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BIOLOGICAL EVALUATION OF LOW – FAT CAKE

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ABSTRACT

Low- fat cake prepared by partial replacement of shortening with Maltodextrin or Simplesse were organoleptically evaluated and subjected to analysis for gross composition and caloric value. A nutrition experiment on rats was conducted to determine the effect of low – fat cake diet on growth parameters and serum lipid profile.

The sensory evaluation results indicated that no significant difference (P≤ 0.05) was found among replacement treatments up to 50% replacement level and the full fat cake, and the panelists considered that, all treatments were acceptable up to 75% replacement level. The results of gross chemical composition and caloric value showed a significant decreased (P≤ 0.05) in fat content and caloric value by increasing fat replacement level. The final body weight, weight gain, feed efficiency ratio and the organ weight (% of body weight) of rats were not significantly (P≤ 0.05) affected by fat replacement. Triglycerides (T.G), total cholesterol and low density lipoprotein cholesterol (LDL-C) of serum were significantly (P≤ 0.05) decreased by replacement 50% or 75% of shortening using both fat replacers. The calculated Atherogenic Index was significantly decreased (P≤ 0.05) by fat replacement at ratio of 25%, 50% and 75% by using maltodextrin or at ratio of 50% and 75% by simplesse.

Keywords : Low- fat cake, maltodextrin, simplesse and serum lipids.

INTRODUCTION

Despite the numerous benefits of fats in our diet, excessive intake of fats, however, is known to be associated with an increased risk of obesity, gall bladder diseases, serious co-morbidities including diabetes, coronary heart diseases and some types of cancers. Obesity is one of today' s most visible yet neglected public health problems (Weber and Clavein, 2006). Obesity has been declared a global epidemic by the World Health Organization (WHO, 2005). Compared with the lean population, the risk of death doubles for individuals with Body Mass Index of 40 kg/m'' (morbidly obese persons) or more and their life expectancy is reduced by between 5 and 20 years (Samore, 2006).

Knowledge and concerns of the adverse health implications of high fat intake in consumers has culminated in a rising demand for low-fat foods. Consequently, the use of fat replacers as alternative food source is fast gaining attention among producers and consumers. These low-fat foods are the result of new and existing food technologies used to replace some or most of the fat without sacrificing the taste, texture and aroma consumers desire (Anon, 2006).

High – fat bakery products constitute a part of the diet of most people; however, they are known to be high in fat and calories. Cakes represent the most popular bakery product that contain high amount of fat. Normal cake contain about 18% fat (Zambrano *et al*., 2004). Therefore there is urgent need to develop fat replacers which can substitute fat in these products and

produce reduced-fat cake options which will be able to match the quality of their full fat complements.

Fat replacers are derived from three main sources (carbohydrate-based, protein- based and fat based). Maltodextrin (carbohydrate- based fat replacer) is starch hydrolysis products obtained by acid or enzymic hydrolysis of starch materials and characterized by a low dextrose equivalent (DE) value. Since maltodextrins when used in solution at a concentration greater than 20% form thermoreversible gels, with some of the sensory characteristics of fats, and caloric value amounts to approximately 1 kcal/g.(Jones, 1996).

Simplesse (protein- based fat replacer) is a microparticulated protein which owes its efficacy in replacing fat in foods to the novel physical form in which it has been caused to gel. This gel is in the form of microparticles, each about one thousandth of a millimeter in diameter (Singer, 1996).

Accordingly, the aim of this research was to biologically evaluate the performance of maltodextrin and simplesse as fat replacers in production of low- fat cake. A feeding experiment on rats was conducted to measure the biological effects including growth parameters, blood serum lipids profile as triglycerides (T.G), total cholesterol (T.C), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) and atherogenic index (AI).

MATERIALS AND METHODS

Materials:

Local wheat flour made from U.S. wheat (72% extraction), powdered sugar, egg, non fat dry milk, salt, baking powder, shortening and vanilla were purchased from the local market Mansoura city, Egypt.

Fat replacers used included maltodextrin (National Co. for Maize Products, 10th of Ramadan City, Egypt) and Simplesse® 100 (CP Kelco Co.,8355 Aero Drive San Diego, CA 92123 U.S.A). Leciprime™(lecithin) and emulsifier type Palsgaard which contains mono- and diglycerides (E-471), guar gum (E-412) and carrageenan (E-407) were obtained from Al-Amreety Co. for Importing Edible Materials, Egypt.

Male albino rats (Sprague Dawley) weighing 100 - 110 g, were obtained from the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Kits used in the determinations of total serum cholesterol, high-density lipoprotein- cholesterol and serum triglycerides were obtained from ALgomhoria Co. for Trading in Medicines, Chemicals and Medical Supplies, Cairo, Egypt.

Methods:

Maltodextrin Sol-Gel Preparation:

Dispersion of corn maltodextrin (20 DE) 30 %w/w was prepared. Sols were prepared by stirring maltodextrin and distilled water, until slightly dissolved**.** The solution was cooked over medium-high heat until boiling. The heat was reduced to medium-low and solution was partially covered, stirring occasionally, until slightly thickened (approximately 15-20 minutes); the maltodextrin solution should coat a spoon and large bubbles should be

apparent. Once the solution started thickening and bubbles began forming, the sol was immediately transferred to a beaker, covered with plastic wrap, and cooled in the refrigerator at 5.5°C for 24 hours until a gel formed (Conforti and Smith, 1998).

Simplesse dispersion Preparation:

Simplesse® 100 dry powder was dissolved at a concentration of 33% (w/w) in cold water. The solutions were stored at 4 °C overnight. Cold storage resulted in gel formation.

Cake processing:

Cupcakes were processed using the method described by AACC (1989) as follows:

The dry ingredients (i.e. flour, non fat dry milk, baking powder, salt and vanilla) were weighed and sifted together. The shortening, emulsifiers and sugar were creamed for 1 min on low speed in a Moulinex mixer (Supermix 150) and then they were creamed for additional 1 min at the high speed. Eggs were added gradually while creaming and all the mixture were creamed for additional 2 min on the high speed. The dry ingredients and half of the water were added and mixed 1.5 min. The remaining half of the water was added and mixed for an additional 1.5 min. After scraping down the mixing bowl, the batter was mixed again 1 min at the high speed. An amount of 60 g of batter was weighed and placed in paper baking cups in an aluminum muffin pan (cup size 7.6 × 3.2 cm, bottom diameter 5.2 cm). The cupcakes were baked in a 180 °C oven for 45 min. After 5 min, the cakes were removed from the pans and cooled for 60 min then wrapped in transparent film to avoid surface drying and stored at room temperature (25° C) for 24 hour.

For low-fat applications, fat replacers (maltodextrin Sol-Gel and simplesse dispersion) were added in the creaming phase to replace 25, 50 and 75% of shortening used in cupcake formula.(Table 1). The emulsifiers was added at the first step of mixing with the sugar and Shortening.

Table (1): Formula of low-fat cakes prepared using fat replacers.

Ingredients (g)	Control	Replacement level		
		25%	50%	75%
Flour	100	100	100	100
Sugar	100	100	100	100
Shortening	50	37.5	25	12.5
Fat replacer (a)	-	12.5	25	37.5
Dry eggs	41	41	41	41
N.F.D.milk	12	12	12	12
Baking powder	5	5	5	5
Salt	3	3	3	3
Vanilla	0.2	0.2	0.2	0.2
Mono and diglycerides	3	3	3	3
Lecithin	0.8	0.8	0.8	0.8
Water	90.5	90.5	90.5	90.5

(a) Maltodextrin or Simplesse gel.

Treatments was prepared using emulsifiers (3% mono-diglycerides and 0.8% lecithin flour weight basis).

Sensory evaluation:

Sensory evaluation was performed by Fifteen panelists who are graduate students and staff members in the Department of Food Industries, Mansoura University. Cakes were evaluated for crumb color, texture, moistness, sweetness, adhesiveness and height according to A.A.C.C.(1983).

Gross chemical composition and caloric value:

Moisture, ether extract (crude fat), crude protein and crude ash contents were determined according to A.O.A.C.(1990). Carbohydrates was Calculated by difference: 100 - [(moisture %) + (ash %) + (crude protein %) + (crude fat %)]. While, the caloric value was calculated from the sum of the percentages of crude protein and total carbohydrates multiplied by a factor of 4 (kcal.g^{-1}) plus the crude fat content multiplied by 9 (kcal. g^{-1}), according to Zambrano *et al*. (2004) .

Biological assay

Animals and experimental design:

Forty eight male albino rats (100 to 110 g) were housed in stainless steel, screen cages and allowed free access to food and water. At the beginning of the study, rats were divided into eight groups, each sex, with similar mean body weight and with body weight normally distributed within each group. Cages were maintained at 25 ◦C and 50% relative humidity with a 12h cycle of light and dark. The basal diet composition was as mentioned in Table (2) (Cadden *et al*.1983) . The full fat and low fat cakes were dried, finely ground and then incorporated into the basal diet at 666.7 g/kg at the expense of corn starch content. Diets were stored at -20◦C and provided to animals daily. All animals were fed a basal diet for one week, then rats were fed for eight weeks according to the following scheme:-

G_1 - Rats fed on basal diet (negative control).
G_2 - Rats fed on full fat cake diet (positive control)
G_3 - Rats fed on cake diet prepared with reduction 25% of fat by maltodextrin.
G_4 - Rats fed on cake diet prepared with reduction 50% of fat by maltodextrin.
G_5 - Rats fed on cake diet prepared with reduction 75% of fat by maltodextrin.
G_6 - Rats fed on cake diet prepared with reduction 25% of fat by simplesse.
G_7 - Rats fed on cake diet prepared with reduction 50% of fat by simplesse.
G_8 - Rats fed on cake diet prepared with reduction 75% of fat by simplesse.

Food intake were recorded daily and body weights were recorded weekly over the eight weeks experimental period. Blood samples were collected two times during the experiment, the first one was at the beginning of the experiment, second was at the end of the experiment. At the end of the experimental period animals were fasted overnight (12hr), anesthetized with diethyl ether and sacrificed. Blood was collected in a syringe. Within 2 to 3 hours of collection blood samples were centrifuged at 2500 rpm for 30 min at 4 ◦C to obtain serum. The obtained sera were kept in the deep freezer at -20°C for the subsequent analysis. The heart, liver, kidneys, spleen and lungs of each animal were removed and weighted immediately after sacrificing.

Table (2): Diet composition.

Ingredients	The basal diet (g)	Cake diet (g)
Corn starch	723	56.3
Dried cake	-	666.7
Casein	122	122
Corn oil	50	50
Cellulose	50	50
Mineral mixture	40	40
Vitamin mixture	10	10
DL-methionine	3	3
Choline chloride	2	2

Biological analysis of serum:

Triglycerides (T.G), total cholesterol and high density lipoprotein cholesterol (HDL-cholesterol) were determined in serum using colorimetric methods of Fossati and Prencipe (1982), Allain *et al*. (1974) and Lopez-Virella *et al*.(1977), respectively.

Low Density Lipoprotein cholesterol (LDL-cholesterol) were calculated as described by Wardlaw and Snook (1990) as following:

LDL-cholesterol = total cholesterol - HDL-cholesterol – (triglycerides/5).

Atherogenic index was calculated using the following equation as described by Kawase *et al*.(2000).

Atherogenic index= (Total cholesterol - HDL-cholesterol) / HDL-cholesterol

Statistical analysis:

Statistical analysis (ANOVA) was done using SPSS (2008) Version12 program for windows.

RESULTS AND DISCUSSION

Sensory evaluation of cakes prepared by using fat replacers.

The obtained results of sensory evaluation (Table 3) indicate that successful replacement of fat by using maltodextrin or simplesse up to 50% replacement level was obtained without significant differences (P≤ 0.05) among control and treatments for texture, moistness, adhesiveness, height and total score. Concerning crumb color and sweetness, there were no significant differences (P≤ 0.05) among control and treatments up to 75% replacement level for maltodextrin treatments and 50% replacement level for simplesse treatments.

Moreover, the panelists considered that all treatments were acceptable up to 75% replacement level by both maltodextrin or simplesse.

Gross chemical composition of low fat Cake formulated by fat replacers.

The data in Table (4) showed that the moisture content of cakes was significantly affected (P≤ 0.05) by fat replacer level and fat replacer type. The moisture content was increased as the replacement level increased. Concerning maltodextrin, values ranged from 21.05% for control to 27.87% for treatment $R_1$75 %. On the same trend the moisture content of simplesse

treatments were increased to 26.52% for 75% replacement level. It is clear that the effect of using maltodextrin on moisture content was more pronounced. This might indicate that maltodextrin had a high affinity for water and can retain moisture in foods.

Table 3: Sensory evaluation of cakes prepared by using fat replacers.

Attributes / Treatments	Texture	Moistness	Adhesiveness	Height	Crumb Color	Sweetness	Total Score
	Out of 10 (acceptable ≥ 7)						Out of 60
R 0% control	9.07 [a] ±0.70	9.20 [a] ±0.77	9.40 [a] ±0.63	9.53 [a] ±0.52	9.53 [a] ±0.52	9.33 [a] ±0.62	56.07 [a] ±2.22
R_1 25 %	9.27 [a] ±0.59	9.33 [a] ±0.62	9.27 [a] ±0.59	9.13 [a] ±0.64	9.27 [a] ±0.59	9.60 [a] ±0.63	55.87 [a] ±2.75
R_1 50 %	8.87 [a] ±0.74	8.67 [a] ±1.1	8.87 [a] ±0.74	9.07 [a] ±0.59	8.73 [ab] ±0.80	9.27 [a] ±0.88	53.47 [a] ±4.10
$R_1$75 %	8.20 [b] ±1.01	8.00 [b] ±1.07	7.93 [b] ±1.10	8.13 [b] ±1.36	8.67 [ab] ±1.05	8.87 [a] ±0.92	49.80 [b] ±4.43
R_2 25 %	8.87 [a] ±0.92	8.80 [a] ±0.77	8.93 [a] ±0.80	9.33 [a] ±0.90	9.33 [a] ±0.62	8.93 [a] ±0.88	54.20 [a] ±4.11
R_2 50 %	9.07 [a] ±0.88	8.93 [a] ±0.70	8.80 [a] ±0.94	8.67 [ab] ±0.72	9.40 [a] ±0.63	8.87 [a] ±0.92	53.73 [a] ±3.71
R_2 75 %	8.13 [b] ±0.83	7.80 [b] ±0.68	7.87 [b] ±1.19	8.07 [b] ±1.22	8.33 [b] ±0.90	7.67 [b] ±1.29	47.87 [b] ±4.02

values are average ± SD of fifteen replicates.
Values in the same column with the same letter are not significantly different at P ≤ 0.05.
R : fat replacer , R_1 : Maltodextrin, R_2 : Simplesse.

Table 4: Gross chemical composition and Caloric value of low fat Cake formulated by fat replacers.

Treatment	Moisture Content %	Ash %		Crude fat %		Protein %		Total Carbohydrates %		Caloric value (Kcal/100g) (wet basis)	Fat - source calories / Total calories %
		wet basis	Dry basis	wet basis	Dry basis	wet basis	Dry basis	wet basis	Dry basis		
R0%Control	21.05 [a] ±0.54	1.87 ±0.03	2.36 ±0.04	19.66 ±0.27	24.91 ±0.35	5.52 ±0.08	6.99 ±0.03	51.90 ±0.28	65.74 ±0.35	406.63 [a] ±1.39	43.52 [a] ±0.46
R_1 25 %	22.47 [b] ±0.25	1.85 ±0.03	2.39 ±0.04	13.17 ±0.44	16.98 ±0.57	5.58 ±0.06	7.20 ±0.07	56.93 ±0.45	73.43 ±0.58	368.56 [c] ±2.18	32.15 [c] ±0.89
R_1 50 %	26.11 [d] ±0.64	1.86 ±0.01	2.52 ±0.02	10.39 ±0.37	14.06 ±0.50	5.50 ±0.07	7.44 ±0.09	56.14 ±0.38	75.98 ±0.52	340.05 [d] ±1.83	27.49 [d] ±0.84
R_1 75 %	27.87 [f] ±0.47	1.86 ±0.03	2.57 ±0.05	6.35 ±0.54	8.81 ±0.75	5.60 ±0.19	7.76 ±0.26	58.32 ±1.02	80.85 ±1.41	312.88 [f] ±5.34	18.25 [g] ±0.77
R_2 25 %	22.84 [b] ±0.10	1.92 ±0.02	2.49 ±0.02	15.50 ±0.11	20.09 ±0.15	6.44 ±0.10	8.35 ±0.02	53.30 ±0.11	69.08 ±0.15	378.47 [b] ±0.53	36.87 [b] ±0.21
R_2 50 %	24.37 [c] ±0.61	1.95 ±0.06	2.58 ±0.08	9.93 ±0.61	13.12 ±0.81	8.06 ±0.26	10.66 ±0.35	55.69 ±0.64	73.63 ±0.84	344.34 [d] ±2.98	25.94 [e] ±1.38
R_2 75 %	26.52 [de] ±0.23	2.14 ±0.03	2.92 ±0.03	8.07 ±0.45	10.98 ±0.61	9.00 ±0.34	12.25 ±0.46	54.27 ±0.44	73.86 ±0.60	325.69 [e] ±2.30	22.28 [f] ±1.09

values are the average ± SD of three replicates.
Values in the same column with the same letter are not significantly different at P ≤ 0.05.
R : fat replacer , R_1 : Maltodextrin , R_2 : Simplesse.

The ash content of different treatments were nearly the same, ranged from 1.85% (wet basis) for R_1 25% to 2.14% for R_2 75 %. Zambrano *et al*.,

(2004) reported less values of 1.4-1.5% on wet basis. On the dry basis, our results were ranged from 2.36% for control to 2.92 for treatment R_2 75%. Abd-El-Khalek. (2007) reported nearly the same range (2.37%-2.83% on dry basis) of ash content of cake made with fat replacers.

The expected decrease in fat content of cake as a result of shortening reduction in respective batter formula were presented in Table (4). The results of fat content were in the order : control > $R_1$25 % > $R_1$50 % > $R_1$75 % for maltodextrin treatments. Same trend was observed in case of using simplesse.

The results of protein content (Table 4) indicate that protein content in cakes made with simplesse (protein based fat replacer) were higher than that of those prepared with maltodextrin or the control sample. On contrast, the carbohydrate content of maltodextrin treatments were higher than those of simplesse treatments and control sample. It is predicted, as a replacement of shortening was made with a carbohydrate based fat replacer (maltodextrin).

The caloric value and fat- source calories as a ratio of total calories intake represent important nutritive factors. Table (4) showed the caloric value and fat- source calories / total calories of cake prepared using fat replacers. It was clear that elevating the fat replacement level significantly ($P \leq 0.05$) decreased the caloric value of cakes. Usage of maltodextrin decreased the caloric value from 406.63 Kcal/100g for control to 312.88 Kcal/100g for 75% replacement level. Same trend were attained with simplesse treatments. This could be attributed to the replacement of a high caloric density constituent (fat-9kca/g) with lower caloric density constituents (protein or carbohydrates-4kca/g). Also, the corresponding increase of non- caloric value constituent (moisture) in cake prepared using fat replacers represents additional factor to reduce the caloric value of the cake.

The ratio of fat- source calories / total calories which represents an important dietary guidelines (Table 4) was significantly ($P \leq 0.05$) decreased as a result of shortening replacement with maltodextrin or simplesse. The lowest ratio was achieved in case of replacement level 75% with maltodextrin, value being 18.25% while control value was 43.52%.

In this connection, Zambrano *et al*., (2004) reported that the substitution of 50% fat with guar or xanthan gums allows the production of light cakes with respect to fat and caloric value reduction. Abd-El-Khalek. (2007) reported that all cakes prepared with fat replacers were found to be lower in their caloric value compared to that of control cake.

Biological evaluation of low – fat cake formulated by fat replacers

The body weight (g), weight gain (g) and feed efficiency ratio of rats fed on low-fat cake diets were estimated to follow up the healthy feed parameters during the experimental period. The results (Table 5) showed that the initial weight of rats ranged from 102.00(g) to 109.33(g). During the eight weeks of feeding period the weight of rats for all treatments were gradually increased. At the end of experimental period rats weight ranged from 255.67(g) for G_3(R_1 25 %) to 290.75(g) for G_6 (R_2 25 %). The weight gain(g) of rats ranged from 146.33(g) for G_3(R_1 25 %) to 190.00(g) for G_6(R_2 25 %). Feed efficiency ratio ranged from 0.139 for G_1(negative control) to 0.206 for G_6(R_2 25 %). The results indicated that most of differences among the control and low fat cake

diet treatments were insignificant (P≤ 0.05). Therefore it could be concluded that neither fat replacer level nor fat replacer type had significant effect(p>0.05) on final body weight, weight gain and feed efficiency ratio of rats and all rats appeared healthy after the experimental period.

Table 5: Body weight , Weight gain(g) and Feed efficiency ratio of rats fed on low-fat cake diets.

Cake diet	Feeding time (weeks)									Weight gain (g) [1]	Feed efficiency ratio [2]
	0	1	2	3	4	5	6	7	8		
G_1 (negative control)	104.67 ±5.86	131.67 ±12.90	154.33 ±17.21	178.00 ±27.51	193.00 ±32.05	215.00 ±35.51	229.67 ±30.27	256.67 ±39.80	268.00^{a} ±32.42	163.33^{abc} ±27.47	0.139^{d} ±0.023
G_2 (positive control)	104.00 ±7.00	132.67 ±13.80	174.67 ±14.01	189.33 ±15.50	208.00 ±11.53	238.67 ±13.58	264.67 ±19.86	284.67 ±18.15	286.33^{a} ±18.50	182.33^{ab} ±11.72	0.198^{ab} ±0.013
G_3 (R_1 25 %)	109.33 ±1.15	134.33 ±2.08	162.00 ±3.00	182.33 ±4.93	193.00 ±4.00	209.33 ±14.57	223.67 ±17.21	241.67 ±21.57	255.67^{a} ±9.02	146.33^{c} ±9.02	0.159^{cd} ±0.010
G_4 (R_1 50 %)	103.75 ±9.39	130.25 ±13.52	162.50 ±15.18	191.75 ±19.82	209.75 ±21.14	229.50 ±18.34	247.50 ±17.79	262.00 ±20.02	257.25^{a} ±15.78	153.50^{bc} ±23.47	0.166^{bcd} ±0.025
G_5 (R_1 75 %)	102.00 ±12.36	133.50 ±14.93	169.50 ±15.61	198.50 ±18.88	211.25 ±24.17	229.00 ±21.24	244.50 ±23.59	257.00 ±28.73	262.75^{a} ±28.29	160.75^{abc} ±28.72	0.174^{abc} ±0.031
G_6 (R_2 25 %)	100.75 ±10.63	133.25 ±9.71	165.25 ±9.29	198.50 ±10.15	221.50 ±9.75	244.50 ±4.12	279.00 ±5.29	293.50 ±1.29	290.75^{a} ±4.11	190.00^{a} ±7.62	0.206^{a} ±0.008
G_7 (R_2 50 %)	102.00 ±12.19	123.75 ±10.63	166.25 ±8.73	194.25 ±10.40	215.50 ±13.58	238.75 ±14.80	262.75 ±19.62	272.25 ±19.60	277.25^{a} ±23.16	175.25^{abc} ±20.69	0.190^{abc} ±0.022
G_8 (R_2 75 %)	103.25 ±9.54	138.75 ±14.03	175.00 ±12.19	204.50 ±11.68	224.00 ±13.04	240.25 ±17.61	255.50 ±19.64	272.00 ±20.46	279.50^{a} ±13.63	176.25^{abc} ±12.69	0.191^{abc} ±0.014

1Body weight gain = final weight(g) - initial weight(g).
2 Feed efficiency ratio = body weight gain(g) / feed consumed during the experimental period(g).
values are average ± SD of six replicates.
Values in the same column with the same letter are not significantly different at P ≤ 0.05.
R_1 : Maltodextrin , R_2 : Simplesse.

Al-Khalifa. (1996) reported that weight and weight gain were not influenced by feeding rats on modified- fat diets. Sigman-Grant (1997) stated that the use of fat substitutes may facilitate reduction of the proportion of calories derived from fat, but the effects on total energy intake and body weight were less certain. Mansour *et al*.(2003) stated that body weight and weight gain were not influenced by diets formulated with fat replacers. Abd-El-Khalek. (2007) mentioned that the differences for body weight, weight gain and feed efficiency of rats fed on full fat cake diet or low fat cake diet were insignificant (P≤ 0.05).

Table (6) represented the organ weight (% of body weight) of rats fed on basal diet, full fat cake diet and low fat cake diet. The results showed that heart weight ranged from 0.303% for G_1(negative control)to 0.386% for G_3(R_1 25 %). Liver weight (% of body weight) ranged from 2.694% for G_7(R_2 50 %) to 3.602% for G_1(negative control). Kidneys weight ranged from 0.545% for G_1(negative control) to 0.805% for G_8(R_2 75 %). Spleen weight ranged from 0.219% for G_1(negative control) to 0.413% for G_4(R_1 50 %). Lung weight ranged from 0.536% for G_6(R_2 25 %) to 0.841% for G_1(negative control).

Table 6: Organ weight (% of body weight) of rats fed on low-fat cake diets.

Cake diet	Heart	Liver	kidneys	spleen	lung
G_1 (negative control)	0.303^{b} ±0.048	3.602^{a} ±0.427	0.545^{c} ±0.056	0.219^{c} ±0.026	0.841^{a} ±0.152
G_2 (positive control)	0.373^{ab} ±0.008	2.756^{b} ±0.364	0.711^{ab} ±0.041	0.258^{c} ±0.021	0.581^{bc} ±0.024
G_3 (R_1 25 %)	0.386^{a} ±0.060	2.859^{b} ±0.177	0.765^{ab} ±0.070	0.276^{c} ±0.039	0.689^{bc} ±0.147
G_4 (R_1 50 %)	0.320^{ab} ±0.037	2.839^{b} ±0.269	0.772^{ab} ±0.047	0.413^{a} ±0.046	0.700^{b} ±0.051
G_5 (R_1 75 %)	0.341^{ab} ±0.034	2.744^{b} ±0.146	0.698^{b} ±0.055	0.346^{b} ±0.030	0.599^{bc} ±0.037
G_6 (R_2 25 %)	0.330^{ab} ±0.032	2.761^{b} ±0.218	0.700^{b} ±0.090	0.267^{c} ±0.045	0.536^{c} ±0.060
G_7 (R_2 50 %)	0.364^{ab} ±0.043	2.694^{b} ±0.236	0.669^{b} ±0.037	0.241^{c} ±0.041	0.689^{bc} ±0.091
G_8 (R_2 75 %)	0.312^{b} ±0.049	2.986^{b} ±0.269	0.805^{a} ±0.077	0.383^{ab} ±0.016	0.676^{bc} ±0.035

values are average ± SD of six replicates.
Values in the same column with the same letter are not significantly different at P ≤ 0.05.
R_1 : Maltodextrin , R_2 : Simplesse.

These results indicated that heart, liver, kidneys and lung weight (% of body weight) were not significantly (P≤ 0.05) affected by fat replacer level or fat replacer type. On the other hand, spleen weight showed a significant differences (P≤ 0.05) among groups. Spleen weight of G_4(R_1 50 %), G_5(R_1 75 %) and G_8(R_2 75 %) were significantly (P≤ 0.05) higher than those of other groups. These results are generally agreed with those obtained by Mansour *et al*.(2003), who mentioned that heart, kidney, and lungs weights were not significantly (P≤ 0.05) affected by fat replacer level. Abd-El-Khalek. (2007) reported that rats fed cake diets containing soybean paste as a fat replacer had a significantly (P≤ 0.05) lower liver weight. Kidneys weight was not significantly (P≤ 0.05) influenced by using amylodextrin gel or simplesse as a fat replacer, but they seemed to be lower in case of using soybean paste. He added that , heart weight was not affected by feeding low-fat cake diets when compared to the control group.

Serum lipid profile for rats fed on basal diet, full fat cake diets and low fat cake diets at zero time and at the end of experimental period are presented in Table (7).

Values of triglycerides (T.G), total cholesterol, high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C) were significantly (P≤ 0.05) the same at the beginning of the experiment, that means good homogeneity of experimental units. Concerning data of the end of the experimental period, T.G, total cholesterol and LDL-C were significantly affected (P≤ 0.05) by fat replacers level and not affected by the fat replacer type. The triglycerides content (mg/dl) attained the highest value (173.60) by G_2(positive control), while triglycerides value for G_1(negative control) was 97. 28 mg/dl. Reduction 75% of fat by maltodextrin or simplesse decreased the triglycerides content (mg/dl) of serum to 103.22 and 110.72, respectively without significant difference (P≤ 0.05) as compared to G_1(negative control)

value. The results (Table 7) indicate that total cholesterol content of G_2(positive control) was significantly (P≤ 0.05) higher than those of G_1(negative control), G_4(R_1 50%) , G_5(R_1 75 %), G_7(R_2 50 %) and G_8(R_2 75 %) which had no significant difference (P≤ 0.05) among them. Concerning low density lipoprotein cholesterol results, no significant difference (P≤ 0.05) was found among G_1(negative control), G_5(R_1 75 %), G_7(R_2 50 %) and G_8(R_2 75 %), values being 16.04 mg/dl, 24.89 mg/dl, 23.62 mg/dl and 18.86 mg/dl, respectively. No Significant difference (P≤ 0.05) for high density lipoprotein cholesterol content was found among G_1(negative control) and all other groups (Table 7) .

The general trend of our results showed a considerable increase in each of serum T.G, total cholesterol and LDL-C as a result of introducing full fat cake in the diet of rats as compared to the basal diet. This effect was minimized by application of replacement shortening using fat replacers and completely neutralized at 75% replacement level.

These results might be attributed to the lower content of saturated fatty acids in the low-fat cake diets compared to that of the full fat control diet. Shortening has a high concentration of saturated fats, particularly myristic and palmitic (Lichtenstein, *et al*., 2003). Several investigators; Hayes, *et al*. (1991), McNamara. (1993) and Hegsted, *et al*. (1993); had attributed the rise in cholesterol concentration in plasma of humans and experimental animals to the presence of high levels of lauric, myristic and palmitic acids in diets.

Table 7: Serum lipids profile of rats fed on low-fat cake diets formulated by fat replacers.

Cake diet	TG (mg/dl)		Total cholesterol (mg/dl)		HDL-C (mg/dl)		LDL-C (mg/dl)		Atherogenic Index (AI)
	0 week	8th week	0 week	8th week	0 week	8th week	0 week	8th week	
G_1 (negative control)	98.76^{a} ±10.31	97.28^{c} ±11.47	82.44^{a} ±4.40	84.55^{c} ±11.43	42.39^{a} ±4.20	52.13^{a} ±6.08	20.30^{a} ±2.90	16.04^{d} ±2.69	0.68^{d} ±0.12
G_2 (positive control)	100.50^{a} ±8.02	173.60^{a} ±15.16	81.56^{a} ±9.32	131.71^{a} ±18.07	46.44^{a} ±3.82	48.27^{a} ±7.29	16.88^{a} ±2.80	50.43^{a} ±8.88	2.00^{a} ±0.28
G_3 (R_1 25 %)	90.43^{a} ±13.07	169.64^{a} ±17.83	79.76^{a} ±10.20	123.90^{ab} ±19.41	46.80^{a} ±4.58	47.97^{a} ±7.52	12.08^{b} ±2.01	44.61^{ab} ±7.29	1.40^{b} ±0.19
G_4 (R_1 50 %)	91.75^{a} ±5.45	136.96^{b} ±13.87	77.85^{a} ±5.23	100.98^{bc} ±12.66	39.62^{a} ±5.57	46.29^{a} ±4.10	19.74^{a} ±3.70	34.42^{c} ±4.39	1.29^{bc} ±0.17
G_5 (R_1 75 %)	86.88^{a} ±13.02	103.22^{c} ±13.53	71.22^{a} ±2.58	87.80^{c} ±12.81	44.82^{a} ±1.53	52.14^{a} ±4.69	10.26^{b} ±1.62	24.89^{d} ±4.08	0.75^{d} ±0.11
G_6 (R_2 25 %)	97.52^{a} ±5.74	167.97^{a} ±14.01	80.73^{a} ±10.27	126.40^{a} ±14.12	46.26^{a} ±2.80	47.94^{a} ±5.98	14.97^{ab} ±2.55	39.50^{bc} ±5.26	1.78^{a} ±0.30
G_7 (R_2 50 %)	97.36^{a} ±8.98	141.63^{b} ±14.29	80.24^{a} ±3.68	101.59^{bc} ±15.50	40.99^{a} ±5.42	49.23^{a} ±6.56	17.29^{a} ±2.37	23.62^{d} ±3.46	1.07^{c} ±0.15
G_8 (R_2 75 %)	94.39^{a} ±8.65	110.72^{c} ±16.80	74.63^{a} ±3.03	92.47^{c} ±3.37	39.87^{a} ±3.95	52.02^{a} ±5.34	16.65^{a} ±1.76	18.86^{d} ±2.49	0.76^{d} ±0.12

values are average ± SD of six replicates.

Values in the same column with the same letter are not significantly different at P ≤ 0.05. significantly different at P ≤ 0.05.

TG, Triglycerides; LDL-C, low density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

R_1 : Maltodextrin , R_2 : Simplesse.

Our results are in agreement with those reported by McNamara. (1993) and Al-Khalifa. (1996) who reported that consumption of saturated fat markedly elevated plasma total cholesterol and triglyceride levels.

The atherogenic index is an indicator for the susceptibility for atherosclerosis (Kawase *et al*.,2000). Table (7) showed the atherogenic index for rats fed on basal diet, full fat and low fat cake diet. These results indicated that the atherogenic index significantly (P≤ 0.05) decreased as a result of shortening replacement. At 75% replacement level the atherogenic index was 0.75 for maltodextrin group and 0.76 for simplesse group without significant difference (P≤ 0.05) as compared to G_1(negative control), value being 0.68.

The obtained results are in agreement with those reported by Mansour *et al*.(2003). They prepared low-fat cookies by partial replacement of butter oil with different types of carbohydrate-based fat replacers and they found that feeding rats low-fat cookies diets resulted in a significant decrease in total serum cholesterol, LDL-cholesterol, HDL-cholesterol and triglycerides compared to rats fed the control diet. Abd-El-Khalek. (2007) evaluated the use of three different types of fat replacers on nutritional quality characteristics of some high fat bakery products. He stated that experimental rats showed significant decreases in total cholesterol, triglycerides, low density lipoprotein cholesterol and atherogenic index in rats fed on the fat - replaced cake diets . He added that High-density lipoprotein cholesterol was not significantly (P≤ 0.05) affected by feeding low-fat cake diets.

Finally it could be concluded that the risk of full – fat cake as a rich fat food can be minimized by replacing 50-75% of shortening by either maltodextrin or simplesse without significant effect (P≤ 0.05) on the organoleptic properties and corresponding consumer acceptance.

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التقييم الحيوي للكيك منخفض الدهن

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تناولت الدراسة إنتاج كيك منخفض الدهن وذلك بإحلال ٢٥%،٥٠% و٧٥% من الدهن بكل من المالتودكسترين أو السمبليز وتم تقييم معاملات الكيك الناتجة حسيا وأجريت اختبارات تقدير التركيب الإجمالي والقيمة السعرية وحساب نسبة السعرات الناتجة من الدهن منسوبة الي السعرات الكلية. وكذلك تم دراسة التأثيرات الحيوية لاستبدال الدهن وذلك من خلال إجراء تجربة تغذية علي فئران التجارب وتقدير التغير في وزن الجسم ووزن الأعضاء منسوبة الي وزن الجسم كقياسات لمعدل النمو وتقدير التغير في تركيب لبيدات دم الفئران.

وقد دلت نتائج التقييم الحسي أنه أمكن بنجاح استبدال الدهن باستخدام المالتودكسترين أو السمبليز حتي مستوي استبدال ٥٠% بدون ظهور فروق معنوية بين المعاملات والعينة القياسية كما أبدي المحكمين قبولا للعينات حتي مستوي استبدال ٧٥% لكل من بديلي الدهن المستخدمين.

أظهرت نتائج تحليلات التركيب الإجمالي للكيك المعد باستخدام بدائل الدهن انخفاض نسبة الدهن والقيمة السعرية ونسبة السعرات الحرارية ذات الأصل الدهني كنسبة مئوية من السعرات الكلية وذلك مع زيادة مستوي استبدال الدهن.

دلت النتائج أن تغذية الفئران علي وجبات تحتوي علي معاملات الكيك المختلفة لم تظهر تغيرا ملحوظا بالنسبة لوزن الجسم أو معدل الزيادة في الوزن وكفاءة استخدام الغذاء وكذلك وزن الأعضاء الداخلية منسوبة لوزن الجسم خلال فترة التجربة الممتدة لمدة ثمانية أسابيع. كذلك لوحظ انخفاض محتوي سيرم الدم من الجلسريدات الثلاثية والكولسترول الكلي وكولسترول الليبوبروتين منخفض الكثافة عند استبدال ٥٠ أو ٧٥% من الدهن بكلا من المالتودكسترين أو السمبليز. كما دلت النتائج علي انخفاض قيمة (Atherogenic Index, AI) باستبدال الدهن بنسبة ٢٥%، ٥٠% و٧٥% باستخدام المالتودكسترين وبإحلال ٥٠% و٧٥% من الدهن باستخدام السمبليز .

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