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(Original Article)

Maximizing the Use of Flaxseed in the Production of Vegan Bakery Products Free of Gluten, Eggs, Milk and Low Carbohydrates

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Abstract

Modern life poses a challenge to sustaining good human health due to the increasing number of various diseases associated with low lifestyle. In this study, crackers were prepared from both wheat and corn and produced from theroasted ground (GF) and unground flaxseed (UF). The ground flaxseed crackers (T3) and unground flaxseed crackers (T4) were compared with wheat crackers (T1) and corn crackers (T2). The physicochemical characteristics, texture, sensory evaluation, fatty acids profile, and storage quality properties were evaluated as a criterion for the product's quality. The ground flaxseed crackers (T3) and unground flaxseed crackers (T4)width, thickness, and weight were significantly increased ($p \leq 0.05$) while the specific volume was massively reduced compared with wheat crackers (T1) and corn crackers (T2). The unground flaxseed crackers (T4) samples showed the highest significant value among all sensory evaluations. Furthermore, the T4 content of protein, fat, and crude fiber increased significantly ($p \leq 0.05$), while its carbohydrate content was reduced. And in terms of textural features, the T4 sample had the highest value in hardness. Mineral concentrations of Ca, K, P, Mg, Fe, and Zn both increased significantly in T3 and T4. The proportions of linolenic fatty acid C18:3 (48.09%), linoleic acid C18:2 (27.15%), and oleic acid C18:1 (22.69%) were discovered to be the greatest in the T4 fatty acid composition, which also showed the highest values in the unsaturated essential fatty acids. Additionally, it was observed that during the 90-day storage period, the samples of T3 and T4 did not significantly rise in terms of storage quality, such as acid and peroxide values. The investigated samples were completely cheaper and could be offered to consumers at a price of about 27% - 34% of market snacks. The review concludes by highlighting flaxseed's potential as a "nutraceutical" and it could be used as food that is both therapeutic and protective.

Keywords: *Vegan Bakeries, Low Carbohydrate Bakeries, Free Gluten Bakeries*

Introduction

Unfortunately, being overweight or obese raises the possibility of contracting conditions including diabetes, heart disease, and several cancers. However, excessive consumption of simple sugars and their involvement in calorie consumption is related to the onset of dental decay. Dental issues account

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for most non-infectious disorders worldwide, and in industrialized countries, their treatment costs account for 5% to 10% of total healthcare expenditures (WHO, 2015). The ketogenic diet, which was initially developed to treat disease, is a high-fat, moderate-protein, low-carbohydrate diet in which the body uses ketones as fuel rather than glucose. It has since been shown to have several other health benefits, including weight loss, fat loss, improved glucose, and insulin levels, sometimes a glow to the skin, and many other advantages. Your body will enter "ketosis" if you consume a ketogenic diet a transformation in which the body switches from burning sugar to burning fat (Goswami and Meghwal, 2021).

Most individuals believe that a ketogenic diet contains too much fat, could increase triglyceride and cholesterol levels and could result in cardiovascular problems. However, scientific research indicated that a ketogenic diet is advantageous and healthful. A low-carb or ketogenic diet replaces carbohydrates with high-fat foods that make you feel full on fewer calories, and lower and manage appetite. The low-carb Ketogenic diet frequently causes more rapid weight reduction than low-fat diets because it aids in flushing out extra water from the body, lowers insulin levels, and requires fewer calories due to its high-fat content (Shrivastava *et al*.,2017).

The scientific name for flaxseed is "*Linum usitatissimum* L.", which comes from the Latin term usitatissimum, which means "most desirable." It is one of the most significant oilseed crops for use in food, feed, and industry. It has been used to make food and clothing for much longer than 5000 years. The terms linseed and flaxseed are frequently used interchangeably. When flax is utilized in industry, it is referred to as linseed; however, when flax is consumed by people, it is referred to as flaxseed. They can be used for a variety of purposes, such as baking and other food preparation (Newkirk, 2008). Many items with additional value have been made from flax seed with success. Commercial use is made of every component of the flaxseed plant, either directly or after processing. People can prevent serious ailments like cardiovascular disease, cancer, diabetes, obesity, and disorders of the gastrointestinal, renal, and skeletal systems by regularly consuming flaxseeds. (Kaur *et al*., 2018).

There are different fatty acids that make up flaxseed's composition. It is rich in linoleic acid, as an essential omega-6 fatty acid, and alpha-linolenic acid (ALA), as a necessary omega-3 fatty acid, and is low in saturated fatty acids. Additionally, it has a lot of polyunsaturated fats. (Bernacchia *et al*., 2014 & Mridula *et al*., 2013). From the above-mentioned report, it appears that trying to find bakery products satisfies the desire of diverse groups, special groups, and sensitive groups. Also, producing bakery products from flaxseeds with high-value, low-carb, free from (eggs, dairy, and gluten). Besides, producing new and economical bakery products from "flaxseeds" as raw materials available in the Egyptian market.

Materials and Methods

Materials

Wheat flour (72 % extraction) was obtained from the South Cairo Mill Company, Giza, Egypt. Flaxseed (Giza11) was obtained from Crop Department, Agricultural Research Center, Giza, Egypt. Yellow corn flour ((97% extraction) was obtained from the Egyptian Company for maize products, 10th Ramadan City, Egypt. Baking ingredients: yeast, sugar, corn oil, baking powder, and salt were obtained from the local market, Giza, Egypt. All chemicals used in the experiment were obtained from Egyptian Scientific Company, El-Dokki, Giza, Egypt.

Methods

Preparation of unground and ground flaxseeds. The seeds were dry-cleaned to remove dust and undesirable materials. After cleaning, the seeds were roasted at 90º C for 10 minutes in an electric oven. The roasting process gave the product a good aroma and grinding effect (as it didn't ooze off the oil) and inactivation of lipase which led to the minimization of fat hydrolysis (Bookwalter *et al*., 1987). The obtained flour with milled using a fractionation Laboratory mill (Brabender Duisburg roller mill, Germany) and was sieved by a sieve No. 30-40 mesh. Then Part of the seis is crushed and part of the roasted seeds are intact and stored at 4°C until used.

Preparation of crackers

Part of the roasted flaxseed was soaked for 12 hours when making crackers in order to reduce nutritional inhibitors and used for the formation of mucilage to bind the crackers.

Table 1. Ingredients (g/100g) of different crackers formulas

Ingredients	T (1)	T (2)	T (3)	T (4)
Wheat flour	100	-	-	-
Corn flour	-	100	-	-
Unground flaxseed	-	-	-	100
Ground flaxseed	-	-	100	-
Yeast	1	1	1	1
Honey	2	2	2	2
Olive oil	7	7	7	-
Salt	1	1	1	1
Cumin powder	2	2	2	2
water	55	52	58	65 before 12 hr.

Production of crackers

Crackers formulas are shown in Table 1. The dry ingredients except honey were placed in the bowl of mixing for 30 s according to the method described by Han *et al*. (2010) with some modified steps. Then mix the wet ingredients alone (honey, water, and oil) for 30 s, then all the ingredients were mixed. until the acquired dough, and then rest for 10 min at room temperature before cutting into the shape of rectangular chips. The crackers were baked for 4 minutes at 175°C in an electric oven, cooled for 30 min, packed in plastic bags, and stored at room temperature.

Physical characteristics of crackers

Textural analysis such as hardness, cohesiveness, adhesiveness, gumminess, and chewiness of cracker samples were measured using Brookfield Engineering Lab. Inc., Middleboro, MA. 02346-1031. USA based on AACC (2002) method 74-09.

Sensory evaluation of crackers: Different treatments of crackers were organoleptically evaluated for general appearance, color, crispiness, flavor, and overall score by using 10 panelists according to the method of Khan and Nowsad, (2012).

Chemical analysis for crackers

Moisture, crude fat, ash, crude fiber, crude protein (N x 5.7), and essential minerals were determined according to AOAC (2012). Available carbohydrate was calculated by difference, 100-(protein + fat + fiber + ash) (Fraser and Holmes, 1959). Total calories were calculated according to FAO/WHO (1991) as follows: E= 4 X (Carbohydrate % + protein %) + 9 X (fat %).

Determination of minerals

The mineral content (Na, Ca, P, K, Fe, Zn, Mg) of the produced crackers was determined by using Perkin Elmer (Model 3300, USA) atomic absorption spectroscopy AA- 6800, Japan as described by AOAC (2012).

Lipid Extraction:

Total lipid extraction was performed according to Folch (1957). This extraction was used to determine fatty acids and peroxide values.

Determination of fatty acid composition by GC–MS:

The methyl esters of fatty acids were prepared from total lipids according to Vogal (1975).

The fatty acid methyl esters were determined by GC–MS using Trace GC Model 2000 series produced by Thermo equipped with Selective Detector Mass Spectroscopy Model SSQ 7000 produced by Finnigan. This equipment was interfaced via HP chem station version A 02.12 software (Hewlett-Packard. Avondale, PA). The gas chromatography was equipped with DB-5 (5 %-phenyl) Methyl polysiloxane 25µ capillary column, 50 m x 0.25 mm i.d, 1.5 m thickness. The operating conditions for gas chromatography were as follows: injector temperature 250 °C, carrier gas: helium at 30 cm/sec, measured at 150 °C, oven temperature 50 °C for 4 min, 150 °C for 4 min and held at 250 °C until the chromatogram was completed. The detector temperature was 280 °C. Mass spectroscopy operating parameters were electron ionization at 70 EV, accelerating voltage 10 kV, and scan M/Z range from 50 to 500. Identification of fatty acid constituents' way was carried out by comparing retention times with those of authentic reference compounds, or peak–matching library (NIST) Standard Mass Library, Version 2.0 and available literature.

Acid value

The acid value of the oil has been determined in accordance with the procedure AOAC (2012) as follows: Known weight (1-2g) of oil was disbanded in neutral ethyl alcohol (30 ml). The mixture was boiled in a water bath for 2 min followed by titration with potassium hydroxide solution (0,1 N) in the presence of phenolphthalein as an indicator. The acid value was calculated as mg KOH/g sample.

Peroxide value

The peroxide value was determined according to AOAC (2012) method. A known weight of oil (2.5 g) was dissolved in a 30 ml mix of glacial acetic acid and chloroform (3:2 v/v). A newly prepared saturated solution of potassium iodide (1ml) was added and the contents of the flask were vigorously shaken exactly for 1 min. Distilled water (30 ml) was added and the solution was titrated slowly with sodium thiosulfate solution (0.01 N) in the presence of starch solution (1%). The peroxide value was expressed as meq. O2/kg.

Production Cost

Data was evaluated according to (Kabil 2016).

Statistical analysis

The obtained results for chemical composition and sensory evaluation were statistically analyzed by the least significant difference value (LSD) at 0.05 levels of probability by (Snedecor and Cochran 1980).

Results and Discussions

Physical properties of crackers

Table 2 revealed that the average diameter of crackers increased with flaxseeds in the composite of flour. These trends were almost similar to those of average thickness. The spread ratio of different treatments gradually decreased with the addition of flaxseeds. This reduction in spread ratio might be due to an increase in protein percentage with the addition of flax and because protein has more binding power and thus it might have reduced the spread ratio of crackers. It is the reason that soft wheat flour varieties are recommended with low protein content to prepare cookies (Miller and Hoseney, 1997 and Kadhamestan *et al*. 1998). The addition of flaxseeds in composite flour led to a reduction in volume. In comparison to all other treatments, the volume of the control was excellent. Due to the high protein content in samples; T3 and T4, which absorbed more water than starch, the weight of the samples dramatically increased with the addition of flaxseeds, as shown in Table (2). Consequently, the specific volume (volume/ weight) was decreased with flaxseed addition as a result of the weight being increased but the volume was decreased.

Table 2. Physical properties of crackers

Sample*	Diameter(d) Cm	Thickness Cm(t)	Spread ratio(d/t)	Weight(g)	Volume (cm3)	Specific volume
T1	3.53c±0.06	2.06b±0.06	1.71 b ±0.05	15.98 c±0.56	74.33a ±0.58	4.65a±0.06
T2	3.9b±0.06	2.1b±0	1.9 a ±0.03	15.82c±0.01	68.67b ±0.58	4.34b±0.03
T3	4.07a±0.06	2.67a±0.06	1.52 c ±0.03	19.45±0.01	65.67b ±00.57	3.37c±0.03
T4	4.07a±0.1	2.73a±0.06	1.49 c ±0.02	22.51a±0.04	67.0b±0.57	2.97d ± 0.01
LSD5%	0.11	0.08	0.05	0.45	0.92	0.06

Samples: T1: wheat crackers, T2: corn crackers, T3: ground flaxseeds crackers, T4: unground flaxseeds crackers; Means in the same column with different letters are significantly different (p≤ 0.05), each mean value followed by ±SD . Number in the same column followed by the same letter are not significantly different at 0.05 level .

Sensory evaluation of crackers

Table 3 shows the sensory evaluation of crackers. Sample T4 (unground flaxseed crackers) had the highest values of all sensory evaluation parameters, which recorded an overall score (38.9) with a significant difference (P≤ 0.05), followed by T2 (corn crackers) (37.9). Additionally, T4 (unground flaxseed crackers) attained the highest scores of crispness, color, flavor, and general appearance by panelists. The crispness recorded the highest value for T4, but the lowest value was found in T3 (ground flaxseed crackers). The color did not register any significant differences in samples: T1, T2, and 4, while the lowest significant value was recorded in T3. The flavor had the highest values in T1,2, and 4, while the lowest value in T3. Samples T1, T2, and 4 did not show any significant changes in general appearance, whereas T3 showed the lowest value. Pradhan and Sethi, (2017) found that flaxseed integration did not alter the color, flavor, or taste of typical recipes but significantly increased the nutritional value of the dishes for all relevant macro and micronutrients. Both 20% and 30% fortification amount in recipes were acceptable. Manthey *et al*., (2002) reported that adding reddish-brown flaxseeds have been improve the texture and flavor of snacks while adding a pleasant nutty flavor.

Table 3. Sensory evaluation of flaxseed crackers

Sample*	Crispness (10)	Color (10)	Flavor (10)	General appearances (10)	Overall Score (40)
T1	8.5b±0.71	9.6a±0.52	9.9a±0.32	9.2a±0.42	37.2b±0.63
T2	9.5a±0.53	9.5a±0.52	9.5a±0.53	9.4a±0.52	37.9ab±1.29
T3	7.9b±1.20	7.2b±1.03	7.3b±0.48	7.8b±0.92	30.2c±3.01
T4	9.8a±0.42	9.7a±0.48	9.9a±0.32	9.5a±0.53	38.9a±0.99
L.S. D 5%	0.701	0.616	0.382	0.567	1.58

Samples: T1: wheat crackers, T2: corn crackers, T3: ground flaxseeds crackers, T4: unground flaxseeds crackers; Means in the same column with different letters are significantly different (p≤ 0.05), each mean value followed by ±SD . Number in the same column followed by the same letter are not significantly different at 0.05 level .

Chemical analysis of crackers

The nutritional value of the crackers is shown in Table 4 on a dry weight basis. The moisture content of all crackers ranged from 4.04% to 5.87%, while samples; T3 and T4 have the highest values. The high protein content of the flaxseed samples, which absorbed more water than starch, may be due to the increase in moisture. The data showed that adding flax seed considerably boosted the protein content when compared to the control sample. Sample T4 showed the most obvious substantial protein increase, followed by T3. This increment may be due to the whole seed in T4 which had the highest protein content. A significant increase in fat content was observed in T3 followed by T4 as a result of flaxseed addition. Flaxseed is a well-known rich source of fat. In T3 and T4, crude fiber levels considerably increased and were the highest compared to the other samples. The sample T4 is higher in the content of crude fibers, and this may be due to the fact that the grinding process increases the surface area and is exposed to digestion than sample T3. This could be a result of the fact that flaxseeds have more protein, fat, and fiber than wheat and maize flour. Meanwhile, T3 and T4 saw a considerable reduction in carbs as a result of the addition of flax seeds. This might be because flaxseeds have fewer carbohydrates than wheat and maize flour.

Table 4. Chemical composition of crackers (on dry weight)

Sample*	Moisture %	Crude protein%	Ether extract%	Ash %	Crude fiber%	Carbohydrates**	Energy kcal/100g
T1	5.0c±0.12	11.51c±0.015	3.98d±0.33	2.67d±0.05	2.87c±0.02	78.97a±0.33	397.74d±1.73
T2	4.04d±0.05	8.65d±0.33	7.29c±0.125	3.03c±0.1	3.02c±0.015	78.0a±0.09	412.21a±0.17
T3	5.87a±0.08	15.62b±0.11	39.68a±1.9	7.18a±0.11	17.23b±0.31	19.59b±1.81	407.96b±3.0
T4	5.55b±0.065	17.98a±0.5	27.72b±1.94	5.77b±0.02	28.27a±0.54	20.26b±1.92	402.44c±1.0
LSD 5%	0.13	0.49	2.19	0.12	0.5	2.13	4.25

Samples: T1: wheat crackers, T2: corn crackers, T3: ground flaxseeds crackers, T4: unground flaxseeds crackers; Means in the same column with different letters are significantly different ($p \leq 0.05$). Number in the same column followed by the same letter are not significantly different at 0.05 level .
** Carbohydrates by a difference

Texture analysis of crackers

The development of new products with desirable properties and attributes might benefit from texture measurements for control and process optimization. (Balestra, 2009). Table (5) presents texture profile analysis (TPA) results for crackers. The hardness showed that samples T2, T3, and T4 became harder compared to T1. Sample T4 recorded the maximal increase in hardness. This increase in hardness may be due to the high fiber content in this sample. The hardness and chewiness of crackers decreased and cohesiveness and gumminess increased with an increasing amount of flaxseed flour in cookies. (Ganorkar and Jain, (2014). Cohesiveness quantifies the internal resistance of food structure. The TPA showed a significant decrease in the cohesiveness of crackers (samples 2, 3, and 4) compared to sample 1. Deora *et al*., (2014) found that the absence of gluten causes dough made from gluten-free formulations to lack the cohesive and elastic qualities of wheat flour. Hardness and cohesiveness combine to create gumminess. The energy required to break down food that may be swallowed is represented by how chewy it is. (Bourne, 1982). Because flaxseed contains water-absorbing ingredients like fiber and protein, the texture of the crackers becomes harder. (Parvinder *et al*., 2019). The TPA results showed an increase in gumminess and chewiness of T2, T3, and T4 compared to T1. The present findings are in accordance with Gomez *et al*., (2007) and Lu *et al*., (2008), who stated that both gumminess and chewiness are parameters dependent on firmness, therefore, their values followed a similar trend to that of firmness. The cohesiveness of the crackers exhibited a decrease with flaxseed addition.

Table 5. Texture analysis of crackers

Sample*	Hardness (N)	Cohesiveness	Gumminess(N)	Chewiness(mj)
T1	8.52	1.07	9.16	6.4
T2	15.5	0.95	14.75	26.3
T3	15.5	0.90	14.01	19.6
T4	21.37	0.62	13.26	13.3

* For samples: T1: wheat crackers, T2: corn crackers, T3: ground flaxseeds crackers, T4: unground flaxseeds crackers Minerals content of crackers

Table (6) represents the important minerals for growth Ca, P, K, Mg, Zn, and Fe content mg/100g of crackers. Data revealed that the unground and ground flaxseed caused a more noticeable increase in Ca, K, P, Mg, Fe, and Zn content in either flaxseed crackers. So, the cracker sample made from unground flaxseed had a higher content of these elements compared to wheat and corn crackers. It could be noticed that flaxseed caused high increments for Ca, K, and P compared with wheat and corn flour, this may be the essence of phytic acid in the coat for flaxseed which is rich with chelating minerals that release some processing as soaking. Ponomareva *et al*.; (2017) reported that flaxseed is a source of polyunsaturated fatty acids, dietary fiber, vitamins, and minerals, so flaxseeds can develop mucus during soaking and retain -linolenic acid after drying. It is therefore indicated that the reasonable flaxseed soaking duration is 40 minutes, which ensures the maximum value of the parameter. Morris (2007) mentioned that flaxseed is an excellent source of nutrients (mg/100), particularly phosphorus (650), magnesium (350–431), and calcium (235–250), and has a very low sodium content (27).

Table 6. Mineral contents of crackers (mg/kg)

Samples*	Na	Ca	P	K	Fe	Zn	Mg
T1	9.46	123.03	37.16	32.49	0.76	0.05	4.75
T2	4.59	116.89	44.72	32.49	0.41	0.08	4.94
T3	34.69	162.99	107.3	121	4.11	1.25	42.6
T4	33.34	133.56	109.19	139	5.22	2.12	46.4

*Samples: T1: wheat crackers; T2: corn crackers; T3: ground flaxseeds crackers; T4: unground flaxseeds crackers

Fatty acids composition of crackers

The fatty acids composition of oil extracts from crackers (by GLC) is presented in Table (7). It could be observed that T3 (unground flaxseed crackers) oil was found to have a high content of unsaturated fatty acids. The major fatty acids in this sample (T3) were linolenic acid (ALA) C18:3 (48.09%), linoleic acid (LA) C18:2 (27.15%), and oleic acid (22.69%). The fatty acid composition of unground flaxseed crackers oil indicated that flaxseed oil is rich in essential fatty acids, in particular the omega-3 fatty acids, thus, flaxseed provides a supply to be used in the keto diet. Gaafar *et al*. (2010) found that flaxseed oil has a high content of unsaturated fatty acids; oleic acid (17.11%), linoleic acid (15.56%), and linolenic acid (58.68 %). Saini *et al*. (2010)reported that flaxseed and its oil prevent tumor growth at a later stage of carcinogenesis and mammalian lignan precursors have the highest inhibitory effect on the growth of new tumors. From Table (7), it can be seen that the ω-6/ ω-3 ratio was 1.77, and this ratio is crucial for protecting humans from certain diseases. WHO (2003) noted that at least 3 and 0.5% of total calorie intake, respectively, should be made up of omega-6 and omega-3 fatty acids, and that the recommended ratio of omega-6 to omega-3 fatty acids may range from 4:1 to 10:1. Azrad *et al*. (2013) decided that the formulation of therapeutic doses for the prevention of colon cancer, asthma, and rheumatoid arthritis may be affected by the differences in the ratio of fatty acids. From Data in Table (7) we observed that samples; T1 and T2 were highest in monounsaturated fatty acid, this may be for used olive oil in the prepared two samples according to the results mentioned by Dubois *et al*. (2007).

Table 7. Fatty acids composition of crackers

Fatty acid profile	**The fatty acid concentration in crackers samples**		
	T1	**T2**	**T3**
Polyunsaturated			
Linolenic-acid (C18:3α/ ω-3)	0.27	1.48	27.15
Linoleic acid (C18:2c/ω-6)	9.42	14.42	48.09
Monounsaturated			
Oleic acid C18:1c/ ω-9	32.68	47.84	22.69
Saturated			
Palmitic acid (C16:0)	29.55	15.17	19.86
Stearic acid (C18:0)	6.65	7.17	3.96
ΣPUFA	9.69	15.9	75.24
ΣSFA	36.2	22.34	23.82
P/S ratio	0.27	0.71	3.16
ω-6/ ω-3 ratio	16	9.74	1.77

Samples: T1: wheat crackers; T2: corn crackers; T3: unground flaxseeds crackers, ΣPUFA: Total polyunsaturated fatty acid content; ΣSFA: Total saturated fatty acid; P/S ratio: ratio polyunsaturated/saturated fatty acid; ω-6/ ω-3 ratio: ratio omega 6: omega 3 fatty acid

Shelf-life quality of crackers

During processing, lipid oxidation can be reduced, but it could get increase during storage. Packaging processed food in opaque containers or under nitrogen or vacuum may further protect it during storage. Additionally, when storing processed food products, environmental elements like temperature, light exposure, and oxygen exposure must be taken into account. The sensory qualities and shelf life of the intended food product are crucial in flaxseed-incorporated food applications, nevertheless, as the highly unsaturated nature of the main fatty acid may cause early rancidity and result in unfavorable sensory taints. (Rajiv *et al*., 2011). Table (8) illustrates the effect of various treatments and storage periods on the acid and peroxide values of crackers. At zero time, the highest acid and peroxide values of 0.47mg KOH/g and 12.76 meq. /Kg were recorded in sample T3 (unground flaxseed). As the storage period advanced, there was an increase in acid and peroxide values. Besides, T3 recorded significant values in storage periods compared to samples T1 and T2. There was a non-significant increase in the acid and peroxide values of crackers from 0 to 90 days of storage. At the end storage period at 90 days, the highest acid and peroxide values of 1.99 mg KOH/g and 14.54 meq. /Kg were registered in sample T3. This is in accordance with the findings of Sharma *et al*. (2017), who noted that treatment S7 (30% flaxseed flour) had the highest free fatty acid content and peroxide value with respect to crackers stored for the sample.

Table 8. Effect of treatment and storage on the quality of crackers fat content

Samples*	Acid value (mgKOH/g)				Peroxide value (meq. /kg)			
	Storage period(days)							
	Z.t	30	60	90	Z.t	30	60	90
T1	0.41b±0.01	0.51b±0.01	0.60b±0.01	1.15b±0.03	11.57b±0.11	11.80b±0.10	12.08c±0.04	12.67b±0.05
T 2	0.42b±0.02	0.53b±0.02	0.63b±0.02	1.23b±0.06	11.70b±0.07	11.99b±0.05	13.09b±0.12	14.17a±0.11
T 3	0.47a±0.04	0.65a±0.01	0.70a±0.02	1.99a±0.11	12.76a±0.06	13.37a±0.17	14.17a±0.30	14.54a±0.58
L.S. D 5%	**0.047**	**0.024**	**0.03**	**0.148**	**0.169**	**0.24**	**0.369**	**0.682**

*Samples: T1: wheat crackers; T2: corn crackers; T3: unground flaxseed crackers Numbers in the same column followed by the same letter are not significantly different at 0.05 level .

Production costs of different samples were calculated and presented in table (9)_. Data showed that the cost reduction was noticeable in flaxseed crackers in the blends. It could be noticed that the cost for one kg of the control samples was high cost in the market. These investigated samples were completely cheaper and could be offered to consumers at a price of about 27% - 34% of market snacks. It could be found that the prices are very suitable for the Egyptian market and thus these results and sensory evaluation recommended that the best type of crackers is unground flaxseed crackers for panelists.

Table 9. Production costs of different treatments of crackers : (L.E./Kg)

Sample	Kg/of ingredients	Electricity	Service	Collection of coasts	Kg of market samples
T1	22	2.5	7.0	31.5	75.0
T2	19	2.5	7.0	28.5	70.0
T3	40	2.5	7.0	49.5	50.0
T4	38	2.5	7.0	47.5	49.0

Note: Commercial crackers make a profit margin of about 80- 90 % .

Conclusions

According to our findings, flaxseeds can be utilized in the creation of crackers and chips at 100% without affecting their physical and sensory properties. With regard to the acidity and peroxide value of the extracted fat in comparison to the control, it can be stored for up to 90 days without experiencing any significant changes. Flaxseed seems to have the ability to serve as both a functional food and an extender in baking goods. The protein, fat, fiber, ash, and all minerals (Fe, Zn, P, Na, Ca, K, Na) were increased in flaxseed crackers compared with wheat and corn crackers (the two samples of control). The volume and specific volume were decreased in flaxseed crackers as compared with the controls. The hardness and chewiness were increased in flaxseed crackers by comparing them with the 2 controls. The ungrounded flaxseed samples were high acceptability by sensory evaluation. So, this sample was subjected to fatty acid and storage tests (acidity and peroxide value). The flaxseed crackers were a good source of unsaturated fatty acids and the acidity and peroxide value were in the acceptable range. This research recommended ungrounded flaxseed crackers for the keto diet. The investigated samples were completely cheaper and could be offered to consumers at a reasonable price than the market snacks.

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تعظيم الاستفادة من بذور الكتان في اعداد مخبوزات نباتية، خالية من الجلوتين، البيض والحليب ومنخفضة الكربوهيدرات

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الملخص

تشكل الحياة العصرية تحديا للحفاظ على صحة الإنسان الجيدة بسبب العدد المتزايد من الأمراض المختلفة المرتبطة بالظروف الاقتصادية الصعبة. في هذه الدراسة تم تحضير المقرمشات من كل من القمح والذرة وبذور الكتان المحمصة المطحونة (GF) وغير المطحونة (UF). وتم مقارنة مقرمشات بذور الكتان المطحونة (T3) ومقرمشات بذور الكتان غير المطحونة (T4) بمقرمشات القمح (T1) والذرة (T2). تم تقييم الخصائص الفيزيائية والكيميائية والملمس والتقييم الحسي ومحتوى الاحماض الدهنية وخصائص الجودة التخزينية كمعيار لجودة المنتج. سجلت مقرمشات بذور الكتان المطحونة (T3) وغير المطحونة (T4)زيادة معنوية في كل من القطر والارتفاع والوزن ($p\leq0.05$) بينما أنخفض الحجم النوعي بشكل كبير مقارنة بمقرمشات القمح (T1) ومقرمشات الذرة (T2). عرضت عينات مقرمشات بذور الكتان غير المطحونة (T4) أعلى قيم معنوية بين جميع التقييمات. بالإضافة سجلت (T4)زيادة معنوية ($p\leq0.05$) في كلا من محتوى البروتين والدهن والألياف الخام بينما انخفض محتوى الكربوهيدرات. ومن حيث خصائص القوام فسجلت T4 أعلى قيم للصلابة. سجل المحتوى من تركيزات المعادن مثل كالسيوم، بوتاسيوم، فسفور، ماغنسيوم، حديد، زنك زيادة ملحوظة في كلا من T3، T4. وكشفت نسبة الحمض الدهني اللينولينيك C18:3 (48.09%)، وحمض اللينوليك C18:2 (27.18%)، وحمض الأوليك C18:1 (22.69%) لتكون T4هي الأعلى في تركيبة الاحماض الدهنية، والتي أظهرت أيضًا أعلى نسبة في الأحماض الدهنية الأساسية غير المشبعة. بالإضافة إلى ذلك، لوحظ أنه خلال فترة التخزين البالغة 90 يومًا، لم ترتفع عينات T3 و T4 بشكل كبير من حيث جودة التخزين، مثل قيم الحمض والبيروكسيد. كانت العينات التي تم انتاجها أرخص من المنتجات الشبيهة الموجودة في السوق، ويمكن تقديمها للمستهلكين بسعر أرخص حوالي 27 % - 34 % من الوجبات الخفيفة في السوق. ونستنتج من هذه الدراسة أن يتم إلقاء الضوء على فوائد بذور الكتان باعتبارها "مغذيات" واستخدامها كغذاء علاجي ووقائي.