Research Bulletin, Ain Shams Univ., 2009

PHYSICAL, CHEMICAL, RHEOLOGICAL AND SENSORY CHARACTERISTICS OF BISCUIT SUPPLEMENTED WITH DIFFERENT PLANT SOURCES

[1]

Bahgaat Wafaa, K. [1]; Rasmy Nagwa, M. [2]; M.A. Khorshid [1]; Foda Mervat, I. [1] and Hassan Amal, A. [2]

ABSTRACT

Increasing awareness in consumer towards health and quality of food has encouraged studies on the utilization of different nutritionally rich ingredients for the production of health and high nutritional quality foods. Therefore, this study was designed to examine the effect of addition plant source flours (flaxseed, mustard and hull-less barley) and flaxseed oil on the physical, chemical, rheological and organoleptic properties and baking quality of biscuits. The wheat flour was replaced by tested plant flours at 5, 10, 15, 20, 25 and 30 %, while the shortening was replaced by flaxseed oil at 25, 50, 75 and 100 % in biscuit preparation. Ash, total protein and crude fiber content of tested samples ranged between 1.94, 5.17, 11.18, 48.01, 1.29 and 10.09 %, respectively. Farinograph and extensograph measurements revealed that addition of tested plant flours increased water absorption in all wheat dough, being maximum (66.9%) in the wheat flour-barley dough. Maximum dough stability (12 min) was recorded in the wheat flour-flaxseed dough, while weakening, maximum resistance to extension, extensibility and mixing energy (area under curve) were decreased. The protein content of biscuit increased approximately 1.37, 1.25, 1.19 and 1.11 times as a result of defatted mustard (10%), mustard (15%), flaxseed (15%) and barley (30%) flours incorporation, coupled with improvement in ash and fiber contents. Sensory evaluation revealed that samples containing 15% flaxseed and mustard flours, 10% defatted mustard flour, 30% barley flour and 100% flaxseed oil, had the highest scores in all attributes comparing with other biscuit samples. It is of interest to notice that 100 g of the resultant biscuit provide with more than one third of recommended daily energy requirements (1000 - 1500 Kcal/ day) for a school age child. The obtained results concluded that, flaxseed, mustard, defatted mustard, barley flours as well as flaxseed oil could be successfully used for making biscuit at 15, 10, 30 and up to 100% incorporation level, respectively, without any unfavorable changes.

1-Dairy Sci. Dept., National Research Center, Dokki ,Giza, Egypt.

2-Food Sci. Dept., Fac. of Agric., Ain Shams Univ., Shoubra El-Kheima, Cairo Egypt.

(Received February 21, 2009)
(Accepted February 21, 2009)

Keywords: Biscuit, Flaxseed flour, Mustard flour, Barley flour, Flaxseed oil, Rheological properties, Sensory evaluation

INTRODUCTION

Barley (*Hordium vulgare* L.) is the fourth cereal crop in the world on the basis of total cereal production (**FAO, 2003**). Barley grain is an excellent source of both soluble and insoluble dietary fiber with clinically proven health benefits (**Newman & Newman, 1991**). β-glucan, the major fiber constituent in barley, has been shown to minimize plasma cholesterol, reduce glycemic index, reduce the risk of colon cancer and also reduce the risk of coronary heart diseases (**McIntosh *et al*, 1991; Brennan & Cleary, 2005 and FDA, 2005**). For a long time, barley was used as a food grain and there is a potential for many forms of barley as ingredients could be used in many food products including chemically leavened caked goods, pasta and breakfast cereals (**Newman and McGuire, 1985**).

Flaxseed is the seed from the flax plant (*Linum usitatissimum* L.) which is a member of the Linaceae family. Flaxseed had three major components making it beneficial in human and animal nutrition: (1) a very high content of alpha linolenic (omega - 3fatty acid essential for humans; (2) a high percentage of dietary fiber, both soluble and insoluble; and (3) the highest content of plant "lignans" of all plant or seed products used for human food. There are numbers of studies indicating the hypolipidemic, hypoglycemic, hypocholesterolemic, antiviral as well as bactericidal activity, ion reduction, laxatives uses, anti-inflammatory effect and anticancer effects of raw flaxseed and its baked products (**Serraino and Thompson, 1992; Bierenbaum *et al.*, 1993; Cunnane *et al.*, 1995; Jenab and Thompson, 1996; Prasad, 1998 and Jenkins *et al.*, 1999**). Flaxseed could be added to baked products as a whole seed, imparting a health appearance and increased texture quality (**Hussain *et al.*, 2006**).

Mustard seeds are from the mustard plant, which is a cruciferous vegetable related to broccoli, brassels sprouts and cabbage. While there are approximately fourty different varieties of mustard plants, there are three principal types used to make mustard seeds: black mustard *(Brassica nigra)*, white mustard (*Brassica alba)* and brown mustard (*Brassica juncea*). Since time immemorial mustard has been known for its antibacterial, antifungal and antioxidant properties, as an appetite stimulant and digestive aid by facilitating the secretion of gastric juices. Allyl isothiocynate present in mustard flour had known remarkable results in inhibiting the growth of food borne pathogens and growth of cancer cells (**Amarowicz *et al.*, 1996 and Rhee *et al.*, 2003**). The mustard seed has a high nutritional value and good techno-functional properties. These valuable properties could be incorporated in human and animal feed too (**Cserhalmi *et al.*, 2001**).

The demand for ready – to - eat processed food with better shelf life, satisfying taste, texture and with high nutritional quality seem to be the most important items that can satisfy consumers, (**Ragab, *et al.*, 2005**). Bakery products, and in particular biscuits, have been identified as one type of food that satisfies these criteria (**Chavan and Kadam, 1999**). However, because a significant proportion of the protein, fat, mineral, vitamin and fiber content of wheat grain is lost during milling, most wheat-based bakery products are low in quantity and quality of proteins as well as in minerals and B-group vitamins. Biscuits can serve as a suitable vehicle to supply additional nutrients (i.e. protein, dietary fiber, antioxidants, omega - 3 and omega- 6 fatty acids) to target populations such as primary schools and daycare centers within urban as well as rural areas (**Mbofung *et al.*, 2002**). Several studies have used legumes as their major protein source to enrich bakery products (**Mbofung and Waldron, 1997 and Chavan and Kadam, 1999**).

Brewer's spent grain was used as a source of fiber for incorporating cookie formulation (**Prentice *et al.*, 1978**) and raw wheat bran up to 30 % could be use to substitute flour in the preparation of high fiber biscuits (**Leelavathi and Rao, 1993**). Wheat bran, rice bran, oat bran, and barley bran were used to enrich the fiber content in the biscuits (**Sudha *et al.*, 2007**). Similarly, defatted mustard flour was used to enrich the protein content in the biscuits (**Tyagi *et al.*, 2007**). In addition, full fat flaxseed flour up to 20 % could be used to substitute flour in the preparation of cookies to obtain the medicinal and nutritional benefits of flaxseed (**Hussain *et al.*, 2006**).

The present work was designed to investigate the effect of addition plant flour source (flaxseed, mustard and barley) as well as flaxseed oil on the physical, chemical, rheological, and organoleptic properties of biscuit and to optimize the incorporation level of flour from these plant sources.

MATERIALS AND METHODS

Materials:

Soft wheat flour (72% extract) was obtained from Flourland Company, 6th October City, Governorate, Egypt. Hull-less barley grains (*Hordium vulgare L.*) were obtained from Barley Research Section, Field Crops Research Institute, Agriculture Research Center, Giza, Egypt. Flaxseed (*Linum usitatissimum L.*) variety "Sakha 1" was obtained from Fiber Crops Research Center, Agriculture Research Center, Giza, Egypt and Mustard seed (*Brassica alba*) was obtained from Medical and Aromatic Plants Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. All other ingredients (e.g. sucrose, shortening, baking powder and salt) were purchased from local market.

Methods:

Preparation of selected plant flour:

Hull-less barley grains, flaxseed and mustard seed were manually cleaned from dust particles, damaged seeds, seeds of other crops and other impurities (weeds and metals), then moisted (to 14%) for 24 h. then milled to get full fat barley, flaxseed and mustard flours. The resulted flours were packed in polyethylene bags and stored at $-18 \pm 2°C$ until use. Defatted mustard flour was obtained using a solvent (n-hexan) extraction in Soxhlet apparatus then drying and grinding were applied on the cake. While, flaxseed oil was obtained by cold-pressing whole flaxseeds (Fat Extract Unit, National Research Center, Dokki, Giza, Egypt).

Preparation of composite flours:

Blends of wheat flour with barley, flaxseed, mustard and defatted mustard by substituting 5, 10, 15, 20, 25 and 30% of wheat flour by the above mentioned flours to produce composite flour which is used in preparing biscuits. Biscuit was also prepared by substituting 25, 50, 75 and 100% of used shortening in biscuit formula with flaxseed oil.

Biscuit processing:

Biscuit was prepared according to **Sai Manohar & Haridas Rao (1999)** with the following recipe:

Ingredient	g
Wheat flour	300
Sugar	90
Shortening	60
Ammonium bicarbonate	3
Sodium chloride	3
Sodium bicarbonate	1.2
Baking powder	0.9

Sugar and fat were creamed for 3-4 min in a mixer, sodium and ammonium bicarbonate and sodium chloride were dissolved in water (60-67ml water) and added to the above cream then mixed for 5 min to obtain homogenous cream. Wheat flour sieved twice with baking powder and added to above cream and mixed for 3 min. Biscuit dough was sheeted to a thickness of 3.5 mm, cut using circular shape (45 mm diameter), placed on a tray and baked at 180°C for 15 min, cooled for 30 min, packaged in polyethylene bags and stored in air-tight containers at room temperature (21 ± 2°C) for further analysis.

Analytical methods:

Chemical analysis:

Moisture, protein, ash, crude fiber and fat contents were determined according to **AOAC (2000)**.

Rheological properties:

Rheological properties of the various blends were determined using Farino-graph and Extensograph system available at Rheology Lab., Food Tech. Research Institute, Agriculture Research Center, Giza, Egypt according to **AACC (1995).**

Physical characteristics of biscuit:

Weight (g), volume (cm), diameter (cm) and thickness (cm) measured according to **AACC (1995).** Specific volume and spread ratio were calculated by dividing biscuit volume on its weight and by dividing the average diameter on the average thickness, respectively.

Organoleptic evaluation:

Biscuit was evaluated for its appear-ance of surface, texture, color, flavor, mouth feel and overall acceptab-ility by 15 staff member of Food Science and Nutrition Division, National Resea-rch Center, Dokki, Giza, Egypt according to the method described by **Sudha *et al.*, (2007).**

Statistical analysis:

Data expressed as mean values were statistically analyzed by performing analysis of variance technique using the statistical program **(SAS, 1996).** Differences among means were compared using Duncan's Multiple Rang Test and Tukey's Studentized Rang Test at 5% of significance.

RESULTS AND DISCUSSION

Chemical composition of flour samples:

The proximate composition of wheat, barley, flaxseed, mustard and defatted mustard flour was presented in Table (1). The highest value of protein was recorded for defatted mustard flour (48.01%) followed by mustard flour (30.55%) and flaxseed flour (23.76%), while barley and wheat flours had lower crude protein values being 11.18 and 9.12%, respectively. The fat content of flaxseed and mustard flours was found to be higher (43.21 and 32.09%, respectively) than that of barley, wheat and defatted mustard flours. It was observed that flaxseed, defatted mustard and mustard flours contained the highest crude fiber (10.09, 9.67 and 8.16%, respectively), and ash levels (4.10, 5.17 and 4.58% respectively), while the lowest values (0.19 and 1.29%) and (0.57 and 1.94%) were observed in wheat and barley flours, respectively.

Moisture content and nitrogen free extract (NFE) were higher in wheat and barley flours compared with other source. These results are approached with those of **Cserhalmi *et al.*, (2001); Hussain *et al.*, (2006)** and **Rizk *et al.*, (2006)**.

Influence of different plant flours on dough mixing properties:

Incorporation of barley, flaxseed, mustard or defatted mustard flours at 30%, 15% and 10% levels showed differences in dough mixing properties as measured by Farinograph and extensograph. The results are depicted in Table (2). Addition of plant flour from different sources mainly increased the water absorption. The highest increase in water absorption was found with the addition of barley flour at 30% incorporation level (66.9%) followed by the flaxseed flour at 15% incorporation level (64.2%), defatted mustard at 10% incorporation level (63.6%) and mustard flour at 15% incorporation level (62.6%). The higher water absorption of wheat flour contained barley flour could be explained by its higher content of protein, fiber and ß-glucan. **(Knuckles *et al.*, 1997; Suzan & El-Azab, 2000; Masoud, 2001 and Kamal, 2003)**. Extent of increase in dough development time was high in case of 10% defatted mustard,15% flaxseed and 15% mustard flour blends, being (3.0, 2.5, and 2.0 min, respectively) compared to the control sample(wheat flour 100%). Arrival time was not markedly changed in case of 30% barley flour blend (1 min), while it was increased in case of 15% mustard, 10% defatted mustard and 15% flaxseed four blends (1.5 min). Dough stability, which indicates the dough strength, decreased from 4.5 to 4.0 min in case of 30% barley flour blend and increased from 4.5 to be 5.5 and 12.0 min in case of 15% mustard and 15% flaxseed flour blends, respectively. Dough weakening value were increased in case of 30% barley, 15% mustard and 10% defatted mustard (from 55 to 85, 140 and

Table 1. Chemical composition of wheat, barley, flaxseed, mustard and defatted mustard flours.

Type of flour	Moisture	Chemical composition (on dry weight basis %)				
		Protein*	Fat	Ash	Fiber	Total carbohydrates (NFE)**
Wheat flour	9.35**b**± 0.09	9.12**d**± 0.20	2.18**c**± 0.02	0.57**e**± 0.02	0.19**d**± 0.02	87.94**a**± 0.23
Barley flour	10.74**a**± 0.06	11.18**d**±0.22	2.22**c**± 0.06	1.94**d**± 0.01	1.29**c**± .0.11	83.36**b**± 0.04
Flaxseed flour	4.68**d**± 0.03	23.76**c**± 0.10	43.21**a**±0.08	4.10**c**± 0.02	10.09**a**±0.35	18.84**e**± 0.36
Mustard flour	4.17**e**± 0.02	30.55**b**±1.22	32.09**b**±0.70	4.58**b**± 0.02	8.16**b**± 0.49	24.**62d**± 1.23
Defatted mustard flour	6.34**c**± 0.12	48.01**a**±0.90	1.96**c**±0.04	5.17**a**± 0.01	9.67**a**± 0.06	35.19**c**± 0.87

Means within the same column followed by the same letter(s) are not significantly different at 0.05 level.,
Means of three replicates± standard error
* wheat flour (NX5.70); Barley, Flaxseed , Mustard and defatted mustard (NX6.25).
** NFE: Nitrogen Free Extract was calculated by difference.

Table 2. Farinogram and extensogram parameters of wheat flour and its blends with barley, flaxseed, mustard, defatted mustard flours.

Flour samples	Farinogram parameters					Extensogram parameters			
	Water absorption %	Arrival time (min)	Develop-ment time (min)	Dough stability (min)	Doudh weaking (B.U)	Elasticity (B.U)	Extensibility (mm)	Proportional number*	Energy of dough (cm^3)
Wheat flour (100%)	60.4	1.0	1.5	4.5	55	680	105	6.5	67
Barley flour blends (30%)	66.9	1.0	1.5	4.0	85	540	70	7.7	49
Flaxseed flour blends (15%)	64.2	1.5	2.5	12.0	30	290	110	2.6	28
Mustard flour blends (15%)	62.6	1.5	2.0	5.5	140	580	60	9.7	46
Defatted mustard flour blends (10%)	63.6	1.5	3.0	4.5	180	550	65	8.5	41

* Proportional number calculated by dividing of the elasticity on the extensibility.

180 BU, respectively), whereas the extent of decrease was marginal in case of 15% flaxseed blend. The weakness of dough might be due to using barley, mustard and defatted mustard flours which reduce the wheat gluten content (dilution effect) in the composite flour. These results are in accordance with those of **Abd El-Rahim (2005)** and **Sudha** ***et al.*****, (2007).**

Influence of different plant flours on the elastic properties of dough:

The effect of incorporation of different plant flours on extensible properties was also illustrated in Table (2). The resistance to extension elasticity values gradually decreased (from 680 to 540, 580, 550, and 290 BU) for 30% barley, 15% mustard, 10% defatted mustard and 15% flaxseed flour blends, respectively. The extensibility values were greatly reduced by the addition of 30% barley, 15% mustard and 10% defatted mustard flour blends (from 105 to 70, 60 and 65 mm, respectively), whereas it increased in case of 15% flaxseed flour blends. This may likely be due to the interaction between polysaccharides and protein from wheat flour as reported earlier by **Jones and Erlander (1967).** Area under the curve energy reduced from 67 to 49, 46, 41 and 28 cm^2 by the addition of 30% barley, 15% mustard, 10% defatted mustard and 15% flaxseed flour blends, respectively. The proportional number (R/E ratio) increased to a greater extent in case of 15% mustard flour blend (from 6.5 to 9.7), followed by 10% defatted mustard and 30% barley flour blends (8.5 and 7.7 respectively). In case of 15% flaxseed flour blend, there was a marginal decrease in R/E value (2.6). These results are in harmony with those of **Rizk** ***et al.*****, (2006)** and **Sudha** ***et al.*****, (2007).**

Chemical analysis of biscuit samples:

Proximate chemical analysis of accepted biscuit samples prepared from different composite flour samples in addition to flaxseed oil are given in Table (3). Results showed that incorporation of 10% defatted mustard flour, 15% mustard flour and 15% flaxseed flour resulted a considerable improved protein, ash and crude fiber biscuit. The protein content of defatted mustard fortified biscuit at 10% incorporation level was almost 1.37 times of control sample. These results are in line with the results reported by **Hooda and Jood (2005)** and **Tyagi** ***et al.*****, (2007).**

Consistent with the normal characteristics of biscuit, their moisture content was generally below 5%. The low level of moisture is an important property of biscuit, which contributes to their keeping quality and crisp texture. Moisture content in different biscuit samples ranged between 1.07 and 4.56%, the highest moisture content in flaxseed biscuit compared with other tested samples might be due to the higher water binding capacity of flaxseed flour. These results are in agreement with those obtained by **Mbofung** ***et al.*****, (2002); Tyagi** ***et al.*****, (2007)** and **Sudha et al., (2007).**

On the contrary, the replacement of shortening with 100% flaxseed oil adversely affects the protein content of biscuit sample compared to other fortified biscuit samples. This is probably due to the trace amount of protein in flaxseed oil.

Table 3. Chemical composition of biscuit prepared from different composite flours.

biscuit samples	Moisture	Chemical composition (on dry weight basis %)					Value of energy Cal/100g***
		Protein*	Fat	Ash	Fiber	Total carbohydrate (NFE)**	
Control (100% wheat flour)	3.71B±0.11	8.37E±0.05	14.01BC± 0.06	1.32A± 0.02	0.21D±0.02	76.09A±0.00	455.98AB±0.30
Barley biscuit (30% barley flour)	1.07D± 0.18	9.30CD± 0.38	14.62AB± 0.17	1.49C± 0.01	0.43C±0.02	74.15BC±0.27	456.44AB±0.82
Mustard biscuit (15% mustard flour)	2.41C±0.29	10.48B± 0.48	14.96A± 0.06	1.61B± 0.01	0.83A±0.00	72.15E±0.45	455.09AB± 0.44
Defatted mustard Biscuit (10% defatted mustard flour)	3.10BC± 0.29	11.44A± 0.23	13.71C± 0.20	1.68A± 0.02	0.70AB±0.10	72.46DE±0.41	449.36C±1.14
Flaxseed biscuit (15% flaxseed flour)	4.56A± 0.05	10.01BC± 0.05	14.42AB± 0.28	1.68A± 0.02	0.66B± 0.03	73.23CD±0.26	453.52B± 1.18
Flaxseed oil biscuit (100% flaxseed oil)	2.54C±0.22	8.97DE± 0.43	14.54AB± 0.19	1.44D± 0.01	0.17D±0.01	74.88B±0.51	457.58A± 0.76

Means within the same column followed by the same letter(s) are not significantly different at 0.05 level.,
Means of three replicates± standard error
*(NX6.25).
**NFE: Nitrogen Free Extract was calculated by difference.
*** (Protein X 3.47 + Fat X 8.37 + carbohydrate X 4.07).

The fat content of mustard fortified biscuits at 15% incorporation level was significant ($P < 0.05$) higher than that of control and defatted mustard fortified biscuit samples. Data also indicated that carbohydrates content was ranged between 72.15 and 74.88% for different fortified biscuit samples. The energy content of 100g of these prepared biscuits is quite high and constitutes more than one third of daily energy requirements (1000-1500 Kcal per day) for a school age child as recommended by **FDA, (2003).**

Incorporation of 30% barley, 15% mustard, 10% defatted mustard and 15% flaxseed flours increased the ash content of fortified biscuit samples (1.32-1.68%), suggesting an important increase in mineral content of biscuit.

Influence of different plant flours and flaxseed oil on physical characteristics of biscuit:

Biscuit prepared using barley, mustard, defatted mustard and flaxseed flours at different levels were evaluated for various physical characteristics Table (4). The thickness of biscuit prepared from 20, 25 and 30% flaxseed flour was significantly ($P< 0.05$) reduced (from 0.67 to 0.47 and 0.50 cm, respectively). The diameter of flaxseed fortified biscuits at all incorporation levels did not change. The greater significance ($P< 0.05$) increase in the spread ratio for the flaxseed fortified biscuits occurred with 25% incorporation level (10.03), while mean values of the spread ratio of other biscuit samples was not significance.

Data regarding the mean values of the weight of the biscuits showed gradual decrease as the replacement level of flaxseed flour increase. The lowest values were recorded in the biscuits at 25 and 30% incorporation level (10.18 and 9.88 g, respectively). The same trend was also found with mean values of the volume, while the specific volume of prepared biscuit samples was significantly ($P< 0.05$) increased by replacing wheat flour with 10, 20, 25 and 30% flaxseed flour (from 0.499 to 0.658, 0.674, 0.693 and 0.619 g/cm^3, respectively). Results disclosed that the diameter, the thickness and the spread ratio of the biscuits prepared from the composite flour containing different levels of barley flour did not change compared to the control sample, while the weight of the biscuits was significantly ($P< 0.05$) improved (from 8.87 to 10.02 g) at 15% incorporation level, as well as the significance improvement in the specific volume was found in the biscuit samples with 25 and 30% incorporation levels (from 0.504 to 0.664 and 0.672 g/cm^3, respectively).

From the same table, it could be noticed that the diameter, the thickness and the spread ratio of mustard, defatted mustard fortified biscuits had the same trend observed for barley fortified biscuits. Whereas the weight and the volume of the biscuits were reduced but the specific volume at 20 and 25% incorporation levels was significantly ($P< 0.05$) improved (from 0.593 to 0.999 g/cm^3, for mustard fortified biscuits and (from 0.548 to 0.756 g/cm^3) for defatted mustard biscuits, respectively.

On the other hand, replacement of 25, 50, 75 and 100% of shortening with an equivalent weight of flaxseed oil in the biscuit recipe did not affect the diameter, the thickness, the spread ratio and the weight of biscuits, while mean values of the volume were significantly ($P<0.05$)

Table 4. Physical characteristics of biscuits prepared from different plant flours and flaxseed oil.

Biscuit sample	Replacement level (%)	Diameter (D) cm	Thickness (T) cm	Spread ratio(D/T)	Weight g	Volume cm^3	Density g/cm^3
Barley flour	0	4.60a±0.06	0.47a±0.03	9.98a±0.89	8.87bcd±0.19	17.67a±0.67	0.504d±0.02
	5	4.70a±0.06	0.50a±0.00	9.40a±0.12	8.42cd±0.12	14.33b±0.33	0.588b±0.02
	10	4.67a±0.03	0.50a±0.00	9.33a±0.07	9.29abc±0.49	17.67a±1.45	0.529cd±0.02
	15	4.73a±0.03	0.50a±0.00	9.47a±0.07	10.02a±0.23	18.00a±0.58	0.557bc±0.01
	20	4.70a±0.00	0.47a±0.33	10.18a±0.78	8.22d±0.19	14.33b±0.33	0.574bc±0.01
	25	4.70a±0.06	0.47a±0.33	10.17a±0.67	9.51ab±0.22	14.33b±0.33	0.664a±0.01
	30	4.67a±0.03	0.47a±0.33	10.10a±0.70	8.28d±0.11	12.33b±0.33	0.672a±0.01
Mustard flour	0	4.37a±0.07	0.47a±0.03	9.45a±0.66	7.52a±0.21	13.00a±1.53	0.593d±0.06
	5	4.30a±0.06	0.47a±0.03	9.30a±0.60	7.26ab±0.22	12.67a±0.33	0.574d±0.02
	10	4.43a±0.03	0.43a±0.03	10.33a±0.67	6.61ab±0.21	7.33b±0.67	0.912ab±0.06
	15	4.43a±0.07	0.47a±0.03	9.62a±0.82	7.11ab±0.64	9.00b±0.58	0.789bc±0.04
	20	4.43a±0.07	0.43a±0.03	10.37a±0.88	6.99ab±0.20	7.00b±0.00	0.999a±0.03
	25	4.47a±0.33	0.43a±0.03	10.42a±0.71	6.45bc±0.29	8.00b±1.15	0.833abc±0.98
	30	4.47a±0.33	0.40a±0.58	11.68a±1.80	5.59c±0.23	8.33b±0.33	0.674cd±0.52
Defatted mustard flour	0	4.47b±0.03	0.50a±0.00	8.93b±0.07	8.57b±0.09	15.67a±0.67	0.548c±0.00
	5	4.60a±0.00	0.50a±0.00	9.20b±0.00	9.48a±0.25	15.67a±0.88	0.607bc±0.02
	10	4.60a±0.06	0.50a±0.00	9.20b±0.12	8.86ab±0.19	11.67b±0.88	0.768a±0.08
	15	4.53ab±0.03	0.47a±0.03	9.82b±0.72	7.22c±0.45	10.00bc±1.00	0.729ab±0.05
	20	4.50b±0.00	0.50a±0.00	9.00b±0.00	6.84c±0.13	9.33c±0.33	0.735ab±0.03
	25	4.50b±0.00	0.40b±0.00	11.25a±0.00	7.29c±0.38	9.67bc±0.33	0.756a±0.05
Flaxseed flour	0	4.60ab±0.06	0.67a±0.03	6.93b±0.29	12.62a±0.87	25.33a±1.45	0.499b±0.01
	5	4.63ab±0.07	0.67a±0.03	6.99b±0.43	12.64a±0.15	25.33a±0.67	0.499b±0.01
	10	4.73a±0.03	0.57ab±0.03	8.41ab±0.49	10.51bc±0.16	16.00bc±0.58	0.658a±0.01
	15	4.60ab±0.06	0.60ab±0.06	7.80ab±0.73	11.62ab±0.18	19.33b±1.45	0.607ab±0.04
	20	4.60ab±0.06	0.50b±0.06	9.47ab±1.16	10.74bc±0.14	16.00bc±0.58	0.674a±0.03
	25	4.63ab±0.03	0.47b±0.03	10.03a±0.74	10.18c±0.19	15.00c±1.53	0.693a±0.07
	30	4.47b±0.03	0.50b±0.06	9.19ab±1.13	9.88c±0.15	16.00bc±0.58	0.619a±0.03
Flaxseed oil	0	4.50a±0.000	0.50a±0.00	9.00a±0.00	9.05ab±0.75	17.33a±1.20	0.521b±0.02
	25	4.50a±0.000	0.43a±0.03	10.50a±0.75	7.64b±0.35	13.67b±0.67	0.559b±0.00
	50	4.50a±0.000	0.47a±0.03	9.75a±0.75	9.24a±0.17	15.00b±0.58	0.617a±0.02
	75	4.50a±0.000	0.47a±0.03	9.75a±0.75	8.33ab±0.45	13.00b±0.58	0.641a±0.02
	100	4.47a±0.03	0.50a±0.00	8.93a±0.07	7.79b±0.18	12.67b±0.33	0.615a±0.01

Means within the same column followed by the same letter(s) are not significantly different at 0.05 level.

decreased (from 17.33 to 15.00, 13.00 and 12.67 cm^3) for the biscuits samples with 50, 75 and 100% flaxseed oil. The specific volume of the biscuits was significantly (P< 0.05) improved (from 0.521 to 0.617, 0.641 and 0.615 g/cm^3), for the biscuit samples with 50, 75 and 100% flaxseed oil. The changes in these variables may be related to the moisture, fiber and protein contents of flaxseed, barley, mustard and defatted mustard flours as well as the characteristics of flaxseed oil and its content.

Several studies reported that incorporation of wheat bran at levels 20, 30 and 40% decreased the spread ratio of the biscuits from 8.38 to 7.52 without much change in the thickness of the biscuit, while incorporation of rice bran at the same levels did not affect the thickness of the biscuits from 8.38 to 7.76. Oat bran incorporation showed an increase in diameter (from 55.3 to 55.6 and 56 mm), and thickness (from 6.6 to 5.5 mm) and increased spread ratio of the biscuits (from 8.38 to 9.34) **(Sudha *et al.*, 2007)**. Furthermore, incorporation of flaxseed flour at level 5, 10, 15, 20, 25 and 30% decreased the spread ratio of the cookies (from 58.33 to 47.71) but increased the diameter and the thickness of the cookies (from 260.33 mm to 291 mm) and from 43.33 mm to 61 mm, respectively, **(Hussain *et al.*, 2006)**.

Influence of different plant flours and flaxseed oil on sensory characteristics of biscuit:

Values of sensory evaluation of biscuit as appearance of surface, texture, color, crumb color, flavor, taste, mouth feel and overall acceptability are presented in Table (5). Color is very important parameter in judging the properly baked biscuit that not only reflects the suitability of raw material used for the preparation but also provides information about the formulation and quality of the product (Figs. 1- 5). The color scores of biscuit prepared from the composite flour containing flaxseed flour at replacement level 5, !0, 15% were not significantly (P>0.05) different from the control, while increasing the replacement level of flaxseed flour beyond 15% resulted in significantly (P< 0.05) decrease in color scores of the biscuits. The same trend was also observed in the other sensory attributes of the biscuits.

Data also showed that, flavor, taste, texture and overall acceptability were improved as the replacement level of barley flour was increased up to 30%, but this important was not significant. The overall acceptability of barley fortified biscuits was 90.2% for the biscuits with 30% barley flour against 83.73% for the control sample. Panelists were accepted the biscuits prepared from the composite flour containing barley flour at any replacement level.

Biscuits contains 15 and 20% mustard flour showed mean maximum color scores of 8.93 and 8.8, while were the highest values obtained among the other replacement levels and control. The appearance of surface, crumb color and overall acceptability were also significantly (P<0.05) highest in the 15% mustard fortified biscuits. While, texture, flavor and mouth feel were not significantly (P>0.05) different from the control for any of the replacement levels. However, increasing the replacement level of mustard flour beyond 20% caused significantly (P< 0.05) changed in the taste and overall acceptability (from 16.07 to 13.13 and 11.80 and from 77 to 76.33 and 71.73) for mustard fortified biscuits at replacement levels 25 and 30%, respectively.

Biscuits containing 10% defatted mustard flour showed mean maximum appearance of surface score of 8.87, which was the highest value obtained among the replacement levels 20 and 25% and control. The texture, color, flavor and mouth feel were not significantly (P>0.05) different from the control for any of the replacement levels. However, the scores of crumb color, taste and overall acceptability were significantly (P<0.05) decreased as the replacement levels of defatted mustard flour increased up to 20 and 25%.

Replacement of 100% shortening with an equivalent weight of flaxseed oil in the biscuit recipe brought about 11.92, 16.28, 14.49 and 7.39% increasing in the appearance of surface, color, crumb color and overall acceptability of the biscuit with relatively no change in texture, flavor, taste and mouth feel of the biscuit.

These results are in harmony with those obtained by **Sharma *et al.*, (1999)** who reported that, increasing the level of flaxseed flour, matri flour and cowpea flour in biscuits resulted in the significant decrease in the sensory attributes of the cookies.

The obtained results are also similar to **Singh *et al.*, (2005)** who reported that, highest sensory score of the biscuits containing soy flour at 15% incorporation levels. **Eneche (1999)** reported that highest sensory scores in terms of flavor, texture and general acceptability for the biscuits prepared from 65% millet flour and to 35% pigeon pea flour.

Hussain *et al.*, (2006) concluded that cookies containing flaxseed flour in their formulation were acceptable at 20% incorporation level. **Sudha *et al.*, (2007)** mentioned that the quality of biscuits was acceptable at 20% incorporation level of wheat bran and barley bran and at 30% incorporation level of oat bran.

CONCLUSION

Addition of flour as a source of protein, dietary fiber, lignans, omega-3 and omega-6 fatty acids from plant sources (barley, mustard and flaxseed) to wheat flour affected the rheological characteristics in various ways. Biscuit containing flaxseed (15%) and mustard (15%), defatted mustard (10%), barley (30%) flours and flaxseed oil (100%) are highly acceptable in terms of nutritional and sensory attributes. In addition the energy content of 100 g of these biscuits is quite high and constitutes more than one third of daily energy requirements (1000-1500 Kcal per day) for a school age child.

Table 5. Organoleptic evaluation of biscuits prepared from different plant sources.

Biscuits sample	Replace-ment level (%)	appearance of surface (10)	Texture (20)	Color (10)	Crumb color (10)	Flavor (20)	Taste (20)	Mouthful (10)	Overall acceptability (100)
Barley flour	0	8.33 A	16.20B	8.33A	8.40A	16.87A	17.47 A	8.13 A	83.73A
	5	8.40 A	16.73AB	8.53A	8.80A	17.67A	17.73 A	8.47 A	86.33A
	10	8.80 A	17.13AB	8.80A	8.60 A	17.73A	18.00 A	8.33 A	87.40A
	15	8.80 A	17.20AB	8.93A	8.73A	17.87A	18.20 A	8.53 A	88.27A
	20	9.00 A	17.73AB	8.87A	8.60A	18.13A	18.20 A	8.60 A	89.13A
	25	8.93 A	18.07AB	8.93A	8.80A	18.13A	18.53 A	8.73 A	90.13A
	30	8.67 A	18.47A	8.80A	8.33A	18.40A	18.73 A	8.80A	90.20A
MSD		1.165	2.104	1.204	1.275	1.597	1.845	0.952	7.665
Mustard flour	0	7.07 B	16.47AB	6.93B	7.53B	16.00ABC	16.07A	7.53AB	77.00BC
	5	7.47 AB	16.80AB	7.80AB	8.20AB	16.73AB	16.87A	7.80AB	81.67AB
	10	7.93 AB	16.67AB	8.20AB	8.73AB	17.07AB	17.00A	8.20AB	83.80AB
	15	8.60 A	17.27A	8.93A	9.13A	17.60A	17.13A	8.53A	87.20A
	20	8.53 A	16.53AB	8.80A	8.93A	16.40AB	15.13AB	7.73AB	82.07AB
	25	8.27 AB	15.73AB	8.27AB	8.67AB	15.13BC	13.13BC	7.13AB	76.33BC
	30	8.00 AB	15.07B	7.80AB	8.27AB	14.00C	11.80C	6.80B	71.73 C
MSD		1.456	2.017	1.466	1.369	2.223	2.418	1.519	7.713
Defatted mustard flour	0	7.40B	16.60A	8.13ABC	8.13AB	17.13AB	16.93A	8.00A	82.33AB
	5	8.27AB	17.07A	8.60AB	8.67A	17.60AB	17.47A	8.33A	86.00AB
	10	8.87 A	17.60A	8.93 A	8.93A	17.87A	17.67A	8.53A	88.40A
	15	7.93 AB	17.27A	8.40 AB	8.27AB	16.87AB	15.67AB	8.27A	82.67AB
	20	7.20B	16.73A	7.60 BC	7.33BC	16.20AB	13.73BC	7.60A	76.40BC
	25	7.07B	16.53A	7.00 C	6.80C	15.53B	12.20C	7.07A	72.20C
MSD		1.307	1.879	1.227	1.211	2.226	2.722	1.509	9.737
Flaxseed flour	0	7.87A	17.20AB	8.40 A	8.40 A	17.87ABC	17.47AB	7.40BC	84.60AB
	5	7.80A	16.87ABC	8.13 A	8.13A	18.20ABC	18.07AB	8.27AB	85.47AB
	10	7.60A	17.60 AB	7.93 A	7.93A	18.40 AB	18.33AB	9.07A	86.87AB
	15	7.80A	17.87 A	8.33 A	8.13A	18.60 A	18.67A	9.27A	88.67A
	20	6.93AB	16.40 BC	6.80 B	6.67B	17.47ABC	17.33AB	8.27AB	79.87BC
	25	6.00B	15.60 BC	5.67C	5.67BC	16.60BC	16.40BC	7.53BC	73.47CD
	30	5.93B	15.07 C	5.53C	5.53C	16.33C	15.27C	6.60C	70.27D
MSD		1.088	2.076	1.071	1.102	1.986	1.934	1.139	7.455
Flaxseed oil flour	0	7.80B	17.27 A	7.80B	7.80B	17.60A	17.47A	8.07A	83.80B
	25	8.13AB	18.07 A	8.53AB	8.40AB	17.67A	17.93A	8.53A	87.27AB
	50	8.60AB	18.00 A	8.87A	8.47AB	17.93A	18.07A	8.47A	88.40AB
	75	8.73A	17.93 A	9.07A	8.93A	18.07A	18.33A	8.73A	89.80A
	100	8.73A	18.13 A	8.80A	8.87A	18.07A	18.40A	9.00A	90.00A
MSD		0.928	1.396	0.972	0.965	1.359	1.083	1.003	5.875

Means within the same column followed by the same letter(s) are not significantly different at .05 level

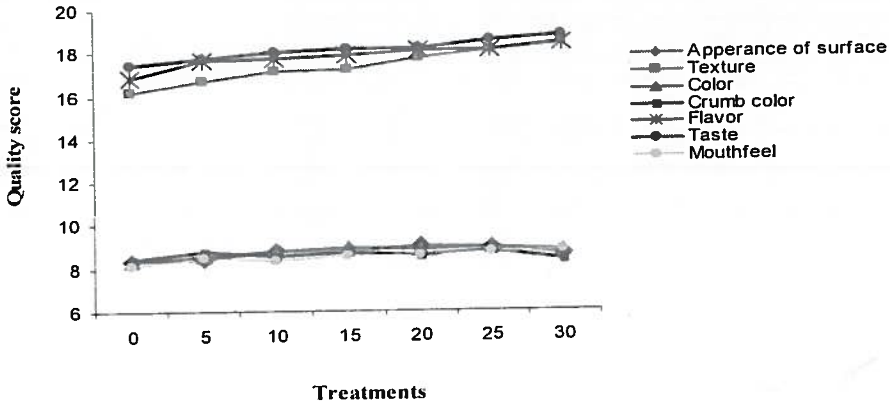

Fig. 1. Quality score of biscuits with different barley flour content.

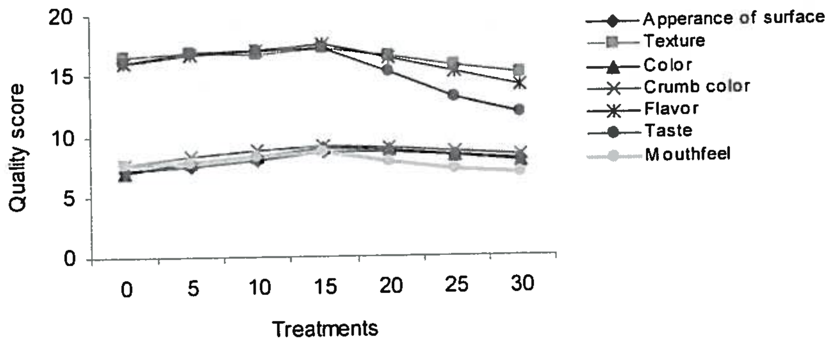

Fig. 2. Quality score of biscuits with different mustard flour content.

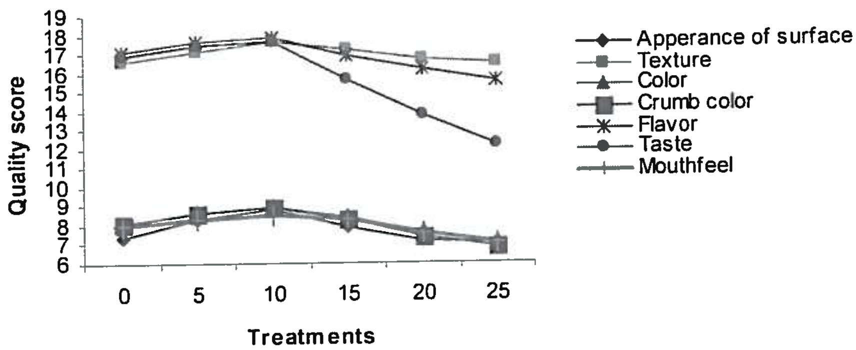

Fig. 3. Quality score of biscuits with different defatted mustard flour content.

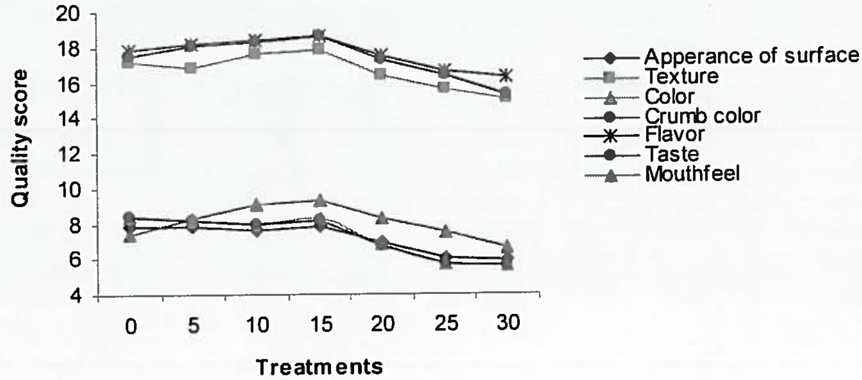

Fig. 4. Quality score of biscuits with different flaxseed flour content.

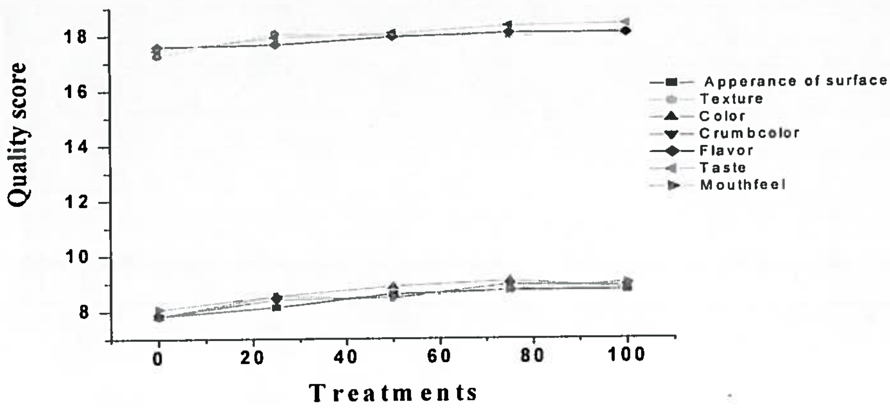

Fig. 5. Quality score of biscuits with different flaxseed oil content.

REFERENCES

AACC (1995). *American Association of Cereal Chemists. Approved Methods of the AACC 9 th ed. Method: 54-21 farinograph; Method: 54-10 extensograph: Method 10-85 rapeseed displacement, first approved April 1961, revised October 1982. The Association, St. Paul, FIN.*

Abd El-Rahim, E.A. (2005). Effect of baking process on the quality of flat bread prepared from some cereal flour blends. **Egypt. J. Nutr., Vol., xx, 1, 179.**

Amarowicz, R.; U.N. Wanasundara; M. Karamac and F. Shahidi (1996). Antioxidant activity of ethanolic extract of mustard seed. **Nahrung, 40; 261-263.**

AOAC (2000). *Official Methods of Analysis.Association of Official Analytical Chemists (17th ed.),Gaithersburg, Maryland. USA.*

Bierenbaum, M.L.; R. Richstein; T.R. Watkins (1993). Reducing athrogenic risk in hyperlipidemic humans with flaxseed supplementation: a preliminary report. **J. Am. College of Nutr.,12;401-504.**

Brennan, C.S. and L.J. Cleary (2005). The potential use of cereal (1→3, 1→4) – β-D-glucans as functional food ingredient. **J. Cereal Sci., 42; 1- 13.**

Chavan, J.K. and S.S. Kadam (1999). Nutritional enrichment of bakery products by supplementation with non-wheat foods. **Crit. Reviews in Food Sciences and Nutrition 33; 189- 226.**

Cserhalmi, Zs.; Zs. Márkus;B. Czukor; B. Baráth and M. Tóth (2001). Physico-chemical properties and food utilization possibilities of re- treated mustard seed. **Innovative Food Science & Emerging Technologies 1; 251- 254.**

Cunnane, S.C.; M.J. Hamadeh; A.C. Liede; A.C. Thompson; T.M.S. Wolever; D.J.A. Jenkins (1995). Nutritional attributes of traditional flaxseed in healthy young adults. **Am. J. Clin. Nutr., 61; 62- 68.**

Eneche, E.H. (1999). Basciuts making potential of millet/pigonpea flour blends. **Plant Foods for Human Nutrition, 54 (1); 21-27.**

FAO (2003). Food and Agriculture Organization of the United Nation. Production Year book.**Vol. 57, pp. 74; 81 and 83.**

FDA (2005). Food and Drug Administration allows barley products to claim reduction in risk of coronary heart disease. FDA News, December 23. http://www.fda.gov/bbs/topics/news/2005/NEW01287.html

Hooda, S. and S. Jood (2005). Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. **Food Chem., 90; 427 – 435.**

Hussain, S.; F.M. Anjum; M.S. Buitt; M.I. Khan and A. Asghar (2006). Physical and sensoric attributes of flaxseed flour supplemented cookies. **Turk J. Biol., 30; 87- 92.**

Jenab, M. and L.U. Thompson (1996). The influence of flaxseed and lignan on colon carcinogenesis and beta-glucuronidase activity. **Carcinogenesis, 17: 1343- 1348**

Jenkins, D.J.A.; C.W. Keendall; E. Vidgen; S. Agarwal; A.V. Rao; R.S. Rosenberg; E.P. Diamandis; R. Novokmt; C.C. Mehling; T. Perera; L.C. Griffin and S.C. Cunnane (1999).

Health aspects of partially defatted flaxseed, including effectson serum lipids, oxidative measures, and ex vivo androgen and progestin activity: a controlled crossover trial. **Am. J. Clin. Nutr., 69; 395- 402.**

Jones, R.W. and S.R. Erlander (1967). Interactions between wheat proteins and dextrains. **Cereal Chem., 44; 447 – 453.**

Kamal, H.M. (2003). Production and quality of multi-grain balady bread. **Ph.D. Thesis, Fac. of Agric,. Ain Shams Univ., Egypt.**

Knuckles, B.E.; C.A. Hudson; M.M. Chiu and R.N. Sayre (1997). Effect of β-glucan barley fractions in high fiber bread and pasta. **Cereal Foods World, 42; 94 – 100.**

Leelavathi, K. and P.H. Rao (1993). Development of high fiber biscuits using wheat bran. **J. Food Sci. & Technol., 30; 187 - 191.**

Masoud, M.A. (2001). Study on some technological methods to improve quality for some bakery products. **Ph.D. Thesis, Fac. of Agric., Moshtohor, Zagazig Univ. (Benha Branch), Egypt.**

Mbofung, C.M.F. and K. Waldron (1997). Nutritional and sensory characteristics of cookies made from wheat: HTC speckled bean composite flours. **Can. J. Biol. Bioch. Sc., 7; 110- 114.**

Mbofung, C.M.F.; T. Silou and I. Mouragadja (2002). Chemical characterization of safou (*Dacryodes edulis*) and evaluation of its potential as an ingredient in nutritious biscuits. **Forests, Trees and Livelihoods 12; 105- 117.**

McIntosh,G.H.; J. Whyte; T. Mc-Arthur and P.J.Nestel (1991). Barley and wheat foods influence on plasma cholesterol concentrations in hyperchol-esterolemic men. **Am. J. Clin. Nutr., 53; 1205-1209.**

Newman, C.W. and C.F. McGurie (1985). *Nutritional quality of barley. In: Barley Chemistry and Technology. Rammsson, D.C. (Ed.). Am. Soc. Agronomy, Madison, WI., USA.*

Newman, R.K. and C.W. Newman (1991). Barley as a food grain. **Cereal Foods World 36; 801- 805.**

Prasad, K. (1998). Purified secoisolariciresinol diglucoside (SDG) as an antioxidant. U.S. Patent, 5846944.

Prentice, N.; L.T. Kissel; F.C. Lindsay and W.T. Yamzaki (1978). High fiber cookies containing brewers'spent grain. **Cereal Chem., 55; 712- 721.**

Ragab, G.; W. Baszczak; J. Forual and A. Ramy (2005). Effect of surfacting on the rheological behaviour of biscuit dough, quality and microstructure of biscuits. **Egypt. J. Food Sci., 33 (1):1- 13.**

Rhee, M.S.; S.Y. Lee; R.H. Dougherty and D.H. Kang (2003). Antimicrobial effects of mustard flour and acetic acid against *Escherichia coli* 0157:H7, *Listeria monocytogenes* and *Salmonella enterica Serovar typhimurum*. Appl. & Environ. **Microbiol., 69; 2959- 2963.**

Rizk, I.R.S; M.M.M. Abd El-Razik; E.A. Abd El-Rahim and M.R.G. Yousif (2006). Effect of selected cereal flours on chemical composition, rheological properties and cake quality. **Egypt. J. Food Sci., 34; 59 - 80.**

Sai Manohar, R. and P.H. Rao (1999). Effect of emulsifiers, fat level and type on the rheological characteristics of biscuit dough and quality of biscuits. **Journal of Science of Food and Agriculture, 79; 1223-1231.**

SAS (1996). *Statistical Analysis System for windows. In: SAS / STAT user's guide, version 4.10, release 6.12. SAS Institute Inc. Cary, NC. USA.*

Sharma, S.; U. Bajwa and H.P.S. Nagi (1999). Rheological and baking properties of cowpea and wheat flour blends. **J. Sci. Food Agric., 7; 656 – 662.**

Serraino, M.R. and L.U. Thompson (1992). The effect of flaxseed supplementation on early risk markers for colon carcinogenesis. **Cancer Lett.,63;159- 165.**

Singh, D.P.; S. Ahmed; P.K. Srivastava. and A.K. Srivastava (2005). Effects of soy flour incorporation on nutritional, sensory and textural characteristics of biscuits. **Beverage and Food World, 32; 27 – 31.**

Sudha, M.L.; R. Vetrimani and K. Leelavathi (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. **Food Chem., 100; 1365- 1370.**

Suzan, R.M. and M.A. El-Azab (2000). Supplementation of balady bread with barley, corn, defatted soy and sorghum flours for improving its nutritive value. **Egypt. J. Nutr., Vol. xv., 1; 175.**

Tyagi, S.K.; Manikantan M.R.; H.S. Oberoi and G. Kaur (2007). Effect of mustard flour incorporation on nutritional, textural and organoleptic characteristics of biscuits. **J. Food Eng., 80; 1043- 1050.**

الخواص الطبيعية والكيميائية والريولوجية والحسية للبسكويت المدعم بمصادر نباتية مختلفة

[1]

وفاء كامل بهجات [١] - نجوى موسى رسمى [٢]، محمد عبد الجليل خورشيد [١] - ميرفت إبراهيم فودة [١] - آمال أحمد حسن [٢]

١- قسم الالبان - المركز القومى للبحوث - الدقى - مصر.

٢- قسم علوم الأغذية - كلية الزراعة - جامعة عين شمس- شبرا الخيمه- مصر.

أدى إزدياد وعى المستهلك نحو الصحه وجودة الغذاء إلى تشجيع إجراء دراسات على استخدام الخامات الغنية بالمغذيات لإنتاج أغذية صحيه ذات جودة غذائية عالية، لذا كان الهدف من البحث دراسة تأثير إضافة دقيق من مصادر نباتية (الكتان - الخردل - الشعيرالعارى) بالإضافة الى زيت الكتان على الخواص الطبيعية والكيميائية والريولوجية والحسية وجودة عملية الخبيز للبسكويت. حيث تم استبدال دقيق القمح بدقيق كل من النباتات موضع الدراسة بنسب استبدال 5 ، 10 ، 15 ، 20 ، 25 ، 30 ٪ كما تم إحلال الدهن بزيت الكتان بنسب إحلال 25 ، 50 ، 75 ، 100% فى انتاج البسكويت.

وقد أظهرت النتائج أن محتوى الرماد والبروتين الكلى والالياف لدقيق النباتات تروح بين 1.94 و5.17 ؛ 11.18 و48.01 ؛ 1.29 و10.09% على الترتيب. كما أوضحت قياسات الفارينوجراف والاكستنسوجراف أن إضافة دقيق النباتات أدى إلى حدوث زيادة فى نسب امتصاص الماء فى عجائن دقيق القمح وبلغت هذه الزيادة الحد الاقصى (66.9٪) فى عجينة دقيق القمح مع دقيق الشعير وتم الحصول علي أقصى مدة ثبات للعجينة فى عجينة دقيق القمح مع دقيق الكتان (12 دقيقة) ، بينما حدث تناقص لكل من درجة الإضعاف وأقصى مقاومة للشد والإنسيابية والطاقة (المساحة تحت المنحنى).

أظهرت النتائج وجود زيادة فى محتوى البسكويت من الرماد والالياف والبروتين حيث قدرت الزيادة فى البروتين بنحو 1.37 ، 1.25 ، 1.19 ، 1.11 ضعفاً نتيجة لإضافة دقيق الخردل منزوع الدهن (10٪) ودقيق الخردل (15٪) ودقيق الكتان (15٪) ودقيق الشعير (30٪) على الترتيب. كما أظهرت نتائج التقييم الحسى أن عينات البسكويت التى تحتوى على 15٪ من كل من دقيق الكتان والخردل و 10٪ من دقيق الخردل منزوع الدهن و30٪ من دقيق الشعير و100٪ من زيت الكتان سجلت أعلى القيم فى جميع الخواص الحسية المختبره. كما أتضح أن البسكويت الناتج يمد

بأكثر من ثلث الاحتياجات اليومية من الطاقة الموصى بها للطفل فى عمر المدرسة (1000 – 1500 كيلو كالورى / يوم).

أوضحت النتائج المتحصل عليها إمكانية استبدال دقيق القمح بدقيق الكتان والخردل والخردل منزوع الدهن والشعير بمستويات استبدال15،10،30٪ على الترتيب، كما يمكن إحلال الدهن المستخدم فى صناعة البسكويت بزيت الكتان حتى نسبة إحلال 100٪ دون حدوث تغيرات غير مرغوبة فى المنتج النهائى.

تحكيم : أ.د. محمد فرج نصر خلاف — أ.د. أحمد توفيــق العاقل