Assiut J. Agric. Sci., (47) No. (5) 2016 (83-94) *ISSN: 1110-0486*
Website: http://www.aun.edu.eg/faculty_agriculture *E-mail: ajas@aun.edu.eg*

Assessment of Proximate Chemical Composition and Nutritional Status of Wheat Biscuits Fortified with Oat Powder

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Received on: 28/6/2016 **Accepted for publication on:** 10/7/2016

Abstract

Oat (*Avena sp*.) is a species of cereal grain grown for its seeds and it contains many valuable constituents. Gross chemical composition, caloric value, minerals, vitamins and amino acids composition of two oat varieties namely: Common oat (*Avena sativa*), and Red oat (*Avena byzantina*),were assessed. Data revealed that, common and red oat had a high content of total carbohydrates (75.625 and 69.435%) and protein (11.61 and 13.62%). Oat powder is rich source of P, K and Mg (472.57- 469.61mg), (350 – 362mg) and (120.67 - 112.25mg); respectively. As well as vitamin B_1 and B_2. Common and red oat powders are good source of essential amino acids namely Leucine and phenylalanine (8.19 and 8.01g/100gm) and (6.21and 6.42 g/100gm protein). Biscuits fortified with different levels (10, 20 and 30%) oat powders were also evaluated for their chemical, physical and sensory evaluation. Biscuit constituents ranged between 6.06%-7.8% Crude protein, 16.12%-18.39% Crude fat, 1.31%-1.59% Ash and 0.61%-0.91% Crude fiber ; respectively. Highly acceptable biscuits could be obtained by incorporating 10% oat powders in the wheat biscuits formulation.

Keywords: *Oats, Chemical composition, Minerals, Physical characteristics, Sensory evaluation, Vitamins, Amino acids, Biscuits.*

1. Introduction

Oats are grown for use as grain as well as forage and fodder, straw for bedding, haylage, silage and chaff. Oats can be used as oat meal, oat flour, oat bran and oat flakes as breakfast cereals and as ingredients in other food stuffs. Oats are one of the most nutritious grain cereals, high in protein and fiber. Oat protein is generally greater than that found in other cereal grains. It contains high amount of vitamins and minerals (Ahmad and Zaffar, 2014).

Oats are an important source of nutrients; they contain protein, digestible carbohydrates and dietary fiber fractions required for a balanced human diet. Likewise, oats were mainly used as feed for animals, but recent findings had pointed out new possibilities for the health-promoting properties of oats and oat products (Brennan and Cleary, 2005).

Many positive effects of oats are associated with beta-glucan, due to its beneficial effect on serum cholesterol levels, and recently the European Food Safety Authority approved health claims for beta-glucan (EFSA, 2009).

Jones (2002), stated that oat (*Avena sativa* L.) had long been recognized as a natural ingredient of functional foods because they provide dietary fiber, good protein, unsaturated lipids, vitamins, minerals com-

ponents and antioxidants required for human health.

Oats (*Avena sativa* L.) is a cereal consumed at lower rates than wheat and rice all over the World. However the dietary fiber content and nutritional value of oats are high. Oats contain many essential amino acids (methionine, cysteine, threonine, isoleucine, tryptophan, valine, leucine, histidine, methionine, phenylalanine, and tyrosine) necessary for human body (Biel *et al.,* 2009), and high antioxidant activity components such as tocopherols, tocotrienols, and flavanoids (Koenig *et al*., 2014).

Oat products are characterized by a unique nutritional profile, able to bring significant benefits to our diet. Oat is characterized by a high content of lipids, 2-3 times more than other cereals and a high protein content that can be of great exogenous source of amino acids (Butt *et al*., 2008) Likewise, fibers from oat can bring important benefits to the health of the digestive tract, due to the contribution of the increase of faecal mass. In addition to β- glucans benefits, products derived from oat had a significant content of phenolic compounds and other antioxidants, (Madhujith and Shahidi 2007; Inglett and Chen 2012).

Many researchers recognized the beneficial effects of consuming oat and oat based food products. Oat had been reported to be effective in moderating the effects of hypertension, lowering the total serum- and LDL-cholesterol, regulating blood glucose and insulin levels, controlling weight and promoting gastrointestinal health. Many of these effects were attributed to the presence of dietary fibers, principally the β-glucans (Bekers *et al*., 2001; Lambo *et al.*, 2005).

The main objective of this investigation was assessing the gross chemical composition, minerals, vitamins, and amino acids profile in two raw oat varieties, as well as assessing the physical characteristics, sensory quality and nutritive value of fortified wheat biscuits with oat powder.

2. Materials and Methods

2.1. Materials

Ten kilograms of each varieties of oat grains: Common oat (*Avena sativa*), and Red oat (*Avena byzantina*) were purchased from Agricultural Research Center, Giza, Egypt. The samples were obtained in 2014. All chemicals used in the study were purchased from El Gomhouria Company in Assiut city.

2.2. Methods

2.2.1. Preparation of oat flours

The oats were carefully hulled by hand to ensure that the germ was not excluded. The grains so prepared were then finely ground in a Christy-Norris mill and the resultant whole grains samples were used in the preparation of oat flours according to Heathcote (1950).

2.2.2. Determination of Gross Chemical Composition

Moisture, protein, crude fat, crude fibers, and ash contents were determined according to the methods described in the (AOAC, 2008). Total carbohydrate was calculated by difference. All determinations were performed in triplicates and the means were reported. The caloric value was calculated using values of 4 k.cal/g

for protein, carbohydrates and 9 k.cal/g for fat according to Livesy (1995).

2.2.3. Determination of Minerals Content

To extract Na, K, Mg, P, Ca, Zn, Cu, Mn and Fe, samples were dried, ashed then the ash was dissolved in hydrochloric acid (Jackson, 1973). Sodium and potassium were determined by the flame photometric procedure (Corning instrument model 410), in the Centurial Labs,Faculty of Agric, Assiut University, as described in (Chapman and Pratt, 1961). Determination of phosphorus according to the procedure described by (Tan, 1996). Calcium and magnesium were determined by titration with version 0.0156 N according to (Jackson, 1973). Iron, zinc, copper and manganese were determined using a GBC Atomic Absorption 909 AA, in the Centurial Labs, Faculty of Agric, Assiut University, as described in A.O.A.C. (2008).

2.2.4. Determination of Vitamins

Vitamin E was calorimetrically estimated by the method of Quaife and Harris (1948); where HPLC technique was used as described by (Batifoulier *et al.,* 2005) was used for the separation and quantification of thiamine, riboflavin, Niacin, Pyridoxine, and B12 by a new reversed-phase chromatographic method. The analysis was performed in Central Service Unit, National Research Center, Egypt.

2.2.5. Determination of Amino Acids Composition

Amino acids were determined according to the method described by Pellet and Young (1980) by using Beckman Amino acid Analyzer Model 119 CL, in the Central Service Unit, National Research Center, Egypt.

2.2.5.1. Determination of Tryptophan

Tryptophan was determined using spectrophotometric method as described by Sastry and Tummuru (1985).

2.2.6. Preparation of biscuits:

Biscuits were baked on an aluminum tray in an electric oven at 180°C for 6 minutes. The biscuit was cooled for 30 minutes, packed in polyethylene bags stored under desiccation, method as described by Rao and Manohar (1997). Preparation of biscuits was carried out using wheat flour samples replaced separately with 10, 20 and 30% oat flours.

2.2.7. Physical Characteristics of biscuits:

Height (cm), width (cm), spread ratio and spread factor were determined in five biscuits and averages were recorded. Spread ratio and spread factor were calculated according to Rao and Manohar (1997) as follow:

$$\text{Spread ratio} = \frac{\text{Width}}{\text{Height}}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$$

2.2.8. Sensory Characteristics of Biscuits:

Sensory characteristics color, texture, taste, odor and overall acceptability were done in order to de-

termine consumer acceptability. A numerical hedonic scale ranging from 1 to 10 (1 is very bad and 10 for excellent) was used for sensory evaluation (Larmond, 1977).

2.2.9. Statistical analysis:

Data were subjected to analysis of variance (ANOVA) and the least significant difference (LSD) at 5%probability according to (Snedecor and Cochran, 1980).

3. Results and Disscuion

3.1. Gross Chemical Composition of Oat Flour

Data of gross chemical composition and caloric value of red and common oat flours are presented in Table (1).

Data revealed that the chemical composition of oat flours ranged between 9.96% - 10.47% moisture, 11.61% -13.62% Crude protein, 7.23% -8.92% Crude fat, 3.535% - 5.875%, Crude fiber, 2% -2.15% Ash, and 69.435% - 75.625% Carbohydrates. The caloric values of oat flours were 412.5 and 414.01 Kcal /100 g for both red and common oat.

From these data it could be stated that oat flour is good source of protein, fiber and ash compared with wheat flour, in agreement with that reported by Webster (2002), Masih *et al*. (2013) and Biel *et al*. (2009).

From the same Table it could be noticed that red oat flour recorded higher amount from protein, fat and fiber compared with common oat flour.

Table 1. Gross chemical composition*and caloric value of oats

Sample	Red oat	Common oat	L.S.D $_{0.05}$
Moisture %	9.96 ±0.008	10.47 ±0.016	0.035
protein % *	13.62 ±0.60	11.61±0.73	1.87
fat % *	8.92±0.08	7.23 ±0.13	0.656
Crude fiber % *	5.875±0.14	3.535±0.10	0.770
Ash % *	2.15 ±0.08	2 ±0.00	NS
Carbohydrates% **	69.435 ±0.81	75.625 ±0 .67	2.07
Caloric Value (Kcal)*	412.5	414.01	

*On dry weight basis, ** calculated by difference.

3.2. Minerals Composition of Oat Flour

Data concerning minerals content of oat powders are given in Table (2). Oat powders were relatively higher in phosphorus, potassium, magnesium, calcium, and iron, while it had lower in copper, sodium, zinc and manganese. Similar results were reported by Hu *et al.* (2014), who found that, the range of the minerals (mg/100g) content in Chinese naked oat flakes, were Ca, Na, Zn and Fe; were as follows, 27.2-109.8, 2.81-45.77, 1.28-5.05and 12.2-55.3; respectively. The elements,i.e. copper (Cu) and manganese (Mn) act as cofactors of antioxidant enzymes to protect the body from oxygen free radicals that are produced during oxidative stress (Leung, 2009).On the other side, red oat had higher amount from iron, calcium, sodium and potassium than anther oat species.

Table 2. Mineral composition of oats (mg /100g ash a sample; on dry weight basis).

Treatments	Micro elements				Macro elements				
	Fe	Mn	Cu	Zn	Ca	Mg	Na	K	P
Red oat	24.21	3.66	1.20	3.62	71.71	112.25	7.03	362	469.61
Common oat	13.76	4.42	1.33	3.44	54.70	120.67	5.35	350	472.57

3.3. Vitamins

Vitamin E is a major biological antioxidant quenches free radicals and acts as a terminator of lipid per-oxidation, particularly in membranes that contain highly unsaturated fatty acids (Burton and Traber, 1990). The vitamins content in oats is presented in Table (3). The data outlined the B-complex vitamins content (Thiamine B_1, Riboflavin B_2, Niacin B_3, Pyri-doxine B_6, cobalamin B_{12}) and vita-min E (tocopherol) of the two studied oat varieties. It was observed that the red oat powder recorded the highest amounts of vitamins E (0.87mg/100g), B_1 (0.533mg/100g), B_6 (0.33mg/100g) and B_{12} (0.113mg/100g), while common oat powder recorded the highest amount of B_2 (0.6mg/100g). Niacin (B_3) was not detected in the two studied oat varieties. (Kirk and Sawyer, 1999) found that Thiamine (B_1) 0.50mg/100g; Riboflavin (B_2) 0.14mg/100g; Niacin (B_3) 1.3mg/100g. (Maboodurrahman and Swapnil, 2015) recorded that vita-mins contents was Thiamine (B_1) 0.763mg; Riboflavin (B_2) 0.139mg; Niacin (B_3) 0.961mg; Folate (B_9) 56µg.

Table 3. Vitamins E and B-complex of oats (mg /100g).

Vitamins	**Treatments**		**Recommended nutrient intakes (25-50 yr.)** RDA**	
	Red oat	Common oat	Male	Female
Vitamin E	0.87	0.125	10 mg	8 mg
Thiamin B1	0.533	0.435	1.5 mg	1.1 mg
Riboflavin B2	0.4	0.6	1.7 mg	1.3 mg
Niacin B3	ND*	ND	19 mg	15 mg
Pyridoxine B6	0.33	0.243	2 µg	1.6 µg
cobalamin B12	0.113	0.09	200 µg	180 µg

* ND = not detected ** RDA: Recommended Daily Allowance (Welch and Graham,2004)

3.4. Essential Amino Acids

The amino acids compositions of oat powders are presented in Table (4). The obtained data revealed that oat powders had highest amounts of isoleucine, leucine, lysine, threonine, phenylalanine and valine, while; it had lowest amounts of methionine and tryptophan. These data are in agreement with Biel *et al.* (2014).

Similar results were previously reported by (Sterna *et al*., 2015) who found that isoleucine, leucine, lysine, threonine, phenylalanine, valine, me-thionine and tryptophan; were as fol-lows, 3.60, 7.34, 3.33, 3.44, 4.57, 4.93, 1.48and 3.01; respectively. The data indicated that, the total essential amino acids were 32.78 and 34.13 g / 100g protein for red and common oat

powder. In general, leucine recorded the highest values 8.01, 8.19 g / 100g protein in red and common oat powder; respectively.

Table 4. Essential amino acids content of oats

Amino acids (g.A.A/100g. Protein). Essential A.A.:	Treatments		FAO/WHO (1985) g.A.A/100g protein)	
	Red oat	Common oat	School child	Adult
Isoleucine	4.09	4.23	2.8	1.3
Leucine	8.01	8.19	4.4	1.9
Lysine	4.09	4.43	4.4	1.6
Methionine	0.50	1.69	2.2	1.7
phenylalanine	6.42	6.21	2.2	1.9
threonine	3.42	2.44	2.8	0.9
Tryptophan	1.00	1.11	0.9	0.5
Valine	5.25	5.83	2.5	1.3
Total E.A.A	32.78	34.13		

3.5. Gross Chemical Composition of Biscuits

The mean value of gross chemical composition and caloric value of wheat biscuits and fortified wheat biscuits with oat flour is given in Table (5).Results revealed that moisture (g/100g on dry weight basis) content was ranged between 4.63 - 4.98% for control, 10, 20 and 30% oat biscuits. Data shows that moisture increased gradually by increasing the oat level in biscuits due to the higher content of oat flour moisture as compared to wheat flour moisture. These results explained that total protein increased by increasing the oat level in biscuits due to the higher content of protein in oat as compared to wheat flour.

Similarly, total fat content ranged from 16.70% to 18.39% in fortified biscuits containing oat flours compared to 16.12% fat in control. One of the studies carried out by Salehifar and Shahedi (2007) showed that protein and fat content of biscuits increased with increasing oat fortifications.

Dietary fiber content in the fortified biscuits was also found to be higher which may be due to the incorporation of oat flours.

The ash content of biscuits samples with different proportion of red and common oat flour ranging from 1.33% to 1.59% was higher than the control (1.31%). The increase in the ash content may be due to an incorporation of oat flours containing higher proportion of ash. The incorporation of oat flours in biscuits resulted in a decrease in the carbohydrate content to 71.31% as compared to the control with 75.74%.These results are in good agreement with (Flander *et al*.,2008) and (Habbal and Samaan, 2012).

Table 5. Gross chemical composition and caloric value of enriched biscuits with oat powder

Treatments	Moisture %	protein % *	fat % *	Crude fiber % *	Ash % *	Carbohydrates% **	Caloric Value (Kcal)*
Control (100%wheat flour 72%extraction).	4.63 ±0.08	6.06± 0.67	16.12 ± 0.20	0.61± 0.01	1.31±0.03	75.9±0.74	472.92
Fortified biscuits with 10%red oat	4.76 ±0.02	6.61 ±0.52	17.25 ±0.07	0.72±0.01	1.37±0.008	74.05±0.60	477.89
Fortified biscuits with20 % red oat	4.87±0.01	7.21 ±0.46	17.80 ±0.02	0.81±0.01	1.47±0.04	72.71±0.51	479.88
Fortified biscuits with30%red oat	4.98 ±0.03	7.8 ±0.52	18.39 ±0.18	0.91±0.01	1.59±0.008	71.31±0.40	481.95
Fortified biscuits with 10%common oat	4.67±0.03	6.39±0.083	16.70 ±0.18	0.67±0.02	1.33±0.01	74.91±0.68	475.5
Fortified biscuits with 20% common oat	4.73±0.05	6.91±0.43	17.40±0.13	0.74±0.02	1.43±0.008	73.52±0.55	478.32
Fortified biscuits with 30% common oat	4.78±0.05	7.63±0.71	17.93±0.17	0.81±0.02	1.58±0.01	72.05±0.55	480.09
$L.S.D_{0.05}$	0.095	NS	0.332	0.054	0.054	1.26	
*On dry weight basis, ** calculated by difference.							

3.6. Physical Characteristics of biscuits

Oat flour had been considered as a functional food supplement in certain good products because they are reckoned as a good source of dietary fibers, minerals and vitamins.

The mean values of physical characteristics of wheat biscuit and fortified wheat biscuits with oat flour are presented in Table (6). Data recorded a gradual increment of width and thickness of all fortified biscuits with oat flour. On the other hand spread ratio and spread factor increased slightly till 20% addition.

Table 6. Physical properties of enriched wheat biscuits with oat flour

Treatments	Width (cm)[a]	Thickness (cm)[a]	Spread ratio□	Spread factor □
Control (100%wheat flour 72%extraction).	7.1	0.72	9.86	100
Fortified biscuits with 10%red oat	7.46	0.74	10.08	102.23
Fortified biscuits with 20 %red oat	7.82	0.79	9.89	100.30
Fortified biscuits with 30 %red oat	7.92	0.84	9.42	95.53
Fortified biscuits with 10% common oat	7.76	0.76	10.21	103.54
Fortified biscuits with 20% common oat	8.2	0.81	10.12	102.63
Fortified biscuits with 30% common oat	8.42	0.86	9.79	99.29

a: n = 5 b : Width / Thickness c: Spread ratio of sample / Spread ratio of control ×100

3.7. Sensory Characteristics of Biscuits

The effects of oat flour supplementation on the sensory characteristics of biscuits are presented in Table (7). From this table it could be observed that with the increase in the level of oat flour (red and common) in formulation, the sensory scores for color and odor of biscuits decreased. While the sensory scores for texture of biscuits was increased. Table (7) indicated that, both fortified biscuits with 10%, 20% red oat and fortified biscuits with 10% common oat had the best taste score according judges' score. Based on the above mentioned results biscuits containing both 10% red and common oat were found to be most acceptable by the panelists.

Table 7. Sensory quality of enriched wheat biscuits with oats flour.

Treatments	color	texture	taste	odor	Overall acceptability
Control (100%wheat flour 72%extraction biscuits).	8.6 ±0.47	7 ±0.81	7.8±0.47	8.2±0.47	8.2±0.47
Fortified biscuits with 10%red oat	7.9 ±0.40	8.3 ±0.40	8.5±0.40	8.7±0.40	8.5±0.40
Fortified biscuits with 20 %red oat	7.52 ±0.23	8.54 ±0.41	8.32 ±0.41	7.92±0.28	8.32±0.18
Fortified biscuits with 30 %red oat	6.72 ±0.65	8.76 ±0.09	7±0.47	7.34±0.80	7.14±0.80
Fortified biscuits with 10%common oat	8.24 ±0.32	8±0.23	8.8±0.47	8.8±0.47	8.82±0.04
Fortified biscuits with 20% common oat	7.84 ±0.47	8.4±0.47	8.52±0.41	8.04±0.20	8.5±0.40
Fortified biscuits with 30% common oat	7.6 ±0.47	8.6±0.23	8 ±0.47	7.7±0.40	8±0.62
$L.S.D_{0.05}$	1.07	0.864	0.863	0.708	0.941

In conclusion the oat flour has nutritional value due to its high levels of dietary fiber. The soluble fibers in particular are thought to exert a preventative role against heart disease, as they appear to have the ability to lower serum cholesterol. In the light of the above – mentioned data, oat flour proved to have high levels of the nine studied minerals. Moreover,

the present study indicated that there were good balanced essential amino acids required for human nutrition, besides leucine was the highest essential amino acid, followed by phenylalanine. Finally it could be stated that, oat flour has an increasing interest as they are important ingredients in the food industry such as functional and healthy foods formulations as biscuits, bread, and cakes.

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تقدير التركيب الكيميائى الأجمالى والقيمة التغذوية للبسكويت المدعم بدقيق الشوفان

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الملخص

يعد الشوفان من المحاصيل التى تزرع من أجل الحصول على حبوبها التى تحتوى على العديد من المكونات المفيدة. وتهدف هذه الدراسة الى تقدير التركيب الكيميائى الأجمالى والقيمة السعرية وكذلك تقدير محتوى العناصر المعدنية والفيتامينات والأحماض الأمينية فى صنفين من الشوفان هما : الشوفان الأبيض (*Avena sativa*) والشوفان الأحمر (*Avena byzantina*). وأظهرت الدراسة ارتفاع محتوى الشوفان من الكربوهيدرات والتى تراوحت بين (٦٩،٤٣٥% – ٧٥،٦٢٥%) وكذلك محتوى البروتين (١١,٦١% – ١٣،٦٢%). كما يعد الشوفان مصدرا للأملاح المعدنية كالفسفور والبوتاسيوم والمغنيسيوم الى جانب الفيتامينات وخاصة فيتامين الثيامين (ب١) والريبوفلافين (ب٢). كما اظهرت الدراسة إرتفاع محتوى الشوفان من الأحماض الأمينية الأساسية وخاصة الليوسين والفينيل الانين. هذا وقد شملت الدراسة أيضا استخدام دقيق الشوفان فى إنتاج البسكويت وقد تم تدعيم دقيق القمح استخلاص ٧٢% بدقيق الشوفان بنسب ١٠و٢٠و٣٠ % وأظهرت النتائج إرتفاع محتوى البسكويت الناتج من البروتين والدهون والرماد والألياف الغذائية مقارنة بالعينة الكنترول. هذا وقد سجل البسكويت المدعم بنسبة ١٠% من دقيق الشوفان الأبيض والأحمر أعلى درجات تقييم الخواص الحسية والتى شملت خواص اللون والقوام والطعم والرائحة ودرجة القبول العامة أيضا.