J. Agric. Sci. Mansoura Univ., 33 (7): 5123 - 5139, 2008

PRODUCTION OF REDUCED FAT SAUSAGE BY USING CHITIN AS A NEW FAT MIMIC

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ABSTRACT

The objective of this study was processing reduced fat sausage by using one fat mimic like chitin at different levels (5, 7.5 and 10 %), reduced fat sausage without chitin (control) and high fat sausage (control). Chemical composition, physical and sensory properties of uncooked and cooked sausage treatments were evaluated. Also, biological and biochemical changes were examined in rats fed on high and reduced fat sausage treatments.

Results indicated that, decreasing fat content in sausage treatments led to significant decrease of sensory properties. Meanwhile, addition of chitin with 5 and 7.5 % to reduced fat sausage treatments led to improve their sensory properties. Values of sensory properties decreased with increase in the level of chitin in the sausage. Generally the highest overall acceptability was recorded for high fat sausage control followed by reduced fat sausage prepared with 5 % chitin with nonsignificant differences between them.

Also, decreasing fat content increased cooking loss due to the high water content of RF sausages besides decreasing water holding capacity and plasticity. On the other hand, addition of chitin with 5 and 7.5 % reduced cooking loss and increased each of water holding capacity, plasticity.

Results of biological evaluation indicated that, rats fed on diet contained high fat sausage had the highest value of liver enzymes activity (GOT and GPT), triglycerides, total lipid, total cholesterol, LDL- cholesterol and VLDL-cholesterol beside being the lowest of the HDL- cholesterol value. Meanwhile, rats groups which fed on diets contained reduced fat sausage prepared with 5 and 7.5 % chitin had the lower values of previous parameters except being higher at of HDL- Cholesterol when compared with rats group fed on reduced fat sausage (control) without chitin addition.

INTRODUCTION

Fat in processed meat products is important due to its contribution to flavor and texture (Lister, 1996). Fat also exerts considerable influence on binding properties, rheological and structural properties of meat products, and in finely comminuted products, such as frankfurters and sausages, fat plays an important role in the formation of a stable meat emulsion. Reducing the fat content in meat products, therefore, presents a number of difficulties in terms of flavor and texture (Hughes *et al.,* 1997). On the other hand, high fat diets consumption is associated with increased risk for obesity, beside; saturated fat intake is associated with high blood cholesterol, coronary heart disease and cardiovascular diseases (Astrup *et al.,* 2000). The demand for reduced fat food products has been increasing due to health risks associated with excessive fat intake.

Fat replacers chemically resemble fats, proteins, or carbohydrates and are generally categorized into two groups; i.e., fat substitutes and fat mimetics. Fat substitutes are macromolecules that physically and chemically resemble triglycerides (conventional fats and oils), and often referred to as lipid-or fat-based fat replacers. Fat mimetics are substances that imitate organoleptic or physical properties of triglycerides. Fat mimetics, often called protein-or-carbohydrate-based fat replacers, such as starch and cellulose, polydextrose, arabinogalactan, chitosan, chitin, gelatine, xanthan, pectin, konjac, gum arabic, soy fiber, inulin, guar gum, beta-glucan, carrageenan, locust bean gum, alginate (Gallaher *et al.,* 1993 and Akoh, 1998). Water may replace fat in a formulation on an equal weight basis, but increased amounts of water may affect sensory texture, juiciness, color and cooking loss of meat products (Small *et al.,* 1995 and Cofrades, *etal.,* 1997).

To the best of our knowledge there are no reports on the use of chitin as a fat replacement or mimic in meat products. Chitin, poly {β-(1-4)-N-acetyl-D-glucosamine}, is a natural polysaccharide of major importance, first identified in 1884. In spite of the presence of nitrogen, it may be regarded as cellulose with hydroxyl at position C-2 replaced by an acetamido group (Majeti and Kumar, 2000; Harish Prashanth and Tharanathan, 2007 and Abdou*,* Entsar*, et al.,* 2008). This biopolymer is synthesized by an enormous number of living organisms and considering the amount of chitin produced annually in the world, it is the most abundant polymer after cellulose. Chitin occurs in nature as ordered crystalline microfibrils forming structural components in the exoskeleton of arthropods such as crabs, shrimps and lobsters or in the cell walls of fungi and yeast (Rinaudo, 2006). Chitin is being advertised as a food supplement that effectively lowers blood cholesterol concentration and controls obesity (Koide, 1998). Therefore, our objectives were to evaluate the chemical composition, some physical properties and sensory evaluation of reduced fat sausage which prepared with adding chitin (as a new fat mimic) at different levels, and to compare with reduced fat sausage without chitin (control) and high fat sausage (control). Also, biological and biochemical changes were examined in rats fed on high and reduced fat sausages.

MATERIALS AND METHODS

Materials:

Lean beef and fat tissues:

Fresh lean beef from boneless round and fat tissues (sheep tail) were purchased from the private sector shop in the local market at Giza, Egypt.

Chitin pure is a product of Oxford Laboratory, Mumbai. It was obtained from the International Company for Scientific and Medical Supplies, Cairo, Egypt.

Other ingredients such as soy flour were obtained from Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Also, food grade sodium tripolyphosphate and sodium nitrite (El-Gomhoria for Chemicals Co., Egypt.), ascorbic acid (British Drug Houses Ltd, Pool, England). Salt and spices were obtained from local market at Giza, Egypt. The spices were powdered in a laboratory mill, and a mixture of the powdered spices was prepared as follows: 4.74% laurel leaf powder; 1.84%

cardamom; 2.69% nutmeg; 10.52% Arab yeast, 9.91% cinnamon, 7.05% clove, 14.61% rose wood, 4.97% thyme, 25.22% cubeb, 8.22% corengan and 10.22% white pepper.

Methods

Technological methods

Preparation of high and reduced fat sausages

Lean beef was trimmed from all subcutaneous and intermusclar fat as well as thick visible connective tissues. Both trimmed lean beef and fat tissues were ground separately through 4.5 mm plate (twice). The minced lean beef was analyzed for fat content, before using in preparation of high and reduced fat sausages. Five formulas of sausage were manufactured i.e., high fat sausage control (HFC), reduced fat sausage control (RFC) and three reduced fat sausages was prepared by adding chitin (as a fat mimic) with different levels i.e., 5% (RF1), 7.5 % (RF2) and 10 % (RF3) as shown in Table (1). All formulas were prepared by mixing minced lean beef (4.55% fat) with half of the ice and salt for 5 min in a laboratory chopper (Hobart Kneading machine, Italy), then other ingredients i.e., fat, soy flour, sodium nitrite, sodium tripolyphosphate, ascorbic acid, remaining ice and chitin (according to the treatment) were added and emulsified or chopped for another 5 min. Obtained emulsions were stuffed in natural mutton casings, then samples placed in fibrous plates, wrapped with polyethylene film and kept at - 18ºC for further analysis.

Table (1) Ingredients (%) used for the preparation of high and reduced fat sausage formulas.

Ingredients (%)	HF (control)	RF (control)	RF treatments by using chitin at different levels		
			RF1	RF2	RF3
lean beef (4.88 % fat)	60.0	60.0	60.0	60.0	60.0
Fat tissues	25.0	5.0	5.0	5.0	5.0
Water	10	30.0	25.0	22.5	20.0
Soy flour	1.64	1.64	1.64	1.64	1.64
Spices mix.	1.50	1.50	1.50	1.50	1.50
Salt	1.50	1.50	1.50	1.50	1.50
Sodium nitrite	0.01	0.01	0.01	0.01	0.01
Ascorbic acid	0.05	0.05	0.05	0.05	0.05
Sod. tripolyphosphate	0.3	0.3	0.3	0.3	0.3
Chitin	-	-	5.0	7.5	10.0

Analytical methods

Proximate composition:

Moisture, protein, fat and ash contents were evaluated according to **A.O.A.C. (1995).** Carbohydrate was calculated by difference.

Physical properties:

Cooking loss of prepared high and reduced sausages was determined and calculated as described by A.M.S.A (1995).This measurement was carried out after cooking in hot water at 85ºC for 15 min. The cooking losses were calculated as follows:

% cooking loss = Fresh sample weight – cooked sample weight / Fresh sample weight × 100

Water holding capacity and plasticity (cm^2/0.3 g) were determined by using filter- press method described by **Soloviev (1966)**. Hence, bound water % of moisture content was calculated as follows:

$$\% \text{ Bound water} = \left[\frac{\% \text{ Moisture} - \dfrac{Cm^2 \times 100 \times 8.4}{0.3 \times 1000}}{\% \text{ Moisture}} \right] \times 100$$

Where; Cm^2 area resembling WHC in cm^2, 8.4 = mg free water / each 1 cm^2 of WHC. 0.3 = Sample weight.

The moisture retention and fat retention values were calculated according to the following equations which reported by El-Magoli, Salwa *et al.,* (1996) and Berry (1993) respectively.

Moisture retention = Percent yield × percent moisture in cooked sample / 100

$$\textbf{Fat retention} = \frac{\text{Cooked weight} \times \text{percent fat in cooked product}}{\text{Raw weight} \times \text{percent fat in raw product}} \times 100$$

Feder value was calculated for high and reduced fat sausages according to the method of **Pearson (1991)** as follows:

$$\textbf{Feder value} = \frac{\% \text{ Moisture content}}{\% \text{ Organic non-fat content}}$$

Where; % Organic non-fat = 100 – (% fat + % ash + % moisture)

Sensory evaluation

Sensory evaluation of high and reduced sausages was carried out according to Watts *et al.,* (1989) by aid of ten panelists from the members of Meat and Fish Technology Research Department. Judging scale for each factor was as follows: Very good (8 – 9), Good (6 – 7), Fair (4 – 5), Poor (2 – 3), Very poor (0 – 1).

Biological tests

Animals and experimental design:

Twenty five male albino rats (average weight 80 + 5 g) were obtained from Biological Unit in Food Technology Research Institute, Agriculture Research Center, Giza, Egypt. The rats were kept under normal health laboratory conditions and fed on basal diet (consisted of 12% casein as a source of 15% protein, 10% corn oil, 4% salt mixture, 1.0% vitamin mixture, 4.0% cellulose and 69.0% starch) for one week (adaptation period), after that, the rats were weighed and divided randomly into 5 groups, each of containing five rats and fed on the different diets as shown in Table (2) for 4 weeks according to the method described by Sugano *et al.,* (1980).

Biological evaluation of diets

Biological evaluation of different diets was carried out by determination of body weight gain {(final weight – initial weight) × 100 / initial weight} and food efficiency ratio (gain in body weight / total food intake) according to Chapman e*t al.,* (1959).

Internal organs weight percentages:

At the end of the experimental period, rats were weighed and killed by decapitation. The carcasses were dissected and the internal organs (liver, kidney, brain, spleen, pancreas, testes, bladder and lung) were removed and weighted. The internal organ percentages were calculated (weight of organ / total body weight x 100).

Table (2): Composition of the experimental diets (g / 100g).

Rats groups	Sample wt. (g)*	Fat % From sample	Corn oil (%)	Salt mix. (%)	Vitamin mix. (%)	Cellulose (%)	Starch (%)	Total wt. (g)
Control	16.48	-	10.0	4.0	1.0	4.0	64.70	100
G1	67.23	11.44	-	4.0	1.0	4.0	23.77	100
G2	65.36	5.01	-	4.0	1.0	4.0	25.64	100
G3	73.85	5.53	-	4.0	1.0	4.0	17.15	100
G4	74.70	5.65	-	4.0	1.0	4.0	16.30	100

*** Sample weight in g (contained 15% protein).**
Control: Rats group fed on basal diet which contains casein as protein.
G1: Rats group fed on high fat sausage.
G2: Rats group fed on reduced fat sausage.
G3: Rats group fed on reduced fat sausage + 5 % chitin.
G4: Rats group fed on reduced fat sausage+ 7.5 % chitin.

Blood biochemical assay:

Blood samples were collected at zero time, after 2 weeks and at the end of the experimental period. Blood samples were obtained from the orbital venous plexus of each rat into a centrifuge tube by using heparinized capillary tube and the serum was separated after centrifugation for 10 min. at 3000 rpm and stored at –20 ºC in clean dry plastic tubes for further analysis biochemical of blood. The GOT or GPT activities, total cholesterol (TC), high density lipoprotein (HDL), triglycerides (TG) and total lipids (TL) were determined by using kits according to the methods described by Reitman and Frankel (1957);Richmond (1973); Lopez-Virella (1977); Fassati and Prencipe (1982) and Zollner and Kirsch (1962) respectively. The previous analyses were measured by Spectrophotometer (Beckman Du 7400, USA). Low density lipoprotein (LDL), very low density lipoprotein (VLDL) and risk factor (should not exceed than 4.97) were calculated as follows:

VLDL = TG / 5 **LDL = TC – HDL - VLDL**

Risk factor = TC / HDL

Statistical analysis:

The obtained results were subjected to analysis of variance (ANOVA). Means comparison was performed using Duncan's test at the 5% level of probability as reported by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Sensory evaluation

Sensory evaluation of high and reduced fat sausages as affected by addition of chitin as fat mimic are shown in Table (3). From statistical analysis of these data, it could be noticed that there were significant differences

(P≤0.05) in all sensory properties (taste, odor, color, texture and overall acceptability) between high fat sausage control (HFC) and reduced fat sausage control (RFC), reduced fat sausage prepared with 7.5 % chitin (RF2) and 10 % chitin (RF3). On the contrary there were non significant differences (P>0.05) between HFC and reduced fat sausage which prepared with 5 % chitin (RF1) for all sensory properties.

The highest scores of taste (8.75), odor (8.50), color (7.90), texture (8.50) and overall acceptability (8.41) were given by panelists for HFC followed by RF1 (5% chitin). On the other hand, the lowest sensory properties were recorded for both RF3 and RFC.

Also, all sensory properties of reduced fat sausage which prepared with 7.5 % chitin (RF2) were significantly higher when compared with RFC, except the texture which showed insignificant differences between these treatments. Meanwhile RF3 had significantly lowest sensory properties when compared with RFC with exception for color which had showed insignificant difference.

Table (3) Sensory evaluation of high and reduced fat sausage as affected by addition of chitin at different levels.

Sensory properties / Treatments	Color	Taste	Odor	Texture	Overall acceptability
HFC	7.9^{a}	8.75^{a}	8.5^{a}	8.5^{a}	8.41^{a}
RFC	5.70^{c}	5.15^{c}	5.40^{c}	7.50^{b}	5.94^{c}
RF1	7.60^{a}	8.30^{a}	8.0^{ab}	8.10^{ab}	8.00
RF2	7.0^{b}	7.60^{b}	7.80^{b}	7.50^{b}	7.47^{b}
RF3	6.0^{c}	5.0^{d}	4.0^{d}	4.50^{c}	4.87^{d}
LSD at 0.05 level	0.44	0.55	0.52	0.59	0.48

Where: Mean values in the same column with the same letter are not significantly different at 0.05 level. LSD: Least Significant Differences at 0.05 level
HFC = High fat control. RFC = Reduced fat control.
RF1 = Reduced fat + 5.0 % chitin. RF2 = Reduced fat + 7.5 % chitin.
RF3 = Reduced fat + 10 % chitin.

Generally, addition of chitin with 5 and 7.5 % led to improve sensory properties. On the other hand, chitin increment up to 10 % led to slight deterioration by reducing product sensory properties like hard texture and slight casing tear beside formation of off odor, mainly fishy odor noticed by panelists after cooking. This may be due to chitin and chitosan are primarily produced from crustaceans, shrimp or crab shells and may possess a fishy smell (Lin and Chao, 2001), consequently this treatment (RF3) was refused and neglected for other measurements.

The highest overall acceptability (8.41) was recorded for HFC followed by RF1 (8.0) with insignificant differences (P>0.05) between them. On the contrary, the lowest overall acceptability (4.87) was recorded for RF3. According to judging scale, studied treatments could be arranged in descending order as follows: HFC and RF1 (very good), RF2 (good), RFC and RF3 (fair).

Chemical composition

Data presented in Table (4) show the chemical composition of uncooked and cooked sausages as affected by fat level and addition of chitin with 5 and 7.5 % as a fat mimic. From these results, it could be noticed that, moisture content of all uncooked and cooked reduced fat sausages was significantly (P≤0.05) higher than that of high fat control (HFC). These results to in line with those of Chin *et al.,* (1998) who reported that high fat bologna sausage had lower moisture content when compared with low fat bologna. The differences in moisture content between all sausage treatments are mainly due to reducing the fat in formulations up to 6.9 % and high levels of added water.

Table (4) Chemical composition of raw and cooked sausages as affected by fat level (high or reduced fat) and addition of chitin.

Treatments / Chemical composition	Raw or uncooked treatments				LDS at 0.05 level	cooked treatments				LDS at 0.05 level
	HFC	RFC	RF1	RF2		HFC	RFC	RF1	RF2	
Moisture	58.13[c]	75.38[a]	70.03[b]	67.65[b]	2.80	55.84[c]	64.40[a]	62.32[ab]	60.02[b]	2.75
Protein	14.10[a]	13.60[a]	13.72[a]	13.80[a]	1.39	22.31[a]	22.95[a]	20.31[b]	20.08[b]	1.36
Fat	23.84[a]	6.94[b]	6.89[b]	6.90[b]	0.94	17.02[a]	7.67[b]	7.50[b]	7.57[b]	1.35
Ash	3.11[b]	3.27[b]	3.52[ab]	3.76[a]	0.41	3.56[b]	3.62[b]	3.70[ab]	3.97[a]	0.29
Total carbohydrates	0.82[c]	0.81[c]	5.85[b]	7.89[a]	0.27	1.27[c]	1.36[c]	6.17[b]	8.36[a]	0.33

Where: Mean values in the same row with the same letter are not significantly different at 0.05 level.
HFC = High fat control. RFC = Reduced fat control. RF1 = Reduced fat + 5.0 % chitin. RF2 = Reduced fat + 7.5 % chitin. LSD: Least Significant Differences at 0.05 level.

No significant differences (P≤0.05) in protein content were recorded between all uncooked reduced fat sausages and high fat control (ranged from 13.60 to 14.10 %). On the other hand, protein content of all treatments was increased as a result of cooking; this increasing may be due to the decreasing of moisture content of cooked treatment. The highest protein content (22.95 %) was recorded for RFC (highest moisture loss) followed by HFC (22.31 %) with non significant differences between them. Also, there were insignificant differences between RF1 and RF2 in protein content after cooking.

In spite of the addition of 25 % fat tissues (Table 1) to produce high fat sausage control (HFC), fat content tended to decrease when determined (23.84 %). This may be due to fat tissue contain little moisture and protein. Moreover, fat content of all reduced fat sausages increased as a result of cooking which decreased moisture content. On the contrary, fat content of high fat control (HFC) was decreased from 23.84 to 17.02 % by cooking. These results agree with the findings of Mansour and Khalil (1999) who reported that, low fat beefburgers retained more fat during cooking than high fat beefburgers.

Low significant differences (P≤0.05) were recorded in ash content between all uncooked treatments and also between all cooked treatments. However, ash content slightly increased by the addition of chitin. This may be due to chitin which contains considerable ash percent. Total carbohydrate content was significantly (P≤0.05) higher in both uncooked and cooked reduced fat sausages which prepared with chitin than HFC and RFC. Carbohydrates content of uncooked and cooked reduced fat sausages significantly (P≤0.05) increased as chitin level increased. This may be referring to chitin which considered as natural polysaccharide (Majeti and Kumar, 2000). Total carbohydrate and ash content of all treatments were increased as a result of cooking. This may be due to decrement of moisture content.

Physical properties

Physical properties of high and reduced fat sausage treatments as affected by addition of chitin as a fat mimic are shown in Table (5). The highest cooking loss (21.27 %) was recorded for reduced fat sausage control (RFC) followed by high fat control (15.50 %) with significant differences (P≤0.05) between them. In this concern, Hughes *et al.,* (1997) observed that decreasing fat content increased cooking losses in processed meats. The high losses in reduced fat control (RFC) might be due to high water addition during preparation as a result of reducing fat level in this treatment. On the other hand, high losses in HFC might be attributed to the excessive fat separation and water release from breaking emulation during cooking (Mansour and Khalil, 1999 and Osheba, 2003).

Table (5) Physical properties of high and reduced fat sausage treatments as affected by addition of chitin.

Physical / Treatments	Cooking loss %	Fat retention %	Water retention %	WHC		bound water %		Plasticity		Feder value	
				raw	cooked	raw	cooked	raw	cooked	raw	cooked
HFC	15.50[b]	60.33[c]	47.18[c]	1.10[b]	1.30[b]	94.70[c]	93.48[c]	4.30[c]	4.0[b]	3.89[b]	2.37[b]
RFC	21.27[a]	87.01[b]	50.70[b]	2.40[a]	2.65[a]	91.08[d]	88.48[d]	3.80[d]	2.90[c]	5.23[a]	2.65[a]
RF1	14.05[bc]	93.56[a]	53.56[a]	0.9[c]	1.0[c]	96.40[b]	95.51[b]	4.60[b]	4.20[b]	3.58[b]	2.35[b]
RF2	12.13[c]	96.40[a]	52.74[a]	0.5[d]	0.6[d]	97.93[a]	97.20[a]	5.30[a]	4.85[a]	3.12[c]	2.11[c]
LSD at 0.05	3.19	3.36	2.00	0.18	0.23	0.78	1.07	0.29	0.25	0.33	0.66

Where: Mean values in the same column with the same letter are not significantly different at 0.05 level.
HFC = High fat control. RFC = Reduced fat control. RF1 = Reduced fat + 5.0 % chitin. RF2 = Reduced fat + 7.5 % chitin.
WHC = Water holding capacity (Cm^2/0.3 g). LSD: Least Significant Differences at 0.05 level.

Cooking loss of reduced fat sausage treatments which prepared with 5 % chitin (RF1) and 7.5 % chitin (RF2) was significantly lower than that of reduced fat control sausage (RFC). This may be due to the addition of chitin which is able to bind water and fat, consequently improved the cooking loss (Nauss and Nagyvary, 1983 and Rinaudo, 2006). Also, cooking loss in reduced fat sausages decreased (P>0.05) as level of chitin increased.

Also, from the same table, there were significant differences (P≤0.05) in fat and water retentions, water holding capacity (cm2 / 0.3 g), bound water (%) and plasticity between all treatments. Fat and water retentions were significantly (P≤0.05) increased as fat content decreased. These results coincided with the results of Berry (1992) who reported that, fat retention decreased with increasing the amounts of fat in the product. Fat retention of reduced fat sausages increased (P>0.05) as level of chitin increased. On the contrary, water retention of reduced fat sausage slightly decreased (P>0.05) as level of chitin increased. This mainly due to the differences in levels of added water during sausage preparation as a result of reducing fat level. Generally, addition of chitin with 5.0 and 7.5 % led to significant increment in fat and water retentions when compared with reduced fat sausage control (RFC). This may be due the high ability of chitin for binding water and fat (Nauss and Nagyvary, 1983 and Rinaudo, 2006).

Reduced fat control (RFC) had the lowest WHC, bound water and plasticity when compared with other treatments. The lowest WHC and bound water of RFC were confirmed by the highest cooking loss. Also, water holding capacity and plasticity were significantly improved by addition of chitin at levels of 5.0 and 7.50 %. This may be due to the increment in moisture binding by chitin addition. The highest WHC, bound water and plasticity were recorded for reduced fat sausage which prepared with 7.50 % chitin (RF2). Moreover, WHC, bound water and plasticity of all treatments were decreased as a result of cooking. These results are in agreement with those obtained by Moghazy (1999).

Feder value for all uncooked treatments were less than 4.0 except the reduced fat control (RFC) which had higher feder value (5.23), consequently , all treatments except RFC are good quality according to Pearson (1991) who reported that, good quality meat products should have feder values less than 4.0. On the other hand, feder value of all cooked treatments were less than 4.0, consequently, all cooked treatments are of good quality.

Biological evaluation

Growth of rats

Data in Table (6) shows the weight gain, total feed intake and feed conversion efficiency (FCE) of rats groups which fed on tested diets. There were no significant differences (P>0.05) among the tested rats groups in both the initial and final body weight except of the fourth rats group recorded significant differences (P≤0.05) in its final body weight when compared with other rats groups. Additionally, there were nonsignificant differences in body weight gain percentages between G2 which fed on diet contained low fat sausage control, G3 fed on diet contained reduced fat sausage which prepared with 5% chitin and control group fed on basal diet whereas. Gain showed significant increment positively for G1 which fed on diet contained high fat sausage (control) and negatively for G4 which fed on diet contained reduced fat sausage prepared with 7.5% chitin. These results observed by Naczk and Shahidi, (1990) and Longevity and Natural Medicine (2007) who found that both chitin and chitosan can bind fat or lipids in the small intestine and reduce their absorption into the body, consequently helped people lose weight. Therefore, feed conversion efficiency (FCE) recorded the highest value for G1 was 0.105 after that came the control group was 0.084, but the fourth group had the lowest FCE compared with the other rats group whereas, there were nonsignificant differences between G2 and G3.

Table (6): Rats body weight, body weight gain, mean of total feed intake (gm) and feed coefficient efficiency of rats groups fed on test diets during the experimental period (28 days).

Rats groups	Initial body weight (g)	Final body weight (g)	Body weight gain (g)	Body weight gain (%)	Total feed intake (gm / rat / 28d)	FCE
Control	116.70 a	158.20 a	41.50 ab	35.56 b	494.05b	0.084 a
G1	115.00 a	166.75 a	51.75 a	45.00 a	493.71b	0.105 a
G2	115.25 a	154.25 a	39.00 ab	33.84 b	492.40b	0.079 ab
G3	114.75 a	151.00 a	36.25 b	31.59 b	495.88b	0.073 ab
G4	114.75 a	127.25 b	12.50 c	10.89 c	525.85a	0.024 b
LSD at 0.05	14.86	18.26	13.60	5.95	20.78	0.54

Where: Mean values in the same column with the same letter are not significantly different at 0.05 level
FCE: Feed Conversion Efficiency.
For define the abbreviations see table (2).
LSD: Least Significant Differences at 0.05 level.

Internal organs weight / body weight ratio (%):

The absolute weight of organs is vital to nutrient uptake; utilization and distribution which proportionately change with body weight. Table (7) shows the internal organs weight percentages. There were nonsignificant differences (P>0.05) among all rat groups in the following internal organs weight; kidney, pancreas, spleen, bladder, testis and lung whereas, there were significant differences (P ≤ 0.05) between rats liver of groups (G1 and G4) and nonsignificant differences between both of them and other groups (G2, G3 and control). Rats fed on diet contained high fat sausage (G1) had the highest liver weight/body weight ratio (3.91%). On the other hand, rats fed on reduced fat sausage with 7.5% chitin (G4) had the lowest value of liver weight/body weight (3.36%). The increase of liver weight in the rats fed on different diets may be due to the accumulation of fats in the liver tissues (Halhotra, 1984). Also, there were nonsignificant differences (P>0.05) in brain weight/ body weight ratio (%) between the control group and G3, also between G1 and G4 but, it showed significant differences between G1and G2 whereas, slight significant differences appeared between both of them and rats groups (G3 and control). Generally, the highest brain weight / body weight ratio (1.12%) was recorded for G4 followed by G3 (0.98%), control (0.96 %) and G1 (0.92%) with nonsignificant differences. On the contrary, the lowest brain weight / body weight (0.84%) was recorded for G2 with nonsignificant differences when compared with control, G1 and G3. Also, from the same table, there were nonsignificant differences in heart weight / body weight ratio between control group (0.351%) and other rats groups whereas, showing significant differences between rats fed on diet contained high fat sausage (G1) and that fed on reduced fat (G2).

Table (7): Organs weight / body weight ratio (%) of rats groups fed on tested diets during the experimental period (28 days).

Parameters \ Rats groups	Control	G1	G2	G3	G4	LSD at 0.05 level
Final body wt. (g)	158.20[a]	166.75[a]	15425[a]	151.00[a]	127.25[b]	18.25
Liver (%)	3.47[ab]	3.91[a]	3.50[ab]	3.42ab	3.36[b]	0.47
Kidney (%)	0.55[a]	0.68[a]	0.63[a]	0.59[a]	0.54[a]	0.15
Brain (%)	0.96[ab]	0.92[b]	0.84[b]	0.98[ab]	1.12[a]	0.16
Pancreas (%)	0.18[a]	0.14[a]	0.14[a]	0.22[a]	0.22[a]	0.09
Spleen (%)	0.392[a]	0.387[a]	0.477[a]	0.417[a]	0.435[a]	0.087
Bladder (%)	0.081[a]	0.067[a]	0.092[a]	0.097[a]	0.100[a]	0.061
Heart (%)	0.351[ab]	0.325[b]	0.403[a]	0.375[ab]	0.363[ab]	0.053
Tests (%)	1.81[a]	1.79[a]	2.00[a]	1.93[a]	1.85[a]	0.45
Lung (%)	0.690[a]	0.725[a]	0.70[a]	0.650[a]	0.715[a]	0.17

Where: Mean values in the same row with the same letter are not significantly different at 0.05 level.
For define the abbreviations see table (2).
LSD: Least Significant Differences at 0.05 level.

Liver enzymes activity (GOT and GPT):

Liver functions (GOT and GPT) in serum of rats groups fed on tested diets are shown in Table (8). There were nonsignificant differences (P>0.05) in GOT among all rats groups at zero time and after 2 weeks from beginning of the experiment but significant differences (P≤0.05) were found between control group (fed on basal diet) and rats groups (G1and G2) and between both of them whereas, there were nonsignificant differences between rats groups (G2), (G3) and (G4) on one side and the control from the other side at the end of experimental period (28 days). Also, there were nonsignificant differences among all rats groups at zero time for GPT whereas, significant differences between G1 and control group could be recorded after 2 and 4 weeks but, there were nonsignificant differences among other rats groups (G2, G3 and G4) and they recorded nonsignificant differences when compared with both control group and G1. There were nonsignificant differences in liver enzymes activity (GOT and GPT) among rats at the same group during the experimental period for all rats groups except of the G1 which recorded significant differences after 2 and 4 weeks. At any time of experimental period, the highest GOT and GPT was recoded for rat group fed on diet contained high fat sausage. In this concern, Abdel-Rahim *et al.,* (1995) reported that AST (GOT) and ALT (GPT) activities in serum were significantly stimulated by feeding on hypercholesterolemic diet. On the other hand, rats groups which fed on reduced fat sausage with 5 and 7.5 % chitin had the lowest values when compared with other groups, except with the control group. This may be due to chitin bind the lipids which minimize load on liver consequently reduced serum GOT and GPT. Generally, GOT and GPT in serum of all rats groups were slightly increased with increasing the experimental period.

Table (8): Liver functions (GOT and GPT) in serum of rats groups fed on tested diets during the experimental period (28 days).

Rats groups	GOT (AST) (mg / dl)				GPT (ALT) (mg / dl)			
	Zero time	2 Ws	4 Ws	LSD	Zero time	2 Ws	4 Ws	LSD
Control	17.37 ^{Aa}	17.45 ^{Aa}	17.76 ^{Ac}	4.38	10.75 ^{Aa}	10.97 ^{Ab}	11.28 ^{Ab}	2.78
G1	17.17 ^{Ca}	23.00 ^{Ba}	30.00 ^{Aa}	4.51	10.41 ^{Ba}	15.62 ^{Aa}	18.17 ^{Aa}	4.31
G2	16.95 ^{Aa}	21.66 ^{Aa}	23.00 ^{Ab}	5.88	10.96 ^{Aa}	13.50 ^{Aab}	15.70 ^{Aab}	6.82
G3	17.62 ^{Aa}	19.00 ^{Aa}	19.50 ^{Abc}	3.89	10.55 ^{Aa}	12.14 ^{Aab}	13.15 ^{Aab}	6.15
G4	17.52 ^{Aa}	17.50 ^{Aa}	18.75 ^{Abc}	4.61	10.87 ^{Aa}	12.60 ^{Aab}	13.87 ^{Aab}	4.65
LSD at 0.5 level	6.61	5.76	4.62		4.61	3.76	5.63	

Where: Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different at 0.05 level.
LSD: Least Significant Differences at 0.05 level.
GOT: Glutamic–Oxaloacetic Transaminase. GPT: Glutamic–Pyruvic Transaminase.
For define the abbreviations see table (2)

Triglycerides and total lipids:

Triglycerides (TG) and total lipids in serum of rats groups fed on tested diets are shown in Table (9). There were nonsignificant differences (P>0.05) in triglycerides content (TG) among all rats groups at zero time but significant differences appeared (P≤0.05) between G1 and other groups. On the other hand, nonsignificant differences were recorded between G3 and G4 and between control group and both of G2 and G3 after 2 weeks. Among rats of the same group do not record any significant differences for control and G2 whereas, other rats groups (G1, G3 and G4) recorded significant differences during experimental period. Significant increment in serum triglycerides by feeding on diet contained high fat sausage which raised TG from 78.97 to 112.0 mg/dl at the end of feeding period while, serum triglycerides in rats groups fed on reduced fat sausage prepared with 5 and 7.5% chitin (G3 and G4) significantly decreased to reach 46.32 and 43.85 mg/dl, respectively at the end of feeding period. These results were in line with the findings of Koide (1998) who reported that, chitin-chitosan when used as a food supplement does lower triglycerides and total lipids due to its ability to bind dietary lipids, thereby reducing intestinal lipid absorption.

Table (9): Triglycerides and total lipids (mg / dl) in serum of rats groups fed on tested diets during the experimental period (28 days).

Rats groups	Triglycerides (TG) (mg / dl)				Total lipids (TL) (mg / dl)			
	Zero time	2 Ws	4 Ws	LSD at 0.5 level	Zero time	2 Ws	4 Ws	LSD at 0.5 level
Control	67.55 ^{Aa}	68.12 ^{Abc}	78.97 ^{Ab}	15.21 ^{ns}	367.8 ^{Ca}	475.2 ^{Bb}	596.6 ^{Ac}	31.98
G1	67.27 ^{Ca}	93.15 ^{Ba}	112.0 ^{Aa}	15.99 **	363.7 ^{Ca}	766.1 ^{Ba}	1046.5 ^{Aa}	59.19
G2	66.96 ^{Aa}	74.63 ^{Ab}	80.19 ^{Ab}	14.64 ^{ns}	358.2 ^{Ca}	472.8 ^{Bb}	659.55 ^{Ab}	28.92
G3	67.19 ^{Aa}	60.87 ^{Acd}	46.32 ^{Bc}	14.22 *	360.2 ^{Ba}	395.6 ^{Bc}	450.89 ^{Ad}	45.41
G4	67.84 ^{Aa}	54.26 ^{Bd}	43.85 ^{Bc}	12.04 **	355.71 ^{Ba}	386.4 ^{Bc}	443.37 ^{Ad}	32.50
LSD at 0.05 level	13.64	12.23	13.68		21.55	41.40	45.18	

Where: Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different at 0.05 level.
LSD: Least Significant Differences at 0.05 level.
For define the abbreviations see table (2).

Also, from the same table, it could be noticed that, there were nonsignificant differences (P>0.05) in total lipid content (TL) between rats groups at zero time whereas, significant differences (P≤0.05) were found between groups (G1and G2) and between both of them and control after 2 and 4 weeks but there were nonsignificant differences between groups (G3, G4 and control) after 2 weeks, and significant differences appeared between both (G3 and G4) and control after 4 weeks. During the feeding experiment period, the total lipids significantly increased as the period of experimental increased for all rats groups. Rats group (G1) had the highest value of total lipids (1046.5 mg/dl) meanwhile, rats fed on diets contained reduced fat with 5 and 7.5% chitin (G3 and G4) had the lowest total lipid (450.89 and 443.37 mg/dl, respectively) when compared with rats fed on diet contained reduced fat prepared without chitin (G2).

Total cholesterol (TC), high density lipoprotein (HDL) and risk factor:

Total cholesterol and high density lipoprotein values in serum of rats groups fed on tested diets are shown in Table (10). There were nonsignificant differences (P>0.05) in total cholesterol content (TC), high density lipoprotein (HDL) and risk factor among all rats groups after adaptation period (zero time). Significant differences (P≤0.05) were recorded for serum total cholesterol between different rats groups after 2 and 4 weeks respectively. On the other hand, there were nonsignificant differences in TC between control group and both G3 and G4 after 2 and 4 weeks. Total cholesterol in rats fed on high fat sausage (G1) and that fed on reduced fat (G2) significantly increased from 71.62 and 72.81mg / dl at zero time to reach 146.6 and 98.23 mg / dl, respectively after 4 weeks. Moreover, rats fed on diet contained reduced fat prepared with 5 and 7.5% chitin (G3and G4) had the lowest serum total cholesterol at any time of feeding period when compared with G1and G2.These results are in agreement with those obtained by Koide (1998) who reported that, chitin and chitosan when used as a food supplement does lower plasma cholesterol and improves the HDL-cholesterol / total cholesterol ratio.

Table (10): Total cholesterol, high density lipoprotein (mg/dl) and risk factor in serum of rats groups fed on tested diets during the experimental period (28 days).

Rats groups	Total Cholesterol (TC) (mg / dl)				High Density Lipoprotein (HDL) (mg/dl)				Risk Factor			
	Zero time	2 Ws	4 Ws	LSD	Zero time	2 Ws	4 Ws	LSD	Zero time	2 Ws	4 Ws	LSD
Control	71.06^{Aa}	71.76^{Ac}	70.96^{Ac}	6.31^{ns}	40.21^{Aa}	40.67^{Aab}	40.37^{Aa}	5.28^{ns}	1.77^{Aa}	1.76^{Ac}	1.76^{Ac}	0.16^{ns}
G1	71.62^{Ba}	89.18^{Ba}	146.6^{Aa}	19.8^{**}	40.71^{Aa}	24.00^{Bd}	18.45^{Bd}	6.21^{***}	1.76^{Ca}	3.71^{Ba}	7.94^{Aa}	0.38^{***}
G2	72.81^{Ba}	80.7^{Bb}	98.23^{Ab}	10.5^{**}	40.97^{Aa}	30.66^{Bc}	28.70^{Bc}	5.30^{**}	1.78^{Ca}	2.63^{Bb}	3.42^{Ab}	0.26^{***}
G3	71.75^{Aa}	75.1^{Abc}	77.74^{Ac}	8.47^{ns}	40.00^{Aa}	43.57^{Aa}	38.99^{Aa}	5.02^{ns}	1.79^{Ba}	1.72^{Bc}	1.99^{Ad}	0.157^{*}
G4	70.89^{Aa}	69.15^{Ac}	76.17^{Ac}	6.92^{ns}	39.89^{Aa}	37.10^{Bb}	34.15^{Ab}	5.98^{*}	1.78^{Ba}	1.86^{Bc}	2.23^{Ac}	0.08^{***}
LSD	7.71^{ns}	7.72^{**}	14.53^{***}		4.53^{ns}	5.51^{***}	4.74^{***}		0.13^{ns}	0.28^{***}	0.186^{***}	

Where: Mean values in the same column (as a small letter) or row (as a capital letter) with the same letter are not significantly different at 0.05 level.
LSD: Least Significant Differences at 0.05 level.
For define the abbreviations see table (2).

High density lipoprotein (HDL) of all rats groups insignificantly decreased during feeding period except of the G1 and G2 which significantly decreased. At the end of experimental period, the highest HDL-cholesterol (34.15 mg/dl) was recorded for G4, followed by G3 (38.99 mg/dl) with nonsignificant differences between them. On the contrary, the lowest HDL-cholesterol (18.45 mg/dl) was recorded for rats fed on diet contained high fat sausage (G1). When calculating of risk factor (TC/HDL) as shown in Table (10), it was very low for control and other rats groups at zero time and after 2 weeks from the beginning of the experiment. Also, after 4 weeks, risk factor for all rats groups was lower than 4.97 (permissible limit), except for G1 which had higher risk factor (7.94). This may be due to its high in TC and low in HDL- cholesterol when compared with other rat groups.

Low density lipoprotein (LDL) and very low density lipoprotein (VLDL):

Low density lipoprotein and very low density lipoprotein values in serum of rats groups fed on tested diets are shown in Table (11). After adaptation period (at zero time) there were nonsignificant differences (P>0.05) in LDL-cholesterol values between all rats groups. The differences in LDL values between control group and both G3 and G4 were insignificant (P>0.05) after 2 weeks. On the contrary, there were significant differences (P≤0.05) between G1 and G2 and significant differences between both of them and control, G3 and G4 after 2 weeks. At the end of experimental period, there were significant differences between all rats groups except G3 and G4 which showed no significant differences between both of them.

Table (11): Low density lipoprotein and very low density lipoprotein (mg / dl) in serum of rats groups fed on tested diets during the experimental period (28 days).

Rats groups	Low Density Lipoprotein) (mg / dl)				Very Low Density Lipoprotein (VLDL)			
	Zero time	2 Ws	4 Ws	LSD at 0.05	Zero time	2 Ws	4 Ws	LSD at 0.05
Control	17.34 ^{Aa}	17.47 ^{Ac}	14.80 ^{Ad}	6.27	13.51 ^{Aa}	13.62 ^{Abc}	15.79 ^{Ab}	3.05
G1	17.46 ^{Ca}	46.55^{Ba}	105.74^{Aa}	15.05	13.45^{Ca}	18.63 ^{Ba}	22.41^{Aa}	3.29
G2	18.45 ^{Ca}	35.16 ^{Bb}	53.49 ^{Ab}	7.65	13.39 ^{Aa}	14.93 ^{Ab}	16.04 ^{Ab}	2.93
G3	18.31^{Ba}	19.38 ^{Bc}	29.49 ^{Ac}	3.83	13.44 ^{Aa}	12.17^{Acd}	9.26 ^{Bc}	2.84
G4	17.43 ^{Ca}	21.20 ^{Bc}	33.25 ^{Ac}	2.11	13.57 ^{Aa}	10.85B^{d}	8.77 ^{Bc}	2.40
LSD at	4.27	3.80	10.76		2.78	2.44	2.73	

Where: Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different at 0.05 level.
LSD: Least Significant Differences at 0.05 level
For define the abbreviations see table (2).

Significant increment in serum LDL-cholesterol of all rats groups except control group was noticed as the period of feeding increased. The lowest increment rate was recoded for G3 (29.49 mg/dl) followed by G4 (33.35 mg/dl) with nonsignificant differences. On the other hand, the highest increment rate was recorded for G1 (105.74 mg/dl) at the end of experimental period.

According to the calculations of VLDL-cholesterol, the results of VLDL values recorded the same trend for triglyceride (TG) results of all rats groups.

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إنتاج سجق منخفض الدهن باستخدام الكيتين كبديل جديد للدهن

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قسم بحوث تكنولوجيا اللحوم والأسماك- معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – الجيزة- مصر

نظراً للمخاطر الصحية الناتجة عن تناول الأغذية المرتفعة في محتواها من الدهون وخاصة منتجات اللحوم لذلك أجرى هذا البحث بهدف إنتاج سجق بقرى منخفض الدهن باستخدام مستويات مختلفة من الكيتين (كبديل للدهن) وسجق منخفض الدهن بدون إضافة الكيتين (كنترول) بالإضافة الى عينة سجق مرتفعة فى نسبة الدهن (كنترول). تم تقييم كل من التركيب الكيماوى و الخصائص الطبيعية لمعاملات السجق المختلفة سواء المطهية وغير المطهية بالإضافة الى تقييم الخصائص الحسية. كما تم تقييم التغيرات البيولوجية والبيوكيميائية لمجاميع الفئران التى تم تغذيتها على معاملات السجق المختلفة.

أوضحت النتائج أن خفض محتوى الدهن أدى إلى إنخفاض معنوى فى الخصائص الحسية لمعاملات السجق. إضافة الكيتين بنسب ٥ و ٧,٥ % فى تصنيع السجق منخفض الدهن أدى الى تحسين الخصائص الحسية لهذه المعاملات. كما أوضحت النتائج أن قيم الخصائص الحسية إنخفضت مع زيادة نسب الكيتين فى السجق. وعموما أعلى درجات التقبل العام سجلت لعينة السجق المرتفع فى نسبة الدهن (كنترول) يلى ذلك عينة السجق المنخفض الدهن والمجهز باضافة ٥ % كيتين بدون إختلافات معنوية بينهم.

كما أشارت النتائج الى أن خقض محتوى الدهن فى السجق أدى الى زيادة الفقد بالطهى وخفض كل من القدرة على امساك الماء و البلاستيكية. بينما أدى إضافة الكيتين بنسب ٥ و ٧,٥ % فى تصنيع السجق منخفض الدهن الى تقليل الفقد بالطهى وزيادة كل من القدرة على امساك الماء و البلاستيكية.

أوضحت نتائج التقييم البيولوجى التى أجريت على الفئران أن مجموعة الفئران التى تغذت على السجق المرتفع الدهن كانت الأعلى فى نشاط كل من انزيمات الكبد (GPT و GOT) و الجليسريدات الثلاثية و الدهون الكلية والكوليسترول الكلى والكوليسترول منخفض الكثافة LDL و VLDL بينما كانت هذه المجموعة الأقل فى قيمة الكوليسترول عالى الكثافة HDL . كما أوضحت النتائج أن مجاميع الفئران التى تغذت على السجق منخفض الدهن والمجهز باضافة الكيتين بنسب ٥ و ٧,٥ % كانت الأقل فى قيم الاختبارات السابقة باستثناء الكوليسترول عالى الكثافة HDL كانت هى الأعلى عند مقارنتها بمجموعة الفئران التى تغذت عى السجق منخفض الدهن بدون اضافة الكيتين.