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CHEMICAL, RHEOLOGICAL AND SENSORY PROPERTIES OF WHEAT-OAT FLOUR COMPOSITE SNACKS AND ITS HEALTHY BENEFICIAL EFFECT

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ABSTRACT

Snacks recipes were prepared; using 100% whole meal wheat flour and100% wheat flour , 25 and 50% replacement levels of whole meal wheat flour (WWF) or wheat flour (WF) by Oat flour (OF). Chemical, rheological and organoleptic characteristics of the prepared snacks were studied. Results indicated that there was a gradual increment in water absorption, dough development time, weakening and mixing tolerance index with increasing OF in the snacks. On the other hand, the stability time and arrival time decreased by adding OF to WWF or WF at two levels replacement. The adding of OF to WWF or WF led to increased rapid viscoanalyzer parameters. Regarding color, flavor and crispiness, it could be noticed that no significant differences between snacks from WWF or WF (control) and snacks from mixtures of WWF with OF or WF with OF at two levels. Significant differences were observed when wheat flour was replaced with OF in snacks for taste, appearance and overall acceptability, in addition to its beneficial effect in improving the criteria of the metabolic syndrome. It can be concluded that OF could be useful for preparation of snacks for those suffering from Metabolic syndrome (Obesity, diabetes and hyperlipidemia**).**

Key words: Snacks**,** Chemical, rheological**,** Metabolic syndrome, wheat flour, oat flour**.**

INTRODUCTION

Oat belongs to the family *Poaceae* and genus *Avena*. *Avena sativa L*. is the species that is currently cultivated (McMullen, 2000). Oats are harvested with their hulls on them (Hoseney, 1994). Among cereals, oats are unique for their high protein as well as lipid contents. Oat is a perfect source of soluble dietary fiber ß-glucan, a non-starchy polysaccharide available in the cell walls of the aleurone layer in bran. The most important beneficial effects of ß-glucan are their contribution to a lowering of serum blood cholesterol as well as moderating blood glucose in diabetics (McMullen, 2000; Webster, 1996). Considering the progressive demand for products having lower calories and high levels of dietary fibers, the developing and implementation of dietary breads is an important step forward in meeting these demands (Fortuna *et al.,* 2004).

Oats (*Avena sativa L*.), have received increased interest in human foods due to the dietary benefits associated with β-glucans (FDA, 1997). However, the use of oats in baked products has been limited due to the inability of oat flour to form cohesive, viscoelastic dough that can retain gas, as that found in the gluten network of wheat dough. Addition of wheat gluten to oat flour improves the processing properties of the dough and the quality of the final product (Salmenkallio-Marttila *et al*., 2004; Flander *et al*., 2007).

The addition of oat products to wheat flour affects water absorption and rheological properties of dough. Oat products incorporated into bread may decrease its volume; however, they improve the structure of crumb together with taste, aroma and nutritive value of the final product (Oomah & Lefkovitch, 1998)

Oats are an excellent food for lowering cholesterol and reducing risk of heart disease because of the high soluble fiber content. Almost one third of total fatty acids present in oats are polyunsaturated which are required for good health. Oats are rich in B vitamins, minerals and contain the antioxidant avenathramide. Oat bran is rich in ß-glucan, and these viscous polysaccharides lower the rate of carbohydrate and lipid absorption. Oats are a good choice for diabetics and people conscious about their weight. Phenol compounds in oats are bioavailable and have anti-inflammatory, antiatherogenic, and antioxidant properties (Lifschitz et.al., 2002; Bratt *et al*. 2003; Dykes *et al*., 2007).

The important nutritional attributes of oats relate to the lowering of blood cholesterol and sugar. Oat contains a high percentage of desirable complex carbohydrates which have been linked to reduced incidence of different kinds of cancers. The presence of total and free sugars in oats is very low in comparison with other cereal grains (Lambo et.al., 2004). Whole-grain oats have the greatest percentage of fat among the major cereals with a good balance of the essential fatty acids, which are primarily unsaturated (Salehifar & Shahedi, 2007). The high content of oleic and linoleic acid result in a favorable polyunsaturated to saturated fatty acids ratio of 2:2. Oat flour also has antioxidant properties. In an equal weight basis, the purified oat antioxidant has effectiveness equal to that of commonly used commercial antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (Salehifar & Shahedi, 2007). The metabolic syndrome (MetS) is a collection of conditions associated with metabolic disorders and increased risk of developing cardiovascular disease. Conditions such as dyslipidemia, high blood pressure, impaired glucose tolerance and abdominal fat accumulation fall into this category (Phillips, 1978, Reaven 1988, Grundy 2004). The most widely used definitions were established by the World Health Organization (WHO) and the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATPIII). These organizations regarded the metabolic syndrome as a cardiovascular and type II diabetes mellitus risk factors (Grundy, *et.al*., 2005).

The reported research was aimed at determining the effect of addition of whole oat meal on the chemical, physical properties of flour and wheat dough as well as the quality of snacks. In addition the beneficial health effect of the snacks will be investigated.

MATERIALS, SUBJECTS AND METHODS

MATERIALS

1. Wheat grains Variety (Giza 168) were obtained from Field Crops Department, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt.
2. Oats flour, sugar, vanilla, shortening, active dry yeast, salt and cumin purchased from the local market, Cairo, Egypt.

METHODS

MILLING

Wheat grains varieties were manually cleaned, tempered to 14% moisture content, then milled using Quadrumat Junior flour mill (Model MLV-202, Switzerland). The obtained flour represent whole flour mill (100% extraction), then sieved to obtain flours of 72% extraction.

PREPARATION OF FLOUR MIXTURES

Six blends with WF were prepared and compared with control sample (WWF) as follows: three levels of OF (0%, 25% and50%) and three levels of mixed WF with OF (0%, 25% and 50%). The samples were stored in air- -tight containers and kept in a refrigerator (7ºC) till used.

RHEOLOGICAL PROPERTIES

Rheological properties of doughs were evaluated using Farinograph and extensograph according to AACC (2000). The viscoelastic properties of the prepared oat flour, wholemeal wheat flour and wheat flour were examined using a Rapid Visco Analyser-4 (Newport Scientific, Australia) according to AACC (2000).

PREPARATION AND EVALUATION OF SNACKS

Different blends were mixed at the rate of 100g blended flour with 1.5 g active dry yeast, sodium chloride (1.5 g), sugar (10g), and vanilla (1g). The dough was left to ferment for 1 hr for 30ºC at 85% relative humidity. The dough was divided to pieces each weighted 20gm. The pieces were arranged on trays and were left to ferment for a further 30 min at the same temperature and relative humidity. The pieces of fermented dough and left again for 15 min at the same temperature and relative humidity then were baked at 230 ºC for 10 min. snacks were allowed to cool on racks for about 1 hr before evaluation. Snack samples were evaluated for color (20), flavor (20), taste (20), crispiness (20), appearance (20) and overall acceptability (100) according to the method described in AACC (2000).

ANALYTICAL METHODS

Moisture, ash, fiber, protein and fat of raw materials and different snacks were determined according to AOAC (2000). Changes in Hunter color parameter (L, a &b) of raw materials and different snacks were followed up using Tristimulus Color Analyzer (Hunter, Lab Scan XE, Reston, Virginia) with standard white tile.

SUBJECTS

Seventy four obese women suffering from MetS, shared as volunteers in this study which lasted for 8 weeks. They were enrolled in a program for losing weight in National Research Center (NRC) Egypt that lasted for 8 weeks, after taking approval from Ethical Committee of NRC and written informed consent from each of them. The study was divided into two phases, phase (1) and phase (2) each one lasted for 4 weeks. Patients mean age was 48.8±0.87 years and had a mean BMI of 38.6± 0.90 kg/m². The patients were divided into two groups, group (A) and group (B). At phase (1), group (A) followed a low caloric balanced diet (1000- 1200 K calories), accompanied by the 50% OF plus 50% WWF snacks, that was consumed before breakfast (2 snacks) and before dinner (1snack), each snack weighted 20g, while group (B) consumed the snacks made from 72% WF(50%) and OF (50%) with the same instructions. Phase (2) lasted for 4 weeks in which the volunteers were following only the same low caloric balanced diet. All women were subjected to thorough clinical examination. Blood pressure was recorded.

ANTHROPOMETRIC PARAMETERS AND BLOOD PRESSURE MEASUREMENTS

Relevant anthropometric measurements were reported including height, weight and waist circumference using standard method (Jelliffe, 1966). Body mass index (BMI) was calculated (weight in kg/ height² in meter). Systolic and diastolic blood pressures (SBP& DBP) for each patient were measured 3 times and the mean was recorded.

BLOOD SAMPLING AND BIOCHEMICAL ANALYSIS

Fasting blood samples (12 hour fasting) were drawn from the patients. Fasting blood glucose (FBG) was determined on fresh samples; other biochemical parameters were performed on fasting blood serum that was stored at -70 C° until used. Serum glucose was determined in fresh samples using glucose oxidase method (Barham &Trinder, 1972). Serm total cholesterol (TC), high density lipoprotein-cholesterol(HDL-C)and triglycerides were done using; cholesterol proceed No 1010 (Allain *et al*., 1974), Stanbio, HDL-C proceed No 0599 Stanio Liquicolor (Wornick and Albers, 1978), triglycerides proceed No 2100, (Seidel *et al*., 1993). All the above mentioned parameters were done before the regimen started (basal), after 4 weeks and lastly at the end of the study.

STATISTICAL ANALYSIS

The obtained results were evaluated statistically using analysis of variance as reported by McClave & Benson (1991). In addition the other reported values were expressed as mean ±SD and ±SE, two – tailed Student's t test was used to compare between different groups. . P value less than 0.05 was considered statistically significant. SPSS (Chicago, IL, USA) software window Version 16 was used.

RESULTS AND DISCUSSION

CHEMICAL COMPOSITION OF RAW MATERIALS AND SNACKS

Table (1) summarizes the average of moisture, protein, fat, crude fiber and ash of the WWF 100% extraction, WF 72% extraction, OF and snacks produced from them. The protein, fat, fiber and ash levels of OF were higher than WWF and WF; however the moisture content of WWF was higher than WF and OF. Total carbohydrate (Total CHO) content of WF was higher than WWF and OF. Data presented in Table (1) show the chemical composition of snacks from WWF blends (25% OF: 75%WWF) and (50% OF: 50% WWF) and WF blended (25% OF: 75%WF) and (50% OF: 50% WF). Oat– WWF snacks (50:50) was characterized with higher moisture, protein, fiber and ash content, and lower carbohydrate content than WWF, blend of 25% OF: 75%WWF, WF, blend of 25% OF: 75%WF and 50% OF: 50% WF. The increase in protein, fat, fibers and ash of oat flour supplemented snacks can be attributed to the high content of those ingredients in OF. Such findings were also obtained by Pedo *et al*., (1999); Czubaszek & Karolini-Skaradziñska (2005); Nazni *et.al.*, (2010); Salehifar & Shahed (2007) and Pastuszka *et al*. (2012)

Table (1) - Chemical composition of raw materials and snacks

Samples	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Total CHO (%)
WWF 100%	13.00^{a}±0.15	13.5^{g}±0.10	2.5^{h}±0.01	1.75^{f}±0.001	1.65^{e}±0.0	80.60^{b}±0.85
WF 72% extraction	11.5^{b}±0.11	12.50^{i}±0.12	1.65^{i}±0.03	0.91^{h}±0.00	0.71^{g}±0.0	84.23^{a}±0.81
Oat flour (OF)	7.12^{c}±0.13	16.8^{a}±0.17	5.0^{g}±0.05	4.82^{a}±0.00	1.85^{d}±0.0	71.53^{f}±0.72
Snacks from						
WWF (Control)	5.32^{g}±0.17	13.80^{e}±0.11	8.05^{e}±0.07	1.71^{g}±0.00	1.67^{e}±0.0	74.73^{e}±0.65
75% WWF+25% OF	6.62^{e}±0.11	15.06^{c}±0.09	10.12^{b}±0.05	2.52^{d}±0.00	2.06^{b}±0.0	70.24^{g}±0.56
50% WWF+50% OF	7.18^{c}±0.09	16.32^{b}±0.12	12.15^{a} ±0.06	3.50^{b}±0.00	2.65^{a}±0.0	65.38^{h}±0.60
WF (Control)	5.02^{h}±0.07	12.72^{h}±0.13	7.22^{f}±0.02	0.92^{h}±0.00	0.72^{g}±0.0	78.42^{c}±0.45
75% WF+25% OF	5.96^{f}±0.03	13.64^{f}±0.11	8.19^{d}±0.01	1.95^{e}±0.00	1.20^{f}±.004	75.02^{d}±0.53
50% WF+50% OF	6.85^{d}±0.11	14.65^{d}±0.15	9.82^{c}±0.04	3.12^{c}±0.00	2.00^{c}±0.0	70.41^{g}±0.55
LSD at 0.05	0.082	0.092	0.087	0.175	0.059	1.52

Where: (WWF): Whole meal wheat flour, (WF): Wheat flour, (OF): Oat flour

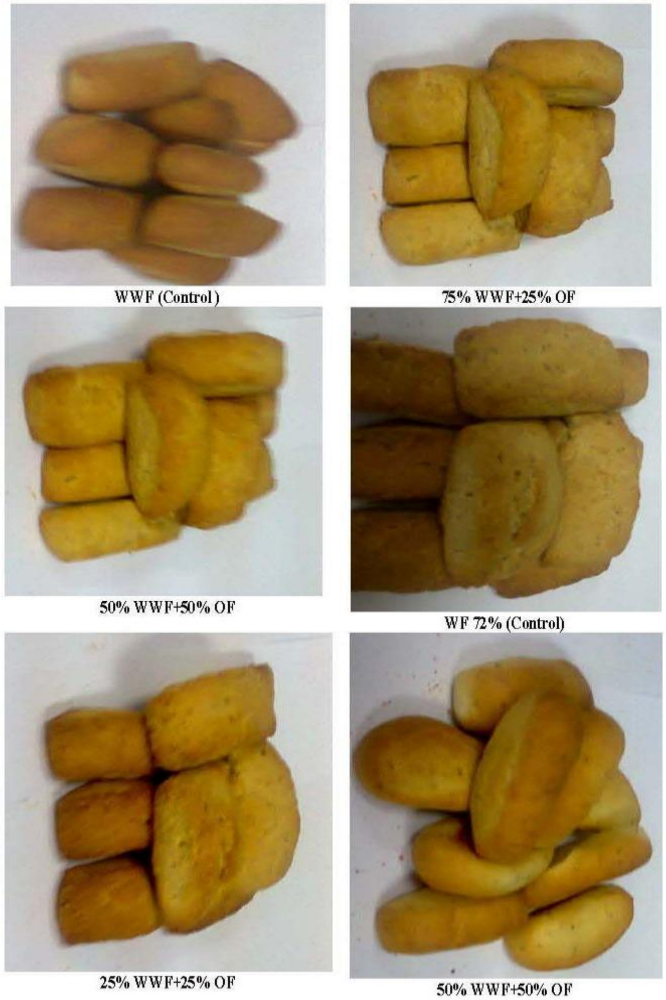

Fig (1): Photo of Snacks produced from WWF, WF and OF flours

COLOR ATTRIBUTES OF RAW MATERIALS AND SNACKS

Color is one of the most important sensory attribute that affect directly the consumer preference of any product. Special attention should be given to bakery products to attract the consumers' attention. The color parameters of raw materials and snacks samples were evaluated using a Hunter laboratory colorimeter (table 2, 3). The L* scale ranges from 0 black to 100 white; the a* scale extends from a negative value (green hue) to a positive value (red hue) and the b scale ranges from negative blue to positive yellow. Whole meal wheat flour (WWF) and mixture from WWF and OF were darker than WF and mixture from WF and OF, where lightness (L*) and redness values (b*) decreased but (a*) increased as rate of OF used in mixture increased. The L, a, b and ΔE values for crust and back of all prepared snacks are summarized in Tables (3). All formulas showed a noticeable lighter color for the crust of snack (L values were increased) but the redness (a values) of crust were decreased as a result of OF addition while the b values were slightly increased compared with the control from WWF or WF. Such findings are in-agreement with Kim *et al*. (1997), Kordonowy &Young (1985), Ramy *et al*. (2002) and Hussein *et al* ., (2012).

FARINOGRAPH CHARACTERISTICS OF WHEAT FLOUR-OF DOUGH

Data presented in (Table 4) show the effect of adding OF at two levels (25% and 50%) to WWF and WF on the rheological properties of dough as evaluated by a farinograph.

Table (2): Hunter colour parameter of flours

Samples	L	a	b	a/b	Δ E	Hue	Saturation
Flours (raw materials)							
WWF (control)	83.45^{c}±0.85	1.29±0.01	13.07^{a}±0.10	0.10^{b}±0.0	84.48^{c}±0.32	84.36^{c}±0.66	13.13^{a}±0.22
75% WWF+25% OF	83.06^{c}±0.62	1.27±0.03	11.49^{b}±0.11	0.11^{b}±0.001	83.86^{d}±0.39	83.69^{e}±0.75	11.56^{b}±0.15
50% WWF+50% OF	82.44^{c}±0.62	1.38±0.01	11.20^{c}±0.21	0.12^{a}±0.002	83.21^{e}±0.52	82.98^{f}±0.82	11.28^{c}±0.19
WF (Control)	89.46^{a}±0.56	0.67±0.05	9.85^{d}±0.13	0.068^{c}±0.00	90.00^{a}±0.29	86.11^{a}±0.85	9.87^{d}±0.29
75% WF+25% OF	86.20^{b}±0.32	0.81±0.01	9.36^{e}±0.12	0.086^{b}±0.0	86.71^{b}±0.36	85.05^{b}±0.62	9.39^{e}±0.33
50% WF+50% OF	86.06^{b}±0.49	0.97±0.02	9.32^{f}±0.09	0.10^{b}±0.001	86.57^{b}±0.52	84.06^{d}±0.65	9.37^{f}±0.42
LSD at 0.05	0.908	N.S	0.016	0.0145	0.182	0.064	0.038

Where: WWF: whole meal wheat flour, WF: Wheat flour and OF: Oat flour

Table (3): Hunter color parameter of snacks

Samples	Crust				Crumb			
WWF	40.42^{f}±0.11	13.83^{a}±0.05	17.61^{f}±0.09	46.21^{d}±0.22	45.22^{b}±0.22	11.57^{a}±0.08	18.72^{d}±0.09	50.29^{c}±0.65
75%WWF +25% OF	53.51^{b}±0.15	9.70^{e}±0.03	23.21^{a}±0.07	59.13^{b}±0.36	45.48^{b}±0.25	13.87^{e}±0.09	21.44^{b}±0.07	52.16^{b}±0.60
50% WWF+50 % OF	54.90^{a}±0.17	9.23^{f}±0.01	22.82^{b}±0.06	60.17^{a}±0.55	40.35^{c}±0.35	11.51^{f}±0.03	17.57^{e}±0.01	45.49^{d}±0.52
50% WWF+50 % OF	54.90^{a}±0.17	9.23^{f}±0.01	22.82^{b}±0.06	60.17^{a}±0.55	40.35^{c}±0.35	11.51^{f}±0.03	17.57^{e}±0.011	45.49^{d}±0.52
WF 72% (Control)	41.41^{e}±0.13	11.96^{c}±0.06	18.23^{e}±0.03	46.80^{d}±0.41	49.72^{a}±0.19	12.0^{c}±0.03	21.58^{a}±0.09	55.51^{a}±0.25
75% WWF+25 % OF	45.12^{d}±0.22	11.77^{d}±0.02	19.33^{d}±0.11	50.48^{c}±0.39	39.38^{c}±0.52	11.96^{d}±0.01	17.06^{f}±0.11	44.55^{d}±0.18
50% WWF+50 % OF	45.79^{c}±0.32	12.18^{b}±0.05	20.70^{c}±0.18	51.71^{c}±0.29	45.23^{b}±0.63	11.77^{b}±0.06	19.44^{c}±0.15	50.62^{c}±0.36
L S D at 0.05 %	0.045	0.048	0.017	0.85	1.77	0.148	0.149	0.85

Where: WWF: whole meal wheat flour, WF: Wheat flour and OF: Oat flour

As shown in table 4, water absorption increased as OF level increased. This increase is due to the high fiber content of OF. Fiber is characterized by its high water holding capacity as reported by Hussein *et al*., (2010). Kawka & Gąsiorowski (1995) demonstrated that water absorption of a wheat-and-oat mixture increased with the increasing share of oat bran. This product showed a higher water binding ability than wheat flour, as it contains more non-cellulose polysaccharides (β-glucans and pentozanes). Also, Duchoňová *et al* (2013) pointed out that water absorption increased as OF level increased in dough. In this study, as the oat level in the flour increased, the time needed for the preparation of a good dough was also increased, due to a weaker formation of gluten matrix. Since pentosans and ß-glucans benefit from high water binding capacities, their presence in the oat flour caused slightly higher water absorption capacities, for doughs made of oat as part of the formula, in comparison with control. This increase in dough development increased and sustained levels of high-fat bran by removing fat, according to research results Sudha *et al*. (2007) and Peymanpour *et al*.,(2012). On the other hand, dough weakening and mixing tolerance index were increased by adding OF to wheat flour at all levels replacement. These results are in harmony with those obtained by Oomah (1983), D'Appolonia (1984), Lee et *al*. (1995) and Zhang *et al*. (1998).

Table (4): Farinograph parameters of dough prepared from different formulas.

Samples	Water absorption (%)	Arrival time(min)	Dough development time(min)	Stability time (min)	Weakening (BU)	Mixing tolerance index (BU)
WWF	72.5	2.0	5.5	18.0	50	30
75% WWF+25% OF	75.5	1.5	6.0	15.0	80	40
50% WWF+50% OF	78.0	1.25	7.0	10.0	100	60
WF 72% (Control)	66.0	1.5	4.0	10.0	90	45
75% WWF+25% OF	68.5	1.5	5.0	8.0	110	60
50% WWF+50% OF	71.5	1.0	6.0	6.0	140	80

Where: : WWF: whole meal wheat flour, WF: Wheat flour and OF: Oat flour

EXTENSOGRAPH CHARACTERISTICS OF WHEAT FLOUR-OF DOUGH

Data presented in (Table 5) show the effect of adding of at different levels (25% and 50%) on the rheological properties of dough as evaluated by an extensograph. As shown in table 5, extensibility, resistance to extension, proportion number, and energy decreased as OF level increased. That effect was related to the presence of fiber in defatted rice bran that dilutes gluten content of dough. Viscoelastic properties of wheat doughs depend on gluten quality and quantity. So, as gluten content increases viscoelastic properties are improved. This decrement may be due to the deficiency of gliadin and glutenin in OF. Lapvetelainen *et al.* (1994) reported that dough extensibility and resistance measured with an extensograph decreased following the addition of 3 and 6% of high-protein oat flour to wheat flour. According to those investigators, the weakening of wheat-oat dough may have been caused by enzyme activity in oat flour. Such findings were observed by Oomah, 1983; Krishnan *et al*., 1987; Zhang *et al*., 1998 and Gambuœ *et al*., 2001.

Table (5): Extensograph parameters of dough prepared from different formulas.

Samples	Extensibility (E)(mm)	Resistance to Extension (R) (BU)	Ratio (R /E)	Energy (Cm)^2
WWF	140	580	4.14	85
75% WWF+25% OF	110	420	3.82	70
50% WWF+50% OF	80	280	3.5	50
WF 72% (Control)	110	500	4.5	78
75% WWF+25% OF	90	320	3.56	65
50% WWF+50% OF	70	240	3.43	50

Where: WWF: whole meal wheat flour, WF: Wheat flour and OF: Oat flour

RAPID VISCO ANALYZER (RVA) CHARACTERISTICS OF WHEAT FLOUR-OF DOUGH

The pasting properties of WWF, WF, and their blends with OF at 25% and 50% levels are summarized in Table (6). The adding of OF to WWF or WF led to increased of Peak Viscosity, Trough (cP), Breakdown (cP), Setback (cP), Final viscosity (cP), Pasting Temperature (˚C) and Peak Time.(min). The peak viscosity indicates the water holding capacity of starch and refers to the maximum viscosity reached during the heating and holding cycle. It can be affected by the molecular structure of amylopectin (Shibanuma *et al*., 1996), starch water concentration, lipids, residual proteins (Whistler *et al*., 1997), granule size (Fortuna *et al.*,2000), and instrument operating conditions (Batey, & Curtin 2000). Pasting properties of starch are affected by amylose and lipid contents and by branch chain-length distribution of amylopectin. Amylopectin contributes to swelling of starch granules and pasting, whereas amylose and lipids inhibit the swelling (Tester & Morrison, 1997). Furthermore, the amylopectin chain-length and amylose molecular size produce synergistic effects on the viscosity of starch pastes (Jane et.al., 1992).

Table (6): Pasting profile of WWF, WF and OF flours

Treatments	Peak Viscosity (cP)	Trough (cP)	Breakdown (cP)	Setback (cP)	Final viscosity (cP)	Pasting Temperature (˚C)	Peak Time (min)
WWF	1729	1090	639	1240	2330	69.50	5.53
75% WWF+25% OF	2228	1331	897	1469	2800	84.80	5.80
50% WWF+50% OF	2694	1620	1074	1703	3323	86.30	5.93
WF 72% (Control)	2651	1568	1083	1554	3122	68.85	6.20
75% WWF+25% OF	2752	1634	1118	1659	3293	85.50	6.00
50% WWF+50% OF	2685	1691	995	1675	3366	86.35	6.00

Where: WWF: whole meal wheat flour, WF: Wheat flour and OF: Oat flour

SENSORY ATTRIBUTES

Data presented in Table 7 show the sensory evaluation of snacks as a function of replaced WWF or WF with OF at two levels 25% and 75%. Regarding color, flavor and crispiness, it could be noticed that no significant differences between snacks from WWF or WF (control) and snacks from mixtures of WWF with OF or WF with OF at two levels. Significant differences were observed when wheat flour was replaced with OF in snacks for taste, appearance and overall acceptability. As the replacement level increased the color, flavor crispiness, general appearance and overall acceptability score increased.

METABOLIC EFFECT OF THE TWO SUPPLEMENTS

ANTHROPOMETRIC MEASUREMENTS AND BLOOD PRESSURE

FASTING BLOOD GLUCOSE AND SERUM LIPID PROFILE

Data of this study demonstrated also an important healthy beneficial effect of both snacks on the biochemical parameters which was high in its value when compared to their effect on the anthropometric measurements. In spite of the normal level of the FBG at the start of the study as the diabetic participants were under medical treatment, yet the mean level of the FBG decreased significantly (-16.3 & -5.7%) in both groups, which was much higher among group (A).

The entire investigated serum lipid parameters were high among the patients at the start of the study, however at the end of the first phase, metabolic improvement in the different markers was detected, which was higher in group (A). Significant decrease ranged from -34.03% to -20.2% in group (A) and from -29.4% to -5.7% in group (B) in the mean level of TC, low density lipoprotein cholesterol (LDL-C), non-HDL-C, very low density lipoprotein cholesterol (VLDL-C) and the triglyceride, and in the same time significant increase in the level of the HDL-C was found in both groups. These results reflected on the value of the calculated risk factor where it decreased significantly by -34.9 & -29.4% among the two groups respectively. After stopping the use of the supplement and the patients continue on the low hypocaloric regimen alone,{phase 2}the mean serum concentration of the FBG and the lipid parameters significantly increased in group (A) compared to the values obtained at the end of the first phase, except that of the triglyceride which insignificantly decreased by only 4.3%. Furthermore the mean concentration of the HDL-C decreased significantly in the same group. In group (B) the mean concentration of the FBG decreased significantly and the mean level of the triglyceride increased insignificantly. Previous studies have been reported that elevated total and LDL-C levels are considered major risk factors for cardiovascular disease. Oat β-glucan, a soluble dietary fiber that is found in the endosperm cell walls of oats, has generated considerable interest due to its cholesterol-lowering properties. The United States Food and Drug Administration (FDA) approved a health claim for β-glucan soluble fiber from oats for reducing plasma cholesterol levels and risk of heart disease in 1997. Similarly, in 2004 the United Kingdom Joint Health Claims Initiative (JHCI) allowed a cholesterol-lowering health claim for oat β-glucan. Significant scientific agreement continues to support a relationship between oat β-glucan and blood cholesterol levels, with newer data being consistent with earlier conclusions made by the FDA and JHCI. Oats provide one of the richest sources of the dietary soluble fiber beta-glucan, providing 5.0g (oat meal) to 7.2g (oat bran) per 100 g serving. Both are also valuable sources of total dietary fiber, which ranges from 9.9-14.9g per 100 g serving. Oats also contain more lipids (5-9%) than other cereal crops and are rich in unsaturated fats, including the essential fatty acid linoleic acid. Oats contain unique antioxidants, called avenanthramides, as well as the vitamin E-like compounds, tocotrienols and tocopherols (Wursh & Pi-Sunyer, 1997). Diabetic individuals can benefit from diets that are high in beta-glucan, which, as a component of oats and barley, can be incorporated into breakfast cereals and other products (Sadiq Butt, *et.al*., 2008).

CONCLUSION

From the obtained results it could be concluded that WWF or WF could be replaced with OF at the two levels 25 and 50% without drastic effect on the technological quality and sensory properties of snacks. Moreover, higher nutritive values of these snacks are achieved. Supplementation improved protein, fat, fiber, ash, β glucan and minerals (Ca, P, K and Fe) of snacks. It is evident that OF could be useful for preparation of functional food of potential application for those suffering from Metabolic syndrome (Obesity, Diabetes and Hyperlipidemia). The findings of this trial highlight the beneficial effects on human health.

Table (7): Sensory evaluation of snacks produced from WWF, WF and OF

Samples from	Overall acceptability (100)	Appearance (20)	Crispness (20)	Taste (20)	Flavor (20)	Color (20)
WWF	86.1^{f}±0.48	17. 8^{ab} ± 0.62	16.8±1.03	17.6^{ab}± 0.26	16.9±0.66	17.0±0.45
75% WWF+25% OF	89.9^{a}±0.72	18.^{a} 1± 0.52	18.1±1.45	18.4^{a} ± 0.35	17.7±0.57	17.6±0.91
50% WWF+50% OF	89.6^{b}±0.56	17.9^{ab}± 0.68	17.6±1.12	18.7^{a} ± 0.49	17.9±0.23	17.7±0.65
WF 72% (Control)	89.0^{c}±0.87	16. 2^{c} ±0.42	17.8±1.32	18.8^{a}±062	18.5±0.64	17.7±0.62
75% WWF+25% OF	86.4^{e}±0.72	16.6^{bc}±0.56	16.9±1.62	16. 9^{b} ± 0.56	18.0±0.89	18.0±0.33
50% WWF+50% OF	88.3^{d}±0.78	17.1^{abc}±0.49	17.4±1.51	17.8^{ab} ±0.39	17.8±0.81	18.2±0.79
LSD at .05	0.182	1.35	NS	01.26	NS	NS

Where: WWF: whole meal wheat flour, WF: Wheat flour and OF: Oat flour

Table (8): Mean± SE of anthropometric parameters and blood pressure of obese women at the base, mid and last visits of the dietary therapy

Parameters	Group A (Consuming Snacks 1) (no.=42)			Group B (Consuming Snacks 2) (no.=32)		
	Base (1st visit)	Mid (2nd visit)	Last (3rd visit)	Base (1st visit)	Mid (2nd visit)	Last (3rd visit)
Age (year)	48.24± 1.17			48.63±1.28		
Height (cm)	154.75± 0.84			154.88±0.95		
Weight (Kg)	92.12± 1.58	89.01±1.49**a	85.49±1.71**b	93.32±1.92	90.04±1.79**a	90.37±2.48**b
BMI (Kg/m²)	38.53± 0.69	37.24±0.67**a	35.73±0.78**b	39.04±0.94	37.80±0.89**a	38.19±1.19**b
Waist (cm)	97.12± 1.06	92.33±0.99**a	89.53±1.25**b	98.43±1.52	92.90±1.57**a	93.50±1.71
Abdominal II(cm)	120.43±1.44	115.54±1.19**a	113.27±1.65**b	119.83±1.73	114.70±1.73**a	114.80±2.32**b
Hip (cm)	121.21± 1.44	117.27±1.19**a	114.17±1.62**b	122.48±1.92	116.13±1.76**a	116.30±2.31**b
WHR (cm/cm)	0.80±0.01	0.79±0.01**a	0.79±0.01	0.80±0.01	0.80±0.01	0.81±0.01
SBP (mmHg)	120.24±2.80	116.43±1.79	114.64±2.80	129.50±3.28	125.36±2.73*a,*c	114.44±3.26**b
DBP (mmHg)	79.05±1.55	76.67±1.43	71.07±1.59	80.63±1.95	76.43±1.56*a	74.44±2.39

*P<0.05 **P<0.01, **a:** Base vs. Mid **b:** Mid vs. Last of the same group, **c:** Mid of group A vs. Mid group B **d:** Last of group A vs. Last group B, BMI: Body Mass Index

Table (9): Mean± SE of Fasting blood glucose, and lipid profile of obese women at the base, mid and last visits of the dietary therapy.

Parameters	Group A(Consuming Snacks 1) (no.=42)			Group B (Consuming Snacks 2) (no.=32)		
	Base (1st visit)	Mid (2nd visit)	Last (3rd visit)	Base (1st visit)	Mid (2nd visit)	Last (3rd visit)
FBG (mg/dl)	95.42±2.84	79.87±1.72**a	88.34±2.99**b	90.72±1.84	85.52±1.53**a	83.13±2.01
TC (mg/dl)	230.08±8.15	183.58±5.64**a	204.59±8.72*b	208.76±6.66*c	184.54±4.99**a	205.68±7.24**b
LDL-C (mg/dl)	148.52±8.25	97.98±6.29**a	125.82±8.52**b	130.39±7.34*c	101.47±5.00**a	125.85±8.88**b
HDL-C (mg/dl)	50.03±1.57	61.41±1.94**a	57.04±1.70**b	49.23±1.61	60.61±2.24**a	53.39±2.61**b
Non HDL-C(mg/dl)	180.05±8.85	122.18±6.72**a	148.97±9.64**b	159.52±7.59*c	123.93±4.91**a	152.28±8.62**b
Risk factor (TC/ HDL-C)	4.87±0.29	3.17±0.17**a	3.82±0.26**b	4.43±0.23	3.13±0.11**a	4.05±0.27**b
Triglycerides (mg/dl)	157.63±7.64	120.95±4.96**a	115.76±8.41	145.68±6.71	112.29±5.61**a	132.16±10.40
VLDL-C (mg/dl)	31.53±1.52	24.19±0.99**b	23.15±1.68	29.14±1.34	22.46±1.12**a	26.43±2.08

*P<0.05 **P<0.01 a: Base vs. Mid b: Mid vs. Last of the same group c: Base of group A vs. Base group B

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