4. RESULT AND DISCUSSION

4.1. Use of fat replacers in the production of low-fat cakes:

4.1.1. Proximate chemical composition and caloric value of cakes made with flaxseed gum as a fat replacer:

The effects of replacing 25, 50, 75 and 100% of butter in cake formula with flaxseed gum on the proximate chemical composition and caloric value of cakes are shown in Table (3).

Results showed that moisture content was increased significantly as the replacement level increased. Such observation was noted in a gradual trend with the level of fat replacement. For crude fat, it was reduced significantly by an average of 15.93, 32.92, 56.83 and 86.70% for fat replacement levels of 25, 50, 75 and 100%, respectively. On the other hand, protein content of the replaced cakes was not affected too much and did not show any significant difference ($P \leq 0.05$) when compared to control cakes. Concerning the carbohydrate content, it tended to be of a positive increase with fat replacement level. Replacing 100% of butter with flaxseed gum resulted in cakes with 31.42% higher in carbohydrate content than of the control cakes. Regarding the caloric value of the produced low-fat cakes, it was noted that cakes made with fat replacement levels of 25, 50, 75 and 100% had lower calorie value by 3.74, 7.96, 13.73 and 21.12% in average compared to control cakes, respectively. The aforementioned results are in agreement with Kocer *et al.*, (2005) who reported that the reduction in the caloric content of the high-ratio cake was 6.5% upon 20% sugar replacement, and 10% upon 20% fat replacement based on the total sugar and fat content of the conventional high-ratio cake.

4.1.2. Proximate chemical composition and caloric value of cakes made with okra gum as a fat replacer:

The proximate chemical composition and caloric value of cakes made with okra gum as a fat replacement for 25, 50, 75, and 100% of butter (by weight) are indicated in Table (3). Results showed that the moisture content of cakes was affected by replacing fat with okra gum. A gradual significant increase in the moisture content was associated with the increase in fat replacement level. The percentages of the increase in moisture content was 24.23, 42.85, 51.72 and 85.27% more than the control cakes for fat replacement levels of 25, 50, 75 and 100%, respectively. For crude fat, it was significantly ($P \leq 0.05$) decreased by increasing fat replacement levels. Fat content was lowered by and average of 19.19, 35.31, 52.99 and 74.59% of that of control cake for fat replacement levels of 25, 50, 75 and 100%, respectively. Protein content of fat replaced cakes was not significantly ($P \leq 0.05$) different compared to control cakes. In contrast, to the trend in the crude fat changes, a gradual increase was observed between fat replacement levels and carbohydrate contents. Replacing 100%of butter with okra gum resulted in cakes with 27.15% higher in carbohydrate content than the control cake. This could be attributed to the replacement of a fatty material (butter) with a carbohydrate material (okra gum). For the caloric value (Table 3), it was obvious that replacing butter with okra gum caused significant ($P \leq 0.05$) decrease in the caloric value of cakes.

Table 3: **Proximate chemical composition and caloric value of cake made with flaxseed and okra gums as fat replacers (on dry basis).**

Parameters %	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
Moisture	Flaxseed Okra	18.59±1.67e 20.30±0.31e	20.57±0.43e 25.22±0.41cd	28.10±0.51b 29.00±1.00b	29.48±0.17b 30.80±0.30b	31.94±0.51b 37.61±0.39a
Crude fat	Flaxseed Okra	25.55±0.5a 25.74±0.30a	21.48±0.46b 20.80±0.30b	17.14±0.22c 16.65±0.05c	11.03±0.16e 12.10±0.26d	3.40±0.21g 6.54±0.21f
Crude protein	Flaxseed Okra	4.97±0.07cd 6.55±0.19a	4.80±0.35d 5.70±0.70abc	5.05±0.13cd 5.95±0.17ab	5.00±0.22cd 6.32±0.20a	5.40±0.07bcd 6.35±0.19a
Ash	Flaxseed Okra	0.65±0.02b 1.57±0.40a	0.66±0.07b 1.30±0.31ab	0.79±0.10b 1.00±0.11ab	0.69±0.07b 1.15±0.33ab	0.81±0.08b 2.10±1.00a
Carbohydrate	Flaxseed Okra	68.82±0.15f 66.30±0.12f	73.10±0.20e 72.24±0.74e	77.02±0.40d 76.44±0.18d	83.32±0.41b 80.51±0.35c	90.44±0.35a 84.30±1.30b
Caloric value Kcal/100g	Flaxseed Okra	524.35±0.83a 524.54±3.55a	504.73±2.14b 501.44±1.28b	482.47±0.79c 479.39±0.37c	452.38±0.74d 455.91±1.88d	413.63±0.82f 423.14±4.91e

Means in a columns or rows not sharing the same letters are significantly different at (P<0.05).

The caloric value of cakes was lowered by percentages of 4.40, 8.60, 13.08 and 19.33% than that of control cake for fat replacement levels of 25, 50, 75 and 100%, respectively. The aforementioned results are in parallel with those obtained by Kim *et al*., (2012), who reported that the moisture, ash, and dietary fiber levels in the sponge cakes increased linearly with the addition of 0-9g of cheonnyuncho powder/100g of wheat flour, and the carbohydrate and calorie contents of the samples decreased.

4.1.3. Physical properties of cakes made with flaxseed gum as a fat replacer:

Physical properties of cakes replaced with flaxseed gum at replacement levels of 25, 50, 75 and 100% (of butter weight), are given in Table (4). The pH of fat-replaced formulas ranged from 7.10 to 7.30 which was not significantly ($P \leq 0.05$) different from that of the control cakes. Concerning cake properties, results indicated an obvious significant ($P \leq 0.05$) decrease in cake weights as compared to control cake. Volume of cakes substitute with 25% flaxseed gum did not show any significant difference ($P \leq 0.05$) than control cakes, whereas, 50, 75, and 100% levels showed a significant low volume as compared to control. Zahn *et al*. (2010) reported that the replacement of 50% to 100% baking fat by inulin in muffins caused a reduction of 5-10% of cake volume but insignificantly affected mass loss during baking and thus caused an increase in crumb density. Cake heights at 25% fat-replacement was significantly ($P \leq 0.05$) different than the other treatment at levels of 50, 75 and 100% being of moderate height near to control cakes. The specific volume of the cake can be accounted as an indicator of the volume development and consequently of the porous structure of the product. More specifically, as the level of replacement increased the viscosity of the batter decreased resulting in less air bubble incorporation and air holding capacity during baking. In the present study, replacing up to 50% of butter with flaxseed gum did not have any significant ($P \leq 0.05$) effect on specific volumes of produced cakes. At 75and 100% replacement ratio with flaxseed gum resulted in the production of significantly ($P \leq 0.05$) lower specific volume cakes than their full-fat counterpart.

4.1.4. Physical properties of cakes made with okra gum as a fat repalcer:

The effect of replacing okra gum with butter at levels of 25, 50, 75 and 100% (of butter weight) on the physical properties of cakes (pH, weight, volume, height and specific volume) were studied and the results are shown in Table (4). Results showed that replacing butter with okra gum at levels of 25, 50, 75 or 100% (butter weight) did not have any significant ($P \leq 0.05$) effects on pH, which ranged from 7.21 to 7.24.

Concerning cake properties, the weight of cakes prepared with okra gum at all replacement levels (25, 50, 75 and 100%) were significantly ($P \leq 0.05$) lower than their full fat counterpart. Regarding the volume of cakes, replacing up to 75% of butter with okra gum resulted in cakes which were not significantly ($P \leq 0.05$) different in volume when compared to the control cakes. Increasing the replacement level to 100% caused a dramatic decrease in cake volume. The specific volume of the cake can be accounted as an indicator of the volume development and consequently of the porous structure of the product. More specifically, as the level of replacement increased the viscosity of batter decreased

Table 4: Physical properties of cake made with flaxseed and okra gums as fat replacers

Parameters	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
pH	Flaxseed Okra	7.30±0.00 7.24±0.00	7.10±0.00 7.21±0.00	7.10±0.00 7.24±0.00	7.10±0.00 7.23±0.00	7.10±0.00 7.23±0.00
Weight (g)	Flaxseed Okra	104.35±0.00c 113.17±0.00a	98.09±0.00d 107.98±0.00b	94.75±0.00e 104.69±0.00c	91.03±0.00e 99.06±0.00d	93.27±0.00e 98.26±0.00d
Volume (cm^3)	Flaxseed Okra	220.00±0.00b 237.00±0.00a	215.00±0.00c 235.00±0.00a	203.00±0.00d 232.00±0.00a	177.00±0.00de 224.00±0.00ab	170.00±0.00de 220.00±0.00b
Height (cm)	Flaxseed Okra	4.50±0.00a 4.50±0.00a	4.00±0.00b 4.50±0.00a	3.80±0.00c 3.80±0.00c	3.40±0.00c 3.40±0.00c	3.30±0.00c 3.30±0.00c
Specific volume (cm^3/g)	Flaxseed Okra	2.11±0.00c 2.11±0.00c	2.19±0.00b 2.18±0.00b	2.14±0.00c 2.22±0.00a	1.94±0.00d 2.26±0.00a	1.82±0.00e 2.24±0.00a

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

resulting in less air bubble incorporation and air holding capacity during baking. On the other hand, the specific volume of fat-replaced cakes up to 75% of butter with okra gum did not cause significant ($P \leq 0.05$) reduction in specific volume; notwithstanding increasing the replacement level to 100% caused a dramatic decrease in cake specific volume. It was reported by Vassiliki & Vassiliki, (2013) that the increase of fat replacement from 65% to 100% in cakes prepared with pectin, resulted to higher consistency coefficient and therefore facilitated the formation of many air bubbles(as indicated by lower specific gravity) resulting in cake of specific volume similar to control. Concerning the height of cakes, replacing up to 25% of butter with okra gum did not influence cake height. On the other hand, replacing 50, 75 and 100% of butter with okra gum resulted in cakes with lower heights.

4.1.5. Texture profile analysis of cakes made with flaxseed gum as fat replacer:

Texture is one of the major quality attributes of food, and is determined from the response of tactile senses to the food product (Szczesniak, 1987). Texture profile analysis (TPA) was carried out in order to determine the effect of fat replacement with flaxseed and okra gum at levels of 25, 50, 75, and 100%. Seven textural parameters may be extracted from experimental (TPA) data namely hardness (firmness), cohesiveness, gumminess, chewiness, springiness and resilience. Figure 1 shows a typical experimental force-time graph for texture profile analysis performed on cake. Hardness or firmness was defined as the maximum force of the first compression of the product at the point of 50% compression (1mm/s speed test). As shown in Table (5), the hardness or firmness values of cakes with flaxseed gum as a fat replacer ranged from 2.01-4.71N. It can be seen that hardness at all replacement levels showed significant ($P \leq 0.05$) lower values than the control cakes. Hardness of cakes replaced with 50% flaxseed gum exhibited the lowest value among all the other replacement levels. However, cohesiveness determined from the area of work during the second compression divided by the area of work during the first compression (Borne, 2002), data showed lower cohesiveness values than control for 50, 75, and 100% replacements with flaxseed gum but no significant difference were observed.

Gumminess was calculated as the product of hardness and cohesiveness. The gumminess at all replacements levels showed significantly ($P \leq 0.05$) lower values than control cakes, particularly at replacement level of 50% than 25, 75 and 100%. Whereas chewiness, defined as the energy required to masticate solid food to a state of readiness for swallowing (Karaoglu et al., 2009) was obtained from the product of hardness, cohesiveness and sprininess. Results in Table (5), show that chewiness values are significantly low at all replacement levels compared to control, this was more pronounced in replacement level of 50% than in case of replacement ratios of 25, 75 and 100%. Springiness was defined as the distance to which the sample recovered in height during the time that elapsed between the end of the first compression cycle and the start of the second compression cycle. As shown in Table (5), the springiness values ranged from 0.56 – 0.69 with no significant differences from to the control cakes. Resilience explains how well a product " fights to regain its original position". The resilience values ranged from 0.20 – 0.39 with no significant differences between the samples as compared to the control cakes.

Table 5: Texture profile analysis of cake made with flaxseed and okra gums as fat replacers

Parameters	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
Hardness (Firmness)	Flaxseed	4.71±0.00a	2.65±0.00e	2.01±0.00f	3.33±0.00c	3.68±0.00b
	Okra	3.34±0.06c	1.62±0.03g	2.57±0.02e	1.99±0.04f	3.11±0.01d
Cohesiveness	Flaxseed	0.48±0.00bc	0.60±0.00ab	0.45±0.00bc	0.47±0.00bc	0.42±0.00c
	Okra	0.74±0.06a	0.69±0.03a	0.66±0.02a	0.69±0.03a	0.76±0.01a
Gumminess	Flaxseed	2.26±0.00a	1.59±0.00c	0.91±0.00f	1.55±0.00c	1.56±0.00c
	Okra	2.16±0.06a	1.06±0.03e	1.76±0.02b	1.28±0.03d	2.31±0.02a
Chewiness	Flaxseed	1.41±0.00b	1.11±0.00c	0.55±0.00e	0.87±0.00d	0.97±0.00cd
	Okra	1.48±0.06b	0.86±0.03d	1.36±0.02b	1.03±0.05cd	1.81±0.02a
Springiness	Flaxseed	0.63±0.00bcd	0.69±0.00abcd	0.60±0.00cd	0.56±0.00d	0.62±0.00cd
	Okra	0.77±0.06abc	0.85±0.03a	0.74±0.02abc	0.78±0.04abc	0.80±0.01ab
Resilience	Flaxseed	0.39±0.00abc	0.34±0.00abcd	0.23±0.00cd	0.20±0.00d	0.37±0.00abcd
	Okra	0.42±0.06ab	0.52±0.03a	0.29±0.02bcd	0.37±0.04abcd	0.48±0.01a

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

4.1.6. Texture profile analysis of cakes made with okra gum as fat replacer:

Texture profile analysis is a very useful technique for investigating food products. In the present study, the TPA parameters of cakes with okra gum substitution were determined from the texture analyzer using double compression tests and are shown in Table (5).

Hardness was defined as the maximum force of the first compression of the product at the point of 50% compression (1mm/s speed test). The hardness or firmness values of cakes, showed dramatic significant decrease ($P \leq 0.05$) with the increase in substitution levels. However, cohesiveness determined from the area of work during the second compression divided by the area of work during the first compression (Borne, 2002). The cohesiveness ranged between 0.66 – 0.76 where no significant differences were observed between the replacement samples. Gumminess was calculated as the product of hardness and cohesiveness, whereas chewiness, defined as the energy required to masticate solid food to a state of readiness for swallowing (Karaoglu et al., 2009) was obtained from the product of hardness, cohesiveness and sprininess. Gumminess and chewiness values in cakes replaced by okra gum exhibited a similar trend as the hardness values, as shown in Table (5). Significant low gumminess and chewiness values were found in the cake levels at 25% and 75% substitution.

Springiness was defined as the distance to which the sample recovered in height during the time that elapsed between the end of the first compression cycle and the start of the second compression cycle. The springiness of cakes with okra gum as fat replacer was not significantly different than control. The same trend with resilience except for 50% level which exhibited an obvious lower values than the other levels of okra gum and control. Sanz *et al*. (2009) found that crumb cell structure containing 100% inulin exhibited decrease in springiness and thereby was associated with a decrease in the number of air bubbles and the existence of a denser matrix of muffin. These results may suggest that the gum replacers used in the present study coated the protein and starch granules thus preventing hydration and formation of a continuous gluten-starch network. Consequently, shortening replacement enhance the development of the crumb network, while the replacers may further contribute to this network through hydrogen bonds (Zahn *et al*, 2010). The results also indicate that both gums used in the present study achieved tender and elastic properties in the cakes even at higher levels.

4.1.7. Sensory evaluation of cakes made with flaxseed gum as a fat replacer:

Sensory properties (colour, flavour, texture and over all acceptance) were evaluated in the cakes prepared with flaxseed gum as a replacement of butter at levels of 25, 50, 75 and 100% (butter weight basis), and the results of the sensory evaluation are shown in Table (6). Fig (2) illustrates the appearance of the flaxseed gum containing products. Results showed that colour was not affected by the addition of flaxseed gum as a fat replacer at a fat replacement level of 25 and 50%. .

Table 6: Mean value of the sensory score of cake made with flaxseed and okra gums as fat replacers

Parameters	Fat replacers	Level of replacment				
		Control	25%	50%	75%	100%
Colour	Flaxseed	4.90±0.14a	4.71±0.18ab	4.43±0.20abc	3.57±0.30bcd	3.90±0.26bcd
	Okra	4.00±0.40abcd	4.14±0.34abcd	4.00±0.31abcd	4.14±0.34abcd	3.43±0.30d
Flavour	Flaxseed	4.71±0.18a	4.43±0.20a	4.30±0.30a	3.90±0.34ab	3.30±0.18b
	Okra	4.14±0.34ab	4.71±0.18a	3.90±0.40ab	4.14±0.26ab	3.30±0.18b
Texture	Flaxseed	4.71±0.18a	4.43±0.20ab	4.30±0.40ab	4.00±0.22ab	3.14±0.14c
	Okra	3.90±0.34b	4.57±0.20ab	4.00±0.22ab	4.14±0.14ab	2.90±0.26c
Over all acceptability	Flaxseed	4.90±0.14a	4.30±0.30ab	4.14±0.26ab	4.30±0.18ab	3.30±0.18c
	Okra	4.00±0.40b	4.57±0.20ab	4.14±0.26ab	4.30±0.18ab	3.14±0.26c

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

Replacing 75 and 100% of butter with flaxseed gum resulted in cakes with significantly ($P \leq 0.05$) lower scale (but acceptable) colour when compared with the control cakes. Wafaa *et al.*, (2011) reported that in general, cakes and cookies substituted with 25 and 50% pectin and 50 and 75% egg white were nearly similar in yellowness colour to the control samples.
Concerning the flavour, it was found that replacement up to 75% with flaxseed gum did not significantly affect the flavour of cakes. Texture of cakes was also not affected by replacing levels of 25, 50, and 75% of butter with flaxseed gum, but increasing the fat replacement level to 100% resulted in cakes with significant ($P \leq 0.05$) lower scores texture properties when compared with control. The same trend was found with the overall acceptance which was not significantly ($P \leq 0.05$) different in cakes with 75% fat replacement with flaxseed gum, when compared to the control cake. That is to say, cakes replaced up to 75% flaxseed gum were highly acceptable by panelists.

4.1.8. Sensory evaluation of cakes made with okra gum as a fat replacer:

Sensory properties (colour, flavour, texture and over all acceptance) were evaluated in cakes prepared with okra gum as a replacement of butter at levels of 25, 50, 75 and 100% (butter weight basis), the results of the sensory evaluation shown in Table (6). Fig (3) illustrates the appearance of the okra gum containing products. Results showed that colour of cakes were not affected by the addition of okra gum as a fat replacer at a fat replacement level of 25, 50 and 75%. Replacing 100% of butter with okra gum resulted in cakes with significantly ($P \leq 0.05$) low score (but acceptable) colour when compared with the control cakes. Vassiliki & Vassiliki, (2013) showed that fat was replaced at 35%to 100% in cakes by different type's carbohydrate-and protein-based fat replacers. It was observed that most samples containing fat replacers at levels 35% and 65% presented no significantly different crust colour from the control. Concerning flavour, it was found that replacing butter with okra gum did not significantly ($P \leq 0.05$) affect flavour up to 100% level of substitutions. Texture of cakes was also not affected by replacing 25, 50 and 75% of butter with okra gum, but increasing the fat replacement level up to 100% resulted in cakes with significant ($P \leq 0.05$) lower score texture properties when compared to the control cakes. Kim *et al.*, (2001) concluded that the amylodextrin tended to retrograde or associate quickly after gelatinization. Thus, the cake containing amylodextrin may have set quickly, resulting in textural rigidity.
The same trend was found with the overall acceptability which was not significantly ($P \leq 0.05$) different in cakes with 25, 50 and 75% fat replacement level, when compared to the control cake. From the aforementioned results it can by conclude that cakes prepared with replacing 25, 50 and 75% of butter with okra gum was not significantly ($P \leq 0.05$) different as compared to the control cakes. Cakes with the higher fat replacement levels (100%) were significantly different than all treatments and control but still acceptable.

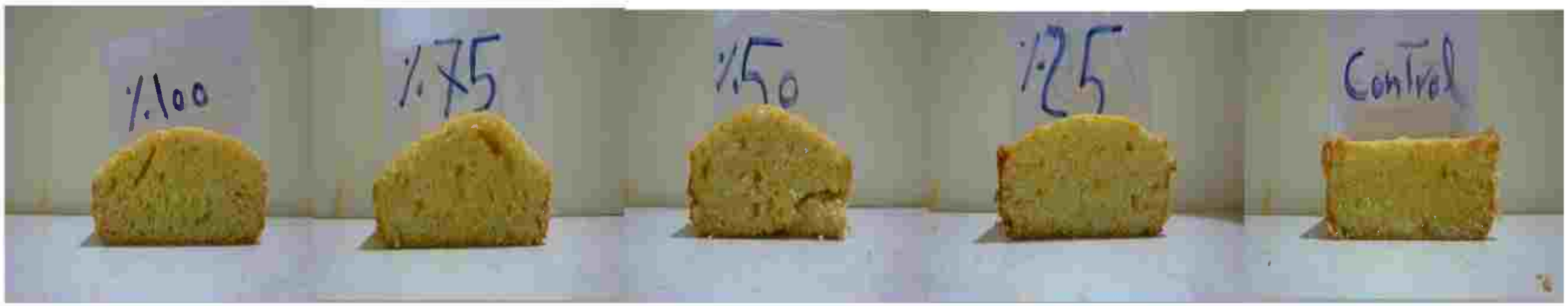

Fig.2: General appearance of cakes made with flaxseed gum as fat replacers.

Fig.3: General appearance of cakes made with okra gum as fat replacers.

4.2. Use of flaxseed gum and okra gum as fat replacers in the production of low-fat cookies:

Flaxseed and okra gum were used as a fat replacers in the production of low fat cookies. The effect of this replacement on the proximate chemical composition, physical properties, texture profile analysis and sensory characteristics of the resulted cookies was as follows:

4.2.1. Proximate chemical composition and caloric value of cookies made with flaxseed gum as a fat replacer:

Flaxseed gum was used to replace 25, 50, 75 and 100% of butter used in the production of cookies. The chemical composition and caloric value of cookies were measured and data are tabulated in Table (7). Results showed that moisture content of cookies was increased significantly by replacing flaxseed gum for butter. Crude fat was decreased as the fat replacer increased. The decrease in crude fat is calculated as 16.74, 35.1, 62.75, and 88.95% of that of the full-fat cookies for fat replacement levels of 25, 50, 75 and 100%, respectively. Concerning the protein content, it was found that cookies with 100%fat replaced with flaxseed gum showed a significant higher protein content. This could be attributed to the decrease in dry matter associated with replacing butter with a high-moisture constituent (flaxseed gum). The ash content was not significantly ($P \leq 0.05$) affected by fat replacement. Regarding the carbohydrate, it was increased significantly as the fat replacement level increased. This could be attributed to the replacement of a fatty material (butter) with a high-carbohydrate material (flaxseed gum). As a result of the decrease in a high-density-caloric constituent (fat), caloric value of reduced-fat cookies was reduced as the fat replacement level increased. The reductions in caloric value are 3.49, 7.37, 13.41 and 18.98% of the original caloric value of control cookies, at fat replacement levels of 25, 50, 75 and 100%, respectively.

4.2.2. Proximate chemical composition and caloric value of cookies made with okra gum as a fat replacer:

Okra gum was used to replace 25, 50, 75 and 100% of butter used in the formulation of cookies. The resultant cookies were subjected to the proximate chemical analysis and the results are given in Table (7). Results showed an increase in the moisture content matched with the increase in substitution level with okra gum. Crude fat exhibited a significant decrease as the fat replacer increased. The decrease in fat was 11.34, 31.64, 51.61 and 79.91% of that the full-fat cookies for fat replacement levels of 25, 50, 75 and 100%, respectively. Concerning the protein content, it was found that cookies with 100% fat replacement with okra gum showed significant higher protein content than control and all other substitution levels.

Table 7: Proximate chemical composition and caloric value of cookies made with flaxseed and okra gums as a fat replacer (on dry basis)

Parameters %	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
Moisture	Flaxseed	1.99±0.30f	3.26±0.09de	3.00±0.11de	3.50±0.20cd	4.33±0.34bc
	Okra	2.60±0.15ef	2.72±0.07ef	3.58±0.04cd	5.10±0.63ab	5.45±0.10a
Crude fat	Flaxseed	21.45±0.37b	17.86±0.02c	13.93±0.34e	7.99±0.30g	2.37±0.40i
	Okra	23.64±0.03a	20.96±0.30b	16.16±0.21d	11.44±0.15f	4.75±0.15h
Crude protein	Flaxseed	5.47±0.06cd	5.22±0.26d	6.03±0.05bc	6.23±0.21b	7.26±0.04a
	Okra	5.57±0.03cd	5.46±0.4cd	5.98±0.12bc	6.50±0.06b	7.13±0.10a
Ash	Flaxseed	0.66±0.06c	0.58±0.11c	0.57±0.07c	0.76±0.02abc	0.76±0.11abc
	Okra	0.86±0.10abc	0.92±0.10ab	1.00±0.10a	0.99±0.12a	0.92±0.09ab
Carbohydrate	Flaxseed	72.43±0.42g	76.39±0.30f	79.46±0.46e	85.01±0.50c	89.61±0.31a
	Okra	69.93±0.11h	72.66±0.32g	77.11±0.4f	81.06±0.12d	87.24±0.08b
Caloric value Kcal/100g	Flaxseed	504.58±1.85b	486.97±0.38c	467.36±1.42e	436.93±1.42g	408.80±2.25i
	Okra	515.08±0.59a	501.16±1.81b	475.98±0.05d	453.25±1.08f	418.88±4.91h

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

Ash content was not significantly ($P\leq0.05$) affected by fat replacement. Regarding the carbohydrate, it was increased as the fat replacement level increased. This could be attributed to the replacement of a fatty material (butter) with a high-carbohydrate material (okra gum). This result was supported by Waffaa *et al.*, (2011) who reported that the apparent total carbohydrates increased with increasing of fat substitute levels than control samples. As a result of the decrease in a high-density-caloric constituent (fat), caloric value of reduced-fat cookies was reduced in a negative relationship as the fat replacement level increased. The average reductions in caloric value were 2.70, 7.59, 12.00, and 18.68% of the original caloric value of control cookies, at fat replacement levels of 25, 50, 75, and 100%, respectively.

4.2.3. Physical properties of cookies made with flaxseed gum as a fat replacer:

The effect of replacing butter used in the production of cookies with flaxseed gum at replacement levels of 25, 50, 75, and 100% (butter weight) on the physical properties of cookies (pH, weight, volume, height, specific volume and width), was studied and the obtained results are shown in Table (8).

The pH value of cookies substituted with okra gum showed significant ($P\leq0.05$) increase with the increase in substitution levels (25, 50, 75, and 100%). Results regarding the weight of reduced-fat cookies showed no significant ($P\leq0.05$) differences as compared to control cookies at levels 25 and 50% whereas, levels of 75and 100% exhibited a significant decrease in weight as compared to control cookies. Concerning the volume of the produced cookies, it was clear that replacing butter with flaxseed gum resulted in cookies with higher volumes as compared to the control cookies. Heights of fat-reduced cookies at all replacement levels did not show significant ($P\leq0.05$) differences as compared to control cookies. As a matter of fact, the width of cookies was not dramatically affected by fat replacement, with a range form 5.43 to 6.13 cm. The specific volume of 75 and 100% substitution level was significantly higher than control cookies as well as 25and 50% level. It was reported by Waffa *et al.*, (2011) that studied the use of microcrystalline, pectin and egg white as fat replacers in cake and cookies, and found that cookies prepared with microcrystalline at 50% and 75% levels had lower volume, heights and specific volumes than those of control and other samples.

4.2.4. Physical properties of cookies made with okra gum as a fat replacer:

The effect of replacing butter used in the production of cookies with okra gum at replacement levels of 25, 50, 75, and 100% (butter weight) on the physical properties of cookies (weight, volume, height, and width), was studied and the obtained results are shown in Table (8). The pH value of cookies substituted with okra gum showed significant ($P\leq0.05$) increase with the increase in substitution levels 25, 50, 75 and 100%.

Results regarding the weight of reduced-fat cookies showed a significant decrease ($P\leq0.05$) at all levels after baking as compared to control cookies. Concerning the volume of the produced cookies, it was clear that replacing butter by okra gum resulted in cookies with significant higher volumes when compared to the volume of control cookies.

Table 8: Physical properties of cookies made with flaxseed and okra gums as fat replacers

Parameters	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
pH	Flaxseed	7.10±0.00 i	7.20±0.00h	7.30±0.00g	7.30±0.00g	7.40±0.00f
	Okra	7.70±0.00d	7.64±0.00e	8.00±0.00c	8.24±0.00a	8.12±0.00b
Weight (g)	Flaxseed	7.40±0.20 b	7.21±0.24b	7.66±0.15b	6.40±0.10c	6.04±0.28 c
	Okra	8.41±0.33 a	6.47±0.20c	6.40±00c	6.54±0.16c	6.10±0.03 c
Volume (cm^3)	Flaxseed	15.00±0.00 h	16.13±0.00g	18.83±0.00f	21.76±0.00c	22.60±0.00 b
	Okra	14.20±0.00 j	14.50±0.00i	20.00±0.00e	21.33±0.00d	26.33±0.00 a
Height (cm)	Flaxseed	0.90±0.00 ab	0.93±0.03a	0.90±0.03abc	0.80±0.03c	0.83±0.03abc
	Okra	0.90±0.00 ab	0.800±0.06bc	0.70±0.03d	0.80±0.03c	0.60±0.00 d
Width (cm)	Flaxseed	5.43±0.12cd	5.60±0.10c	6.10±0.03a	5.63±0.08bc	5.13±0.12d
	Okra	5.63±0.07bc	5.40±0.20cd	5.93±0.07ab	5.93±0.12ab	6.10±0.10a
Specific volume (cm^3/g)	Flaxseed	2.03±0.05f	2.24±0.07fe	2.46±0.05e	3.42±0.05c	3.75±0.18b
	Okra	1.69±0.07g	2.24±0.06fe	3.14±0.07d	3.26±0.07dc	4.34±0.02a

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

Heights of fat-reduced cookies at the replacement level 75% was significantly ($P \leq 0.05$) higher than those of 25and 100% fat reduced cookies. Although the width of cookies was not dramatically affected by fat replacement, with a range from 5.63 to 6.10cm, cookies with fat replacement level of 100% had significantly ($P \leq 0.05$) increased width than the control cookies**.** Sanchez *et al*., (1995) reported that the replacement of 35% of fat with carbohydrate-based fat substitutes and emulsifiers exhibited the least negative effects on the physical properties of cookies, compared with replacement by 45 or 55%.

4.2.5. Texture profile analysis of cookies made with flaxseed gum as a fat replacer:

Texture profile analysis (hardness) of cookies made with flaxseed gum at replacement levels 25, 50, 75 and 100% (butter weight), evaluated by penetration test was performed with a universal testing machine (Cometech, B type, Taiwan) operated at a crosshead speed of 100mm min^{-1}. The force needed to penetrate the sample with a flat ended probe (1mm thickness) to 3mm of the sample height was registered. All measurements were performed at ambient temperature 20̊C. The data are tabulated in Table (9). In the present study results showed that replacement up to 50% did not significantly affect in the hardness as compared to control cake. When increasing replacement to75% and 100% (8.30 and 10.98) a significant ($P \leq 0.05$) increase in hardness was obvious as compared to control cake (2.83). Hardness is the textural property which attracts more attention in evaluation of baked goods, because of its close association with human perception of freshness (Karaoglu & Kotancilar, 2009). According to Seyhun *et al.* (2003)**,** the increased hardness of the crumb can be attributed to the amylase and amylopectin re-crystallization, to the formation of complexes between starch and proteins, and to redistribution of water between the components of the product, as well as other events which may occur in this baked product during storage.

4.2.6. Texture profile analysis of cookies made with okra gum as a fat replacer:

Texture profile analysis (hardness) was evaluated in the cookies prepared with okra gum as a replacement for butter at levels of 25, 50, 75 and 100% (butter weight basis). The results of the texture analysis are shown in Table (9). Results showed that hardness were not affected significantly by the addition of okra gum as a fat replacer at a fat replacement level of 25, 50 and 75%. Replacing 100% of butter with okra gum resulted in cookies with significantly ($P \leq 0.05$) increased hardness when compared to the control cookies. Oreopoulou & Kounalaki, (2002) reported that the results of these tests showed that cookies prepared with polydextrose were significantly harder than the control and other fat-reduced samples.

Table 9: Texture profile analysis of cookies made with flaxseed and okra gum as a fat repacer

Parameters	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
Force	Flaxseed Okra	2.83±0.60c 2.75±0.60c	3.12±0.42c 3.83±0.70c	4.22±0.20c 4.05±0.14c	8.30±1.82b 3.40±0.04c	10.98±0.73a 8.83±0.54b

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

4.2.7. Sensory evaluation of cookies made with flaxseed gum as a fat replacer:

The results of the sensory evaluation of cookies prepared with flaxseed gum used as a fat replacer to replace fat at levels of 25, 50, 75, and 100% are present in Table (10). Fig (4) illustrates the appearance of the flaxseed containing products.

It can be observed that most samples containing fat replacers at all levels showed no significant different colour from the control. It was obvious that panelists could not differentiate between all substitution levels and control cookies concerning the flavour. Concerning the texture, it was found that replacing up to 75% of fat in cookies did not significantly ($P \leq 0.05$) influence the texture of low-fat cookies. As a matter of fact cookies with fat replacement level of 100% were significantly ($P \leq 0.05$) lower in their texture score when compared to the control cookies, but still accepted by panelists. The overall acceptability, did not differ significantly ($P \leq 0.05$) than the control cookies in all replacement levels.

4.2.8. Sensory evaluation of cookies made with okra gum as a fat replacer:

Cookies prepared with okra gum used as a fat replacer to replace fat at levels of 25, 50, 75, and 100%, were subjected to sensory evaluation as presented in Table (10). Fig (5) illustrates the appearance of the okra gum containing products. Results indicated that the colour of cookies with fat replacement levels of 25, 50, 75 and 100% were not significantly ($P \leq 0.05$) different comparing with control cookies. The same effect was observed with the flavour of fat-replaced cookies which were highly acceptable by panelists comparable to the control. Utilization of okra gum as a fat replacer did not affect the texture of the resultant cookies at all substitution levels and control. Concerning the over all acceptance, it was found that replacing up to 100% of fat in cookies did not significantly ($P \leq 0.05$) influence the over all acceptance of low-fat cookies. It was obvious that okra gum was very promising in producing high acceptable cookies as evaluated by the panelists.

Table 10: Mean value of the sensory score of cookies made with flaxseed and okra gum as fat replacers

Parameters	Fat replacers	Level of replacement				
		Control	25%	50%	75%	100%
Colour	Flaxseed Okra	4.30±0.30ab 4.00±0.22abc	4.14±0.26abc 3.57±0.30bc	4.30±0.30ab 4.14±0.14abc	4.14±0.26abc 3.90±0.50abc	3.30±0.30c 4.57±0.20a
Flavour	Flaxseed Okra	4.14±0.26a 4.30±0.18a	3.71±0.18a 4.00±0.31a	4.00±0.31a 3.71±0.18a	4.43±0.30a 3.57±0.30a	3.57±0.48a 3.57±0.30a
Texture	Flaxseed Okra	3.90±0.34a 4.00±0.40a	4.00±0.31a 3.43±0.3ab	4.14±0.26a 3.71±0.30ab	3.57±0.40ab 3.14±0.26ab	2.71±0.42b 3.30±0.40ab
Overall acceptability	Flaxseed Okra	4.43±0.30a 4.00±0.31ab	4.43±0.30a 3.57±0.30ab	4.30±0.30ab 4.00±0.31ab	4.43±0.30a 3.43±0.30b	3.57±0.30ab 4.00±0.31ab

Means in a columns or rows not sharing the same letters are significantly different at ($P<0.05$).

Fig.4: General appearance of cookies made with flaxseed gum as fat replacers.

Fig.5: General appearance of cookies made with okra gum as fat replacers.