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STORAGE STABILITY AND SENSORY PROPERTIES OF FROZEN STORED PIZZA FORTIFIED WITH GROUND FLAXSEED

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ABSTRACT: *Pizza containing 5 and 10% ground flaxseed was prepared and stored in frozen for 3 months at -18°C along with control. Chemical changes in pizza fat characteristic (acid, peroxide and TBA values) and sensory properties were mentored through the period of storage. The results proved that the acid value was 0.6, 1.08 and 0.9 mg KOH/ gm fat for control and that with 5 and 10% ground flaxseed, respectively at zero time. It increased in all samples with storage with highest values in the third month but without any significant differences. Peroxide value followed the same trend as acid value. However, the difference with control was significant and non significant between 5 and 10% ground flaxseed containing pizza. TBA number was 0.51, 0.27 and 0.25 mg malonaldehyde/ kg fat for control and both ground flaxseed treatments. The difference was significant between control and treatments. Thiobarbituric acid (TBA) value increased significantly with increasing the storage time in all samples comparing with control. It was 2.2, 0.81 and 0.72 mg malonaldehyde/ kg fat for control and that with 5 and 10% ground flaxseed, respectively. All sensory properties of pizza with ground flaxseed were reduced with flaxseed level and storage time compared to control. The decrease was marked in the texture, taste and color. There was no significant difference in overall acceptability between control and that with 5% ground flaxseed. Therefore, it is possible to prepare pizza up to 5% ground flaxseed comparable to wheat flour pizza.*

Key words: *Ground flaxseed, sensory evaluation, pizza, storage stability.*

INTRODUCTION

Junk food is defined as "any food, which is low in essential nutrients and high in everything else-in particular calories and sodium. Junk foods contain little or no proteins, vitamins or minerals but are rich in salt, sugar, fats and are high in energy (calories). Highly salted like chips, high in refined carbohydrates (empty calories) like candy, soft drinks and that high in saturated fats like cake and chocolates (Ferrari *et al.*, 2003). Fast food is a growing component of the American diet, and the frequency of fast-food use has increased dramatically since the early 1970s. The number of fast-food outlets increased from about 30,000 in 1970 to 140,000 in 1980, and fast-food sales increased by about 300% (French *et al.*, 2000). Junk foods like potato chips, burgers, pizza, fried chicken etc. have high fats content. The link between saturated fats and trans-fats and increased risk of heart disease is well established. There is also evidence that the risk of type II diabetes is directly associated with consumption of saturated fats and trans-fats and inversely associated with polyunsaturated fats from vegetable sources. Flaxseed is the seed from the flax plant (*Linum usitatissimum L.*), which is a member of thee linaceae family. The plant is not a new crop being native to West Asia, and cultivated since at least 5000 BC; today it is mainly grown for its oil (Oomah, 2001 and Berglund, 2002). There has been renewed interest in the use of flaxseed in the human diet for improved nutritional and health benefits. This has been mainly focused on the high level of alpha linolenic acid (ALA) and other bioactive components such as lignans and soluble dietary fibers in flaxseed (Caragay, 1992). Flax is nature's richest and safest source of omega-3 fatty acids. Flax contains 18 to 24% omega-3 compared to fish that

containing 0 to 2%. The omega-3 from flax is also metabolized more slowly so that a nutritional imbalance is prevented, and flax does not contain any undesirable fats such as cholesterol or trans fatty acids (Stitt, 1988). Whole flaxseed (ground meal, powder or intact seed) contains 28% dietary fiber, (7- 10% soluble fiber, 11- 18% insoluble fiber), 40% fat (73% of it being polyunsaturated fatty acids), and 21% protein. Other flaxseed nutrients include vitamins E and B, sterols, and mineral nutrients such as calcium, iron, and potassium. More than 50% of the fat in flaxseed is an essential fatty acid of omega-3 fatty acid group (alpha-linolenic acid, ALA), which makes flaxseed the richest plant source of omega -3 fatty acid. Flaxseed is rich in antioxidants, such as lignans in ground meal and powder (Bloedon and Szapary, 2004). Flaxseed can be consumed as a diet supplement in its whole seed, powder, ground (flaxseed meal) or oil capsule form. Flaxseed taken as oil capsule lacks the fiber and lignan components. Flaxseed also could be an ingredient in muffin, bread, yogurt and many bakery products. (Bloedon and Szapary, 2004).

The objective of this work is to study the storage stability and the sensory properties of the frozen pizza fortified with ground flaxseed at different levels to improve its nutritional qualities.

MATERIALS AND METHODS

Materials:

Flaxseeds (Cultivar Sakha 9, 2010 production) were obtained from Agricultural Research Center, Oil Crops Department, Giza, Egypt. Wheat flour (72%) (WF), corn oil, salt, sugar, instant dry yeast, green pepper, tomato, mozzarella cheese, black olive and tomato sauce were obtained from the local market of Shibin El-Kom, Minufiya Governorate.

Methods:

Preparation of ground flaxseed (GFS)

Flaxseeds were hand-sorted to remove wrinkled, moldy seeds and foreign materials, and then heated at 150°C for 15 min in an electric air draught oven (VEB MLW Medizinische, Geräte, Berlin, Germany).

The heated seeds were cooled to room temperature then ground in an electric mill equipped with stainless steel blades (Braun, Model1021, Germany), and stored in polyethylene bags in the refrigerator (4°C ± 1) until used.

Preparation of pizza:

Pizza is prepared as home- made method. The different ingredients used in the preparation are shown in table (1). Ground flaxseed (GFS) was replaced at the percentage of 5 and 10 % of the wheat flour (WF), oil added with yeast and sugar; finally a little salt and water were incorporated to holding dough.

The dough was formed, left to ferment for 30 min at room temperature (25 ± 2 °C), and then divided into round equal pieces and finally stored in freezer for three months at -18°C. Slices of tomato, mozzarella cheese, green pepper, tomato sauce and black olive formed the surface cover. The pizza was spreaded out, and then baked at 225°C for 30 min in gas oven. Sensory properties of baked pizza (texture, aroma, taste, color and overall acceptability) were evaluated after 10 min baking.

Storage stability of pizza:

Fat from pizza samples was extracted according to (Bligh and Dyer, 1959) for peroxide, acid and TBA values determinations. These parameters were determined after preparation and through the 3 months of frozen storage. Acid and peroxide values of the oil samples were determined according to AOCS methods (2005). Lipid oxidation potential was evaluated by determining the 2-thiobarbituric acid-reactive substances (TBARs) index according to a modified version of the method of (Witte *et al.*, 1970).

Table (1): Ingredients used in pizza preparation.

Ingredients (gm)	Pizza samples		
	100% WF (control)	95% WF + 5% GFS	90% WF + 10% GFS
Wheat flour	1500	1425	1350
ground flaxseed	-	75	150
Corn oil	60	60	60
Sugar	24	24	24
Salt	12	12	12
Water (ml)	720	750	770
Instant dry yeast	24	24	24
Tomato slices	50	50	50
Tomato sauce	60	60	60
Black olive	150	150	150
Mozzarella cheese	250	250	250
Green pepper	150	150	150

WF: Wheat flour (72%), GFS: Ground flaxseed

Sensory properties evaluation:

Sensory evaluation of control and experimental samples of pizza were carried out by aid of 10 staff members from Food Science Department, Faculty of Agriculture, Minufiya University. The evaluated properties were: texture, aroma, taste, color and overall acceptability. A hedonic scale of 1 to 7 was used, 1= poor and 7= excellent according to the methods described by Gaafar (2005). Panelists evaluated backed pizza samples without special lighting and at ambient temperature (25°C). Water was provided for rinsing purposes.

Statistical analysis methods:

The data of acid, peroxide and TBA values were statistically analyzed using analysis of variance (ANOVA) and least significant difference using SAS (1985). Significant differences between any two means were determined at the $P \leq 0.05$ level. Factorial design was used to determine the chemical fats properties and the sensory attributes of stored pizza.

RESULTS AND DISCUSSION

Effect of frozen storage on the fat quality parameters of pizza:

Acid value:

Table (2) shows the changes of pizza fat acid value due to storage for 3 months. At zero time the value was 1.08, 0.6 and 0.43 mg KOH/ gm fat for control and pizza containing 5 and 10% GFS, respectively. There was a significant difference between pizza with 5% GFS compared to control and that of 10% GFS. The acid value increased

gradually with storage and reached to highest value in the third month. The values were 3.2, 4.1 and 5.1 mg KOH/ gm fat for control and the treatment with 5 and 10% GFS, respectively. The control sample showed the lowest value of (3.2) compared to 4.1 and 5.1 for the other treatment, respectively. From table (2) it could be concluded that pizza with 5% GFS had the lowest acid value compared to control and 10% GFS. The acid value increased as the added GFS increased (10% treatment) due to the increase in the total fat particularly unsaturated. However, the increase in the acid value of the control may be due to the lack of natural antioxidant in wheat flour. These results are expected because flaxseed oil is highly unsaturated, therefore it is probable but it was at low rates due to the reduced temperature of storage.

Peroxide value:

At zero time and after one month there was no significant difference in peroxide value for both treatment and control it was between 0.8 to 1.2 meq O_2/ kg fat for all pizza fat samples (Table 3). The peroxide value increased with storage. The increase was highest in the third month. But pizza with 10% GFS was the lowest with value of 4.31 meq O_2/ kg fat without significant difference with that of 5% GFS and the control which was the highest with significant difference compared to the other treatments. From this table the peroxide value of the pizza fat of 10% GFS was the best due to the increase of the natural antioxidant present in the flaxseed added i.e., lignan specially compared to control.

TBA number:

At zero time and after the first month there was no significant difference in TBA values between the pizza that containing 5% GFS and the pizza containing 10% GFS (Table 4). However, there was significant difference between both treatment and the control sample. At the second month of storage there was significant difference between the control sample, pizza containing 5% GFS and pizza containing 10% GFS. From table(4)it can be noted that pizza with 10% GFS had the lowest TBA value due to the presence of the natural antioxidant in flaxseed. Addition of GFS to pizza markedly and significantly reduced the TBA value compared to control throughout the 3 months of storage. It reduced the fat fraction oxidation and extended its stability and hence the shelf life of the product.

Morris (2010) used flaxseed flour in making cakes at levels of 5, 15, 30 and 45% as substitute to wheat flour. They determined the TBA value of 26.78, 21.59, 21.60 and 11.52 respectively. They finally concluded that 15% was the best. Also they mentioned that adding flaxseed flour in bakery products is a useful strategy to increase the consumption of fiber and omega-3 in the human diet.

Table (2): Changes in acid value (mg of KOH/ gm of fat) of pizza dough prepared with different ground flaxseed (GFS) levels during storage at -18°C

Pizza samples	Storage period (months)*				LSD
	0	1	2	3	
Wheat flour (control)	1.08^{Ac}	2.25^{Ab}	3.08^{Aa}	3.2^{Ba}	0.44
95% Wheat flour + 5% GFS	0.6^{Bd}	1.2^{Bc}	2.4^{Bb}	4.1^{ABa}	0.56
90% wheat flour + 10% GFS	0.9^{ABd}	2.1^{Ac}	3.2^{Ab}	5.1^{Aa}	0.98
LSD	0.43	0.66	0.54	1.14	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
* Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Table (3): Changes in the peroxide value (meq O_2/ kg fat) of pizza dough prepared with different ground flaxseed levels during storage for three months at -18°C

Pizza samples	Storage period (months)*				LSD
	0	1	2	3	
Wheat flour (control)	1.2^{Ad}	3.23^{Ac}	5.45^{Ab}	7.72^{Aa}	1.59
95% Wheat flour + 5% GFS	0.8^{Ad}	2.2^{Ac}	4.21^{ABb}	5.33^{Ba}	0.90
90% wheat flour + 10% GFS	0.95^{Ad}	2.1^{Ac}	3.5^{Bb}	4.31^{Ba}	0.60
LSD	0.74	1.20	1.24	1.43	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
* Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Table (4): Changes in thio-barbituric acid values (TBA) (mg malonaldehyde/kg fat) of pizza dough prepared with different ground flaxseed (GFS) levels during storage for three months at -18°C

Pizza samples	Storage period (months)*				LSD
	0	1	2	3	
Wheat flour (control)	0.51^{Ac}	0.72^{Ac}	1.2^{Ab}	2.2^{Aa}	0.36
95% Wheat flour + 5% GFS	0.27^{Bc}	0.41^{Bc}	0.62^{Bb}	0.81^{Ba}	0.15
90% wheat flour + 10% GFS	0.25^{Bb}	0.28^{Bb}	0.4^{Cab}	0.72^{Ba}	0.35
LSD	0.22	0.18	0.18	0.54	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
* Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Effect of frozen storage on the sensory properties of pizza:

Texture:

Texture of the pizza samples containing ground flaxseed in their formulation was significantly affected with the increase in the level of the GFS and the storage period (Table 5). There was no significant difference between both treatments at zero time the second month. However, there was significant difference between them and the control sample. The texture score was 6.05, 5.5 and 5.6 for control and treatments of 5 and 10% GFS respectively. The increase of added GFS decreased the score of the texture as in pizza containing 10%GFS had the lowest score when compared with control and 5%GFS sample. Hussain, *et al.* (2006) got similar results when fortified cookies with flaxseed flour. Texture of the cookies containing flaxseed flour in their formulation was significantly affected with the increase in the level of the flaxseed flour. Cookies prepared from 0% flaxseed flour got highest (8.50) score while lowest score was obtained in the cookies prepared from 30% flaxseed flour.

Table (5): Texture sensory property of pizza prepared with different ground flaxseed levels during storage for three months at 18 °C.

Pizza samples	Storage period (months)*				LSD
	0.0	1	2	3	
Wheat flour (control)	6.05^{Aa}	5.25^{Ab}	5.05^{Abc}	4.60^{Ac}	0.53
95% Wheat flour + 5% GFS	5.50^{Ba}	4.75^{Bb}	4.40^{Bbc}	4.20^{Ac}	0.38
90% wheat flour + 10% GFS	5.60^{Ba}	5.00^{ABb}	4.45^{Bc}	4.10^{Bc}	0.35
LSD	0.43	0.44	0.46	0.41	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
*Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Aroma:

Aroma is very important parameter in judging the quality of pizza products. Aroma was significantly affected with adding GFS (Table 6). There was significant difference between control sample and pizza containing 10%GFS. Pizza with 10%GFS got the lowest score of aroma (4.45). However, control and 5%GFS sample got close scores (6 and 5.7 respectively). All samples aroma gradually decreased during storage period as it is clear in table 6 and there were significant difference between zero time, first, second and third month for all samples. The supplementation of flaxseed flour up to 15% showed no deleterious effect on the sensory attributes of biscuits as reported by (Zaib-Un-Nisa, 2000).

Taste:

Taste is the main criterion that makes the product to be liked or disliked. At zero time and the other three months there was significant difference in the taste between control sample and pizza containing 10%GFS (Table 7). But pizza containing 5%GFS did not show any significant difference when compared with control sample and pizza containing 10%GFS. The taste in all samples decreased gradually during storage period and there was significant difference between all treatments during storage period as it is clear in (Table 7). From this data it could conclude that adding flaxseed had an effect on the taste score of the treatments but both treatments still acceptable according to the consumers preference. Hussain *et al.* (2006) got close results when fortified cookies with flaxseed flour. The results indicated that the cookies prepared from 0% flaxseed flour significantly got highest score (8.20) for flavor.

Color:

Color is very important parameter in judging the properly baked pizza. However, Montesano *et al.,* (2002) reported that when samples covered with the toppings of pizza (sauce and cheese), the consumers could not detect a difference in the crust made with high gluten flour and high gluten flour with flaxseed. Scores of the color of pizza samples have been given in (Table 8). There was a significant difference between control sample and pizza containing 10%GFS but there was no significant difference between these samples and pizza containing 5%GFS. The color score decreased as the level of added GFS increased (table 8). Also it decreased with increased storage time. The control sample showed the highest color score all over the 3 months of storage. This color decrease was expected since we used the ground flaxseed not flour alls the variety was brown.

Overall acceptability:

Pizza containing 5%GFS had close scores to control sample (Table 9); there was no significant difference between them at zero time or other storage months. Pizza containing 10%GFS had the lowest scores and showed significant difference when compared with control sample. Control sample and pizza containing 5%GFS and 10%GFS showed significant difference between zero time, first and third months. From table 9 we may concluded that control sample was the best come after it pizza containing 5%GFS. However, pizza containing 10%GFS was still acceptable for the consumers. The results of the sensory evaluation of the biscuits prepared from the different treatments of the composite flour are according to the findings of Gambus *et al.*, 2003; Iqbal, 1997; Shearer, 2002; Alpers and Sawyer-Morse, 1996; Sharma *et al.*, 1999 and Ullah, 1990. Who reported increasing the level of flaxseed flour, marti flour, cow pea flour in the biscuits resulted in the significant decrease in the sensory attributes of the cookies.

Table (6): Aroma sensory property of pizza prepared with different ground flaxseed levels during storage for three months at 18°C.

Pizza samples	Storage period (months)*				LSD
	0.0	1	2	3	
Wheat flour (control)	6.00^{Aa}	5.45^{Ab}	4.95^{Ac}	4.45^{Ad}	0.34
95% Wheat flour + 5% GFS	5.70^{ABa}	5.30^{ABb}	4.80^{ABc}	4.35^{Ad}	0.34
90% wheat flour + 10% GFS	5.45^{Ba}	5.05^{Bb}	4.65^{Bc}	4.45^{Ac}	0.32
LSD	0.42	0.33	0.29	0.30	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
*Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Table (7): Taste sensory property of pizza prepared with different ground flaxseed levels during storage for three months at 18 °C.

Pizza samples	Storage period (months)*				LSD
	0.0	1	2	3	
Wheat flour (control)	6.00^{Aa}	5.55^{Ab}	5.10^{Ac}	4.65^{Ad}	0.24
95% Wheat flour + 5% GFS	5.75^{ABa}	5.25^{ABb}	4.95^{ABb}	4.55^{ABc}	0.32
90% wheat flour + 10% GFS	5.50^{Ba}	5.05^{Bb}	4.80^{Bb}	4.35^{Bc}	0.38
LSD	0.37	0.35	0.26	0.29	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
*Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Table (8): Color sensory property of pizza prepared with different ground flaxseed levels during storage for three months at 18 °C.

Pizza samples	Storage period (months)*				LSD
	0.0	1	2	3	
Wheat flour (control)	6.05^{Aa}	5.55^{Ab}	5.15^{Ac}	4.75^{Ad}	0.30
95% Wheat flour + 5% GFS	5.80^{ABa}	5.30^{ABb}	4.95^{ABc}	4.50^{ABd}	0.27
90% wheat flour + 10% GFS	5.50^{Ba}	5.05^{Bb}	4.75^{Bb}	4.35^{Bc}	0.39
LSD	0.38	0.37	0.27	0.28	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
*Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

Table (9): Overall acceptability sensory property of pizza prepared with different ground flaxseed levels during storage for three months at 18 °C.

Pizza samples	Storage period (months)*				LSD
	0.0	1	2	3	
Wheat flour (control)	6.15^{Aa}	5.65^{Ab}	5.30^{Ab}	4.85^{Ac}	0.37
95% Wheat flour + 5% GFS	5.70^{ABa}	5.20^{Bb}	5.05^{Abc}	4.70^{Ac}	0.44
90% wheat flour + 10% GFS	5.40^{Ba}	5.00^{Bb}	4.70^{Bb}	4.30^{Bc}	0.32
LSD	0.45	0.43	0.34	0.29	

* Means followed by different capital letters in the same column are significantly different ($p \leq 0.05$).
*Means followed by different small letters in the same row are significantly different ($p \leq 0.05$).

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ثباتية التخزين و الخواص العضوية الحسية للبيتزا المخزنة بالتجميد و المحتوية علي مطحون بذور الكتان

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الملخص العربي

تم استخدام مطحون بذور الكتان بنسبة ٥ , ١٠% مع دقيق القمح و ذلك لإعداد البيتزا و تم تخزينها بالتجميد لمده ٣ شهور وتم متابعه تأثير ذلك علي التغير في خواص الدهن الكيماوية (رقم الحمض – رقم البيروكسيد – رقم حمض الثيوباربتيوريك) و مقارنته بتلك المحضرة فقط من دقيق القمح هذا بالإضافة إلى متابعه التغير في بعض الخواص العضوية الحسية للبيتزا (القوام- النكهة- الطعم- اللون- الخواص الكلية) وقد أوضحت النتائج ما يلي:

كان رقم الحمض اقل في عينه ٥% مطحون بذور الكتان (٠.٦ مجم بوأيد/ جم دهن) مقارنه بعينه الكنترول (١.٠٨) و عينه ١٠% مطحون بذور الكتان (٠.٩ مجم بوأيد/ جم دهن) و مع تقدم التخزين المجمد كان هناك زيادة تدريجية في رقم الحمض لجميع المعاملات و في الشهر الثالث من التخزين كانت عينه الكنترول ذات رقم حمض اقل من معاملتي ٥ و ١٠% مطحون بذور الكتان بفرق غير معنوي.

رقم البيروكسيد لم يظهر أي تغيرات معنوية بعد التحضير مباشره و حدث زيادة تدريجية مع تقدم التخزين و كانت أعلاها عند الشهر الثالث بقيم ٧.٧٢ , ٥.٣٣ , ٤.٣١ ملليمكافئ أ/ كيلو جرام دهن لعينة المقارنة و ٥ , ١٠% مطحون بذور الكتان علي الترتيب و كانت الزيادة معنوية بالنسبة لعينة المقارنة و لم يظهر فرق معنوي بين معاملتي مطحون بذور الكتان.

أما رقم حمض الثيوباربتيوريك فقد اظهر فرق معنوي لعينة المقارنة ٠.٥١ مجم مالونيك الدهيد/ كيلو جرام دهن مقارنة ب ٠.٢٧ , ٠.٢٥ مجم مالونيك الدهيد/ كيلو جرام دهن في حالتي ٥, ١٠% مطحون بذور الكتان بدون فرق معنوي بينهما. مع التخزين كان التغير ناحية الزيادة في جميع العينات بدرجة معنوية مع الكنترول و بدون فرق معنوي بين معاملتي مطحون الكتان.

بالنسبة للخواص العضوية الحسية فقد لوحظ أن جميع هذه الخواص كانت اقل في حالة إضافة مطحون بذور الكتان مقارنة بالكنترول و زاد التغير في جوده هذه الخواص مع زيادة النسبة المضافة من مطحون بذور الكتان و كان التغير أكثر وضوحا في كل من القوام و الطعم و اللون و بالرغم من ذلك فان الخواص العضوية الحسية الكلية لم تظهر أي فرق معنوي بين الكنترول و عينه ٥% مطحون بذور الكتان في نهاية التخزين أما عينة ١٠% مطحون بذور الكتان فكانت اقل جوده بفرق معنوي مع باقي المعاملتين.

من ذلك فانه يمكن إعداد بيتزا تحتوي علي مطحون بذور الكتان ذات القيمة التغذوية العالية و مقبولة لدي المستهلك و ذلك حتى ٥%.