrosin occurred at lower levels in both oat milk and barley milk than those of the FAO/WHO reference protein (FAO, 1993).

Cow milk protein had higher essential amino acids content (39.06%) than both oat milk protein (34.29%) and barley milk protein (32.41%) (Table 8).

Glutamic acid was the most predominant amino acid followed by proline, aspartic and leucine. The values of amino acids showed that cystine and methionine were in the lowest levels in the three milks, the first in cow milk (0.51%) and the latest in oat and barley milks (1.37 and 1.90%, respectively).

These results were paralleled with those reported by Pomeranz *et al*., (1973) and Fan and Sauer (1995) who found that amino acids presented in a

greater amount in oat and barley proteins were glutamic, proline and aspartic. Different investigations indicated that amino acid composition of oat barley grains depends on varieties of these grains (Morey and Evans, 1983).

Table (7): Chemical and physical properties of oat and barley milks

Property	Oat milk	Barley milk	Cow milk
Total solids (%)	15.08	14.67	12.48
Protein (%)	3.70*	2.90*	3.10**
Fat (%)	0.69	0.47	3.80
Ash (%)	0.49	0.82	0.78
Fiber (%)	1.14	0.57	0.00
Carbohydrate (%)	9.10	9.91	4.80
Calcium (mg %)	34.52	47.50	117.24
Phosphorus (mg %)	160.11	301.19	94.50
Potassium (mg %)	240.20	182.88	135.56
Iron (mg %)	1.56	2.31	0.03
Zinc (mg %)	1.23	2.44	0.35
Titrable acidity (%)	0.14	0.14	0.15
Viscosity (cP)	2.03	1.83	1.71
Specific gravity	1.022	1.020	1.029
Heat stability (min.)	15.43	2.53	2.46

*** protein = N × 6.24 ** protein = N × 6.38**

Table (8): Amino acid composition of oat, barley and cow milks compared with FAO/WHO reference protein (g amino acid per 100 g protein).

Amino acids	Oat milk	Barley milk	Cow milk	FAO/WHO ref. protein
Leucine	7.13	6.78	7.83	4.8
Isoleucine	3.66	3.50	4.70	4.2
Methionine	1.37	1.90	2.30	2.2
Phenylalanine	4.95	5.30	4.74	2.8
Lysine	4.50	4.31	4.88	4.2
Threonine	3.45	3.25	4.50	4.0
Tyrosine	3.70	1.67	4.58	4.1
Valine	5.53	4.45	5.78	4.2
Tryptophan	ND	ND	ND	
Total essential A.A	34.29	31.16	39.31	
Aspartic	8.71	6.91	7.65	
Glutamic	20.91	26.36	20.11	
Serine	4.81	4.10	3.45	
Proline	6.53	11.74	10.60	
Glycine	4.59	3.89	1.24	
Alanine	5.15	4.11	3.34	
Histidine	2.56	2.45	1.73	
Arginine	5.93	4.11	1.97	
Cystine	2.42	2.21	0.51	
Total non-essential A.A	61.61	65.88	50.60	

ND, not determined

Conclusions

This study indicated that soaking + heat treatments of oat and barley grains significantly reduced phytic acid and increased yields of solids and recoveries of protein. Also, this study revealed possibility use of both oat milk

and barley milk as a good substitute to milk especially for who are allergic to milk protein.

REFERENCES

Akinyele, I.O. (1989). Effects of traditional methods of processing on the nutrient content and some antinutritional factors in cowpea (*Vignaunguiculata*). Food Chemistry, 33, 291–310.

Ali, A.A., Mehriz, A.M., Moussa, A.E., and Azzam, M.A. (1992). Quality and properties of soymilk as affected by some technologicalconditions. Egyptian Journal of Applied Science, 7(4), 612–629.

American Association of Cereal Chemists. (2003).Approved methods of the AACC (10th ed.). St. Paul, MN: The Association.

AOAC (Association of Official Analytical Chemists) (2000): Official methods of analysis of the Association of Official Analytical Chemists, Washington, D.C.: USA.

Badau, M. H., Nkama, I., and Jideani, I. A. (2005). Phytic acid content and hydrochloric acid extractability of minerals in pearl millet as affected by germination time and cultivar. Food Chemistry, 92, 425–435.

Basheer, M.P. (2011). Genetic variations in milk components and the effect of milk protein genetic variant on heat stability. International Journal of Pharma and Bio Sciences, Vol. 2, Issue 1, 511–520.

Bello, M., Tolaba, M.P., and Suarez, C. (2004). Factors affecting water uptake of rice grain during soaking. Lebensm.-Wiss.u.-Technol. 37, 811– 816.

Block, R.J., Durrum, E.L., and Zweig, G. (1958). Annual of paper chromatography and paper electrophoresis. 2nd ed. Academic.Butt, M.S., Tahir-Nadeem, M., Khan, M. K. I., Shabir, R., and Butt, M. S.(2008). Oat: unique among the cereals. European Journal of Nutrition,47(2), 68–79.

Calzetta Resio, A.N., Aguerre, R.J., and Suárez, C. (2003). Study of some factors affecting water absorption by amaranth grain during soaking. Journal of Food Engineering, 60, 391–396.

Crean, D. E. C., and Haisman, D. R. (1963). The interaction between phytic acid and divalent cations during the cooking of dried peas. Journal of the Science of Food and Agriculture, 14, 824–833.

Deshpande, S. D., Bal, S., and Ojha, T. P. (1994). A study on diffusion of water by the soybean grain during cold water soaking. Journal of Food Engineering, 23, 121–127.

Duboies, M., Smith, F., Gilles, K.A., Hamilton, J.K., and Rebers, P.A. (1956). Colorimetric method for determination of sugar and related substances. Analysis Chemistry, 28(3), 350.

Egli, I., Davidsson, L., Juillerat, M.A., Barclay, D., and Hurrell, R.F. (2002).The influence of soaking and germination on the phytase activity and phytic acid content of grains and seeds potentially useful for complementary feeding. Journal of Food Science, 67(9), 3484– 3488.

Egounlety, M., and Aworh, O.C. (2003). Effect of soaking, dehulling, cooking and fermentation with Rhizopus oligosporus on the oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean (Glycine max Merr.), cowpea (Vigna unguiculata L. Walp) and groundbean (Macrotyloma geocarpa Harms). Journal of Food Engineering, 56, 249–254.

Fan, M. Z. and Sauer, W. C. (1995). Determination of apparent ileal amino acid digestibility in barley and canola meal for pigs with the direct, difference, and regression methods. Journal of Animal Science,73, 2364– 2374.

FAO, (1993). Food and Agriculture Organization of United Nations. Amino acid content of food and biological data on proteins. FAO Nutrition Studies No. 28.

Gibson, R. S., Hotz, C., Temple, C., Yeudall, F., Mtitimuni, B., and Ferguson, E. (2000). Dietary strategies to combat deficiencies of iron, zinc, and vitamin A in developing countries: Development, implementation, monitoring, and evaluation. Food and Nutrition Bulletin, 21, 219–231.

Grausgruber, H., Scheiblauer, J., Schönlechner, R., Ruckenbauer, P., and Berghofer, E. (2004). Variability in chemical composition and biologically active constituents of cereals. Genetic Variation for Plant Breeding, 23-26.

Hallberg, L., Brune, M., and Rossander, L. (1989). Iron absorption in man: ascorbic acid and dose-dependent inhibition by phytate. American Journal of Clinical Nutrition, 49(1):140–144.

Hídvègi, M. and Lásztty, R. (2002). Phytic acid content of cereals and legumes and interaction with proteins. Periodica Polytechnica Search Chemistry Engineering, Vol. 46, No. 1–2, PP. 59–64

Horwitz, W. (2000). Official Methods of Analysis of AOAC International. Maryland: AOAC International: Association of Official Analytical Chemists, AOAC (Washington, D.C.).

Hotz, C., Gibson, R. S., & Temple, L. (2001). A home-based method to reduce phytate content and increase bioavailability in maize-based complementary diets. International Journal of Food Sciences and Nutrition, 52, 133–142.

Hurrell RF, Reddy MB, Burri J, Cook JD. 2000. An evaluation of EDTA compounds for iron fortification of cereal based foods. British Journal Nutrition, 84(6):903–910.

Jood, S., Chauhan, B. M., and Kapoor, A. C. (1988). Contents and digestibility of carbohydrates of chick pea and black gram as affected by domestic processing and cooking. Food Chemistry, 30,113–127.

Khattab, R.Y., and Arntfield, S.D. (2009). Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional factors. LWT - Food Science and Technology, 42, 1113–1118.

Larsson, M., and Sandberg, A.S. (1995). Malting of oats in a pilot-plant process. Effects of heat treatment, storage and soaking conditions on phytate reduction. Journal of Cereal Science, 21, 87–95.

Lestienne, I., Besançon, P., Caporiccio, B., Lullien-Pellerin, V., and Trèche, S. (2005a). Iron and zinc in vitro availability in pearl millet flours (Pennisetum glaucum) with varying phytate, tannin, and fibre contents. Journal of Agricultural and Food Chemistry, 53(8), 3240– 3247.

Lestienne, I., Caporiccio, B., Besançon, P., Rochette, I., and Trèche, S. (2005b). Relative contribution of phytates, fibres, and tannins to low iron and zinc in vitro solubility in pearl millet (Pennisetum glaucum) flour and grain fractions. Journal of Agricultural and Food Chemistry,53(21), 8342– 8348.

Lestienne, I., Icard-Vernière, C., Mouquet, C., Picq, C., and Trèche, S. (2005c). Effects of soaking whole cereal and legume seeds on iron, zinc and phytate contents. Food Chemistry, 89(3), 421–425.

Lestienne, I., Mouquet-Rivier, C., Icard-Vernière, C., Rochette, I., and Trèche, S. (2005d). The effects of soaking of whole, dehulled and ground millet and soybean seeds on phytate degradation and Phy/Fe and Phy/Zn molar ratios. International Journal of Food Science andTechnology, 40(4), 391– 399.

Lewu, M.N., Adebola, P.O., and Afolayan, A.J. (2010). Effect of cooking on the mineral contents and anti-nutritional factors in seven accessions of Colocasia esculenta (L.) Schott growing in South Africa. Journal of Food Composition and Analysis, 23, 389–393.

Liang, J., Han, B.-Z., Han, L., Nout, M. J. R., and Hamer, R. J. (2007).Iron, zinc, and phytic acid content of selected rice varieties from China. Journal of the Science of Food and Agriculture, 87, 504–510.

Lindahl, L., Ahldén, I., Öste, R., and Sjöholm, I. (1997). Homogeneous and stable cereal suspension and a method of making the same. U.S. Patent, No. 5,686,123.

Mahgoub, S. E. O., and Elhag, S. A. (1998). Effect of milling, soaking, malting, heat-treatment and fermentation on phytate level of four Sudanese sorghum cultivars. Food Chemistry, 61, 77–80.

Morey, D.D., and Evans, J.J. (1983). Amino acid composition of six grains and winter wheat forage. Cereal Chemistry, 60(6), 461–464.

Okalebo, J.R., Gathna, K.W., and Woomer, P.L. (2002). Laboratory methods for soil and plant analysis: A working manual. 2nd ed. Tropical Soil Fertility and Biology Program, Nairobi.

Pearson, D. (1976). The chemical analysis of foods (7th ed.). London,UK: Churchill Livingstone.

Peterson, D.M. (1992). Composition and nutritional characteristics of oat grain and products. In: Oat science and technology. Eds H.G. Marshall, M.E. Sorrells. Madison, WI Am. Soc. Agron., 265-292.

Phillippy, B.Q., White, K.D., Johnston, M.R., Tao, S.H., and Fox, M.R.S.(1987). Preparation of inositol phosphates from sodium phytate by enzymatic and nonenzymatic hydrolysis. Analytical Biochemistry, 162, 115–121.

Pomeranz, Y., Youngs, V.L., and Robbins, G.S. (1973). Protein content and amino acid composition of oat species and tissues. American Association of Cereal Chemists, 50, 702–707.

Ragaee, S., Abdel-Aal, E.M., and Noaman, M.(2006). Antioxidant activity and nutrient composition of selected cereals for food use. Food Chemistry, 98, 32–38.

Saikia, P., Sarkar, C.R., and Borua, I., 1999. Chemical composition, anti-nutritional factors and effect of cooking on nutritional quality of rice bean [Virgna umbellate (Thunb; Ohwi and Ohashi)]. Food Chemsitry 67, 347– 352.

Servi, S., Özkaya, H., and Colakoglu, A.S. (2008). Dephytinization of wheat bran by fermentation with bakers' yeast, incubation with barley malt flour and autoclaving at different pH levels. Journal of Cereal Science, 48,471

Shekib, L.A.E., Zouil, M.E., Youssef, M.M. and Mohammed, M.S. (1985). Effect of cooking on the chemical composition of lentils, rice and their blends (Kohary). Food Chemistry, 18, 163.

Steele, R. G. D., Torrie J. H., and Dickey, D. (1996). Principles and procedures of statistics. A biometrical approach (3rd ed.).

Udensi, E. A., Ekwu, F. C., and Isinguzo, J. N. (2007). Antinutrient factors of vegetable cowpea (Sesquipedalis) seeds during thermal processing. Pakistan Journal of Nutrition, 6, 194–197.

Welch, R. W. (1995). Oats in human nutrition and health. In: The Oat Crop: Production and Utilization. R. W. Welch (Ed.). London:Chapman and Hall., 433–471.

Wheeler, E.L., and Ferrel, R.E. (1971). A method for phytic acid determination in wheat and wheat fractions. Cereal Chemistry,48,312-320.

الظروف التصنيعية المثلى لإنتاج ألبان الشوفان والشعير

فاطمه محمد محمود سلامه* ، محمد أحمد عزام* ، محمود عبد الحفيظ عبد الرحمن ، محمد مبروك عراقي أبو النجا*** ومحمد سعد عبد الحميد***

* قسم علوم الألبان – كلية الزراعة- جامعة القاهرة

** قسم الفسيولوچي – كلية الطب البيطري – جامعة القاهرة

*** معهد بحوث تكنولوچيا الأغذية – مركز البحوث الزراعية**

أجريت ثلاثة محاولات لتحضير معلقات أو ألبان من حبوب الشوفان والشعير ذو خواص حسية مقبولة وخالية من المواد الغير صحية والضارة. وكانت تلك المحاولات الثلاثة:

A- سلق الحبوب بعد نقعها وقبل طحنها مع بيئة الإستخلاص.

B- تحميص الحبوب تحميصاً رطباً بعد نقعها وقبل طحنها مع بيئة الإستخلاص.

C- نقع الحبوب ثم طحنها مع بيئة الإستخلاص.

درس تأثير ظروف التصنيع (النقع – النقع + التسخين – النقع + التحميص) مع إختلاف نسبة الحبوب إلى بيئة الإستخلاص على محتوى الحبوب بعد كل عملية تصنيعية من حمض الفايتك و٪ للبن الناتج و٪ لمقدار ما أستخلص من الجوامد والبروتين من الحبوب. كما قورنت بعض الخواص الكميائية والفيزيقية للألبان الناتجة بمثيلتها للبن البقري (عينة المقارنة).

وقد أظهرت النتائج ما يلي:

- كانت المحاولة B الأفضل لتحضير لبن الشوفان ، والمحاولة A الأفضل لتحضير لبن الشعير.
- إستبدال الماء بشرش حلو كبيئة للإستخلاص أدى إلى زيادة الجوامد الكلية والبروتين في الألبان الناتجة مع تحسن كبير في خواصها الحسية.

- تأثر محتوى الحبوب من حمض الفايتك حيث إنخفض محتوى الحبوب منه بعد نقعها بنسبة ١٣٪ في المتوسط ، وزادت هذه النسبة إلى ٥٦, ١٦٪ بعد نقع وتحميص حبوب الشوفان ، وزادت إلى ٧٣, ٢١٪ بعد نقع وسلق حبوب الشعير.
- أرتفاع محتوى اللبن البقري من الدهن والكالسيوم عن مثيله لألبان الشوفان والشعير، بينما أرتفع محتوى أياً منهما من الكربوهيدرات والفوسفور والبوتاسيوم والحديد والزنك عن مثيله للبن البقري.
- تشابه لبن الشوفان مع اللبن البقري في محتواه من البروتين.
- خلو اللبن البقري تماماً من الألياف.
- إنخفاض محتوى بروتين ألبان الشوفان والشعير من الأحماض الأمينية الأيزوليوسين والميثونين والثريونين والتيروزين قليلاً عن محتوى البروتين المرجعي من تلك الأحماض.
- أرتفاع محتوى بروتين اللبن البقري من الأحماض الأمينية الضرورية قليلاً عن مثيله لبروتين ألبان الشوفان والشعير.
- أرتفاع لزوجة كل من لبن الشوفان ولبن الشعير عن لزوجة اللبن البقري بينما العكس تماماً للثبات الحراري.
- تقاربت قيم الحموضة والوزن النوعي للألبان الثلاثة.

لذلك يمكن أن نعتبر لبن الشوفان أو لبن الشعير أختياراً صحياً للعديد من الناس وخاصة الذين يعانون من الحساسية لبروتين اللبن.

قام بتحكيم البحث

أ.د / طه عبد الحليم نصيب **كلية الزراعة – جامعة المنصورة**

أ.د / منير محمود العبد **كلية الزراعة – جامعة القاهرة**