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The effect of replacing wheat flour with sesame and flax flour on the chemical composition, fatty acids, and antioxidant properties of biscuits

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ABSTRACT

This study examines the chemical composition of sesame and flax seeds, and analyzes how it changes in biscuits containing varying amounts of their flours (0%, 10%, 20%, and 25% replacement ratios). Moisture content in all biscuit samples ranged from 5.90% to 6.33%, but slightly differed among the different types. Notably, the percentage of ash increased significantly with the substitution level, from 1.33% to 1.70%. Protein content was highest in the BS25% treatment (25% flax flour) at 14.43%, and showed a clear upward trend with increasing replacement rates. Similarly, fat content also correlated with substitution levels, peaking at 10.33% in the BS20% treatment. Fiber followed a similar pattern, reaching its highest level (12.20%) in the same group. Conversely, carbohydrate percentages, ranging from 55.10% to 68.33%, were highest in the control biscuits (without substitutes) and steadily decreased as substitution rates increased. Finally, all types of grains studied (sesame and flax seeds) contained both essential and non-essential fatty acids. Interestingly, the highest proportion of antioxidants (58%) was found in the control biscuits.

تأثير استبدال دقيق القمح بدقيق السمسم والكتان على التركيب الكيميائي ، والأحماض الدهنية ، وخصائص البسكويت المضادة للأكسدة

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الخلاصة

الغرض من هذا البحث هو معرفة المزيد عن التركيب الكيميائي للحبوب المختلفة وتحليل محتوى الأحماض الدهنية ومضادات الأكسدة للبسكويت المصنوع بكميات مختلفة من دقيق السمسم والكتان بنسب استبدال (0، 10، 20، و25٪). أظهرت النتائج الخاصة بالتركيب الكيميائي للبسكويت المُصنع باستبدال دقيق السمسم والكتان أن محتوى الرطوبة في جميع العينات كان بين 5.90 و6.33٪ علماً أن النتائج أظهرت تفاوتًا في نسبة الرطوبة لمختلف انواع البسكويت. زيادة معدلات الاستبدال أدت الى زيادة نسبة الرماد بشكل ملحوظ، حيث زادت نسبة الرماد من 1.33 إلى 1.70 %. مع زيادة معدل الاستبدال، لوحظ ارتفاع مقابل في محتوى البروتين وأعلى نسبة بروتين وجد في البسكويت المصنوع بنسبة استبدال 25% من دقيق السمسم وكانت 14.43٪. فيما يخص نسبة الدهون، كان هناك ارتباط بين معدلات الاستبدال في البسكويت المُصنع ونسبة الدهون، حيث بلغت أعلى نسبة دهون (10.33٪). بالنسبة للألياف فكانت أعلى نسبة (12.20٪) في البسكويت المصنوع بنسبة استبدال 20% من دقيق السمسم. أشارت أعلى النسب المئوية التي تم الحصول عليها للكربوهيدرات (55.10-68.33٪) إلى انخفاض نسبة الكربوهيدرات عند زيادة معدلات الاستبدال. أظهرت النتائج أيضًا أن كلًا من الأحماض الدهنية الأساسية وغير الأساسية كانت موجودة في جميع أنواع البسكويت المُصنع من دقيق الحبوب المدروسة. وأخيرًا، سجلت أعلى نسبة من مضادات الأكسدة التي وصلت إلى 58٪ مع البسكويت المصنوع من دقيق الحنطة فقط.

الكلمات المفتاحية: دقيق قمح، سمسم ، تركيب كيميائي، مضاد اكسدة.

INTRODUCTION

Biscuits, also known as cookies, are a light food that is widely consumed in all parts of the world. Biscuits are considered an ideal food due to the availability of nutrients, palatability, and a comfortable taste; they differ from other baked products such as bread and cakes by the low level of moisture, which extends their shelf life and safety ratio due to the low microbial load (Sharif *et al.*, 2009). Biscuits are made with other types of flour in addition to wheat flour, such as rice, oat, and flax flour, in order to produce good products with health benefits (Alpaslan and Hayta, 2006). Sesame *Sesamum indcum* L. is an oil bean belonging to the sesame family (Pedaliaceae) with a high oil and protein content, although it is one of the oldest known spices, it is mostly grown for the purpose of obtaining edible oil (Gandhi and Taimini, 2009). According to Elleuch *et al.* (2007), sesame is an important source of protein (18-25%), fat (44-58%), and carbohydrates (13.5%). Sesame is widely consumed in pastries such as cakes, snacks, condiments, or in the confectionery industry; the seeds are also roasted, passed through various processes, and used to make flour; the roasted sesame seeds are consumed after being flavored with sugar (Dalatu *et al*., 2016).

Flax is a rich source of oil, protein, and fiber, and its seeds contain 30-40% oil, 20-25% protein, 20-28% total fiber, 4-8% moisture, and 3-4% ash (Herchi *et al*., 2012). While the oil contains 70-71% polyunsaturated fat and 18% saturated fat, it has been determined that α-linolenic fatty acids account for more than half of the polyunsaturated fatty acids (Yadav *et al*., 2018).

Roasted flaxseed flour is a rich source of linolenic acid (55.37%) and linoleic acid (11.38%), with 12.3% of the crude fiber and 44.3% of the oil composition (Ganorkar and Jain, 2014). Flaxseed has important potential because it is one of the richest sources of alpha-linolenic acid oil and lignans, as well as containing high-quality protein and being the main source of soluble fiber and phenolic compounds (Doğmuş and Durucasu, 2013).

This study aims at studying the chemical composition of the studied seeds, identifying their properties, and using them in food processing; studying the possibility of replacing wheat flour (whole grain) with sesame flour and flax flour at rates of replacement of 10%, 20%, and 25% in biscuit production; studying the chemical properties of biscuits produced from different replacement ratios; and estimating the fatty acids of the studied grains and their antioxidant activity and their importance in curbing free radicals.

MATERIALS AND METHODS

Sesame, flax, and wheat grains were obtained from the College of Agriculture at the University of Anbar. Other materials used in the manufacturing process (sugar, milk, fat, vanilla, salt, and eggs) were obtained from local markets in Anbar Governorate. The grains were cleaned and washed before being roasted at a temperature of 50 °C for 3-5 minutes to remove the microbial load and facilitate the grinding process. They were then powdered with a laboratory mill and kept in plastic boxes in the fridge until the experiment.

Biscuit Making Process: Biscuits are made with 340 g of flour (alternatives include sesame and flax flour), 100 g of fat, 100 g of sugar, 20 g of skim milk powder, 40 g of fresh eggs, 3 g of baking powder, 2 g of salt, and 1.2 g of vanilla; the proportion of water is flexible and depends on the flour absorption. The biscuits were prepared according to Sulaqa (1990), by mixing sugar and fat together, adding eggs with vanilla, and stirring well, then adding dry ingredients (flour, powdered milk, salt, and baking powder). The dough was thoroughly mixed before being cut, shaped, and placed in cookie molds with a diameter of 6 cm. It was then baked in an oven at 170ºC for 10 minutes, removed from the oven, allowed to cool at room temperature, and stored until laboratory tests were performed.

Table 1: Percentage of wheat flour replaced by sesame and flax flour

Biscuit	replacement ratio	Wheat Flour (gm)	Sesame flour (gm)	Flax Flour (gm)
BW	0%	340	0	0
BS10%	10%	306	34	0
BS20%	20%	272	68	0
BS25%	25%	255	85	0
BF10%	10%	306	0	34
BF20%	20%	272	0	68
BF25%	25%	255	0	85

Chemical Composition: The percentages of moisture, fat, and fiber in the samples were estimated according to the AOAC (2005). The protein and ash were estimated according to the method described in AOAC (2008), while the percentage of total carbohydrates was estimated by the arithmetic difference according to Pearson *et al.* (1981). Fatty acids determination was carried out by using GC-MS according to the method described by Abdul Jalill (2014) using the capillary column, Cap. Inert, 0.25mm, 30m, 0.25m, knowing that the volume of syringes used is 5 ml. The helium was used, and the flow rate was constant (1ml/min).

Determination of Antioxidant Activity: The samples were prepared according to the method described by Paul and Bhattacharyya (2015), in which 2 gm of each sample of the studied biscuit was taken and finely crushed, 100 ml of 60% methanol was added to each of them in a conical flask and the flasks were placed in a shaker device to stir the mixture for one hour at room temperature, and the mixture was centrifuged at 8000 rpm for 10 minutes. The filtrate was collected and used to estimate the antioxidant activity of the studied biscuits using the method proposed by Abo-EL-Maati *et al.* (2016). By means of the inhibition of free radicals, a solution of 1,1-diphenyl-2-picrylhydrazyl (DPPH) was simultaneously prepared in the dark by dissolving 0.004 mg of DPPH in 100 ml of ethanol at a concentration of 95%, then adding 0.5 ml of the biscuit sample solution prepared above, followed by adding 3 ml of DPPH solution. The mixture was left in the dark at room temperature for 30 minutes. The absorbance was then measured at 517 nm using a spectrophotometer in comparison to the absorbance of the control sample containing the synthetic antioxidant BHT. Comparatively, the inhibitory impact of the free radical was computed using the following formula:

$$\text{(Inhibition \%)} = \frac{\text{Absorbance of the control sample} - \text{Absorbance of the sample}}{\text{Absorbance of the control sample}} \times 100$$

Statistical Analysis

The general linear model in the statistical software SAS (2001) was used for the analysis, which looked at how various parameters affected the complete random design (CRD). Duncan's test was conducted to determine the significance of differences between the averages of the factors affecting the studied traits at level (0.05).

RESULTS AND DISCUSSION

Table 2 shows the chemical composition of the studied samples (wheat, sesame, and flax). The moisture content is one of the most important factors involved in maintaining the safety of seeds during storage. The moisture of wheat seeds was about 11.2%, it agreed with what was measured by Belitz *et al*. (2009). The moisture ratio of sesame seeds differs from what Gandhi and Srivastava (2007) discovered, where the moisture ratio of sesame seeds was found to be about 12.07%. This might be attributed to the varied genetic variations of seeds analyzed. The moisture ratio of flax was slightly higher than what was found by Herchi *et al*. (2012). When the moisture ratio was about 8% owing to the varied kinds, the ash ratio was higher for sesame of about 2.53%, while it was about 2.23% for flax, and the lowest ash ratio was for wheat seeds. These findings agreed with those of Herchi *et al*. (2012) and Naji (2016).

The ratio of protein in the grains that were studied was different based on the results. It found that flax had the highest amount of protein, at about 17.67%. Sesame and wheat were next, with 17.03% and 11.93%, respectively. The ratio of protein in wheat grains agreed with that mentioned by Belitz *et al.* (2009), which was about 11.7%, and the protein ratio of sesame agreed with that found by Dashak and Fali (1993), which was about 17.2%. As for flax, it matched what

Herchi *et al.* (2012) had found. The amount of fat in the studied samples varied greatly. The highest ratio of fat was found in sesame, which had a ratio of about 45.93%, followed by flax and wheat with 39.57% and 1.43%, respectively. The amount of fat in wheat matched what Belitz *et al.* (2009) found, which was about 2%, and the ratio of fat in sesame and flax grains agreed with what was found by Elleuch *et al*. (2007).

According to Table 2, flax grains had the greatest fiber content at 26.23%, whereas the ratio of fibers in sesame and wheat grains was comparable at 12.27% and 12.03%, respectively. The ratio of fiber in wheat grains converged with what was found by Belitz *et al.* (2009), as it reached about 13%. As for sesame grains, it agreed with what was found by Dashak and Fali (1993), as it amounted to about 13%, and the ratio of fiber in flax grains was identical to what Herchi *et al.* (2012) found. The highest ratio of carbohydrates in wheat grains was about 61.83%, followed by sesame grains at 10.17% and flax grains at 1.43%. The ratio of carbohydrates in wheat grains was comparable to what Belitz *et al.* (2009) found, and in the sesame, grains was identical to what was found by Dashak and Fali (1993).

Table 2: Chemical composition of the grains

Sample	Moisture %	Ash%	Protein%	Fats%	Fiber%	Carbohydrate%
Wheat grain	11.2	1.53	11.93	1.43	12.03	61.83
Sesame grains	12.07	2.53	17.03	45.93	12.27	10.17
Flax grain	12.87	2.23	17.67	39.57	26.23	1.43

Table 3 shows the fatty acid composition of the investigated grains. The significance of this adjective is in determining the quantity of fatty acids that improve the nutritional and health value of the food. It was discovered that wheat grains contain different quantities of saturated fatty acids; the majority were present, albeit in low quantity. The most saturated fatty acids in wheat grains were palmitic acid (C16:0), stearic acid (C18:0), while the predominant unsaturated fatty acids were oleic acid (C18:1), linoleic acid (C18:2), and linolenic acid (C18:3), and arachidonic acid (C20:4). The reason may be attributable to the grinding of whole grain, including embryo, and these results are consistent with those of Asuman (2012), who found that the wheat grain embryo contains a large amount of unsaturated fatty acids, which account for approximately 80.1%, and saturated fatty acids, which account for approximately 19.0%. The primary fatty acids were linoleic (C18:2) 56.1%, palmitic (C16:0) 17.4%, and oleic (C18:1) 17.4%; secondary fatty acids with a lower ratio were linolenic (C18:3) 6.4%, arachidonic (C20:4) 1.4%, and stearic (C18:0) 0.8%.

Many saturated and unsaturated fatty acids, such as myristic (C14:0) and palmitic (C16:0), as well as palmitoleic acid (C16:1), oleic acid, linoleic and linolenic acid, were found in sesame fatty acids. In accordance with Yi *et al.* (2019), the percentages of oleic, linoleic, palmitic, stearic, and myristic fatty acids identified in sesame oil were 34.42%, 42.43%, 13.88%, 4.22%, and 0.02%, respectively. Moreover, according to the results, the most saturated fatty acids in flax seed were myristic, palmitic, and stearic, whereas the predominant unsaturated fatty acids were oleic, linoleic, and linolenic. Flax seed oil contains 38.8% linolenic acid, 14.40% linoleic acid, and 16.20% oleic acid. These findings are consistent with Nitrayová *et al.* (2014).

Table 3: The content of fatty acids in the studied grains

Wheat Grain	Sesame Grain	Flax Grain
-	C14:0 Myristic	C14:0 Myristic
C16:0 Palmitic	C16:0 Palmitic	C16:0 Palmitic
-	C16:1 Palmitoleic	-
C18:0 Stearic	C18:0 Stearic	C18:0 Stearic
C18:1 Oleic	C18:1 Oleic	C18:1 Oleic
C18:2 Linoleic	C18:2 Linoleic	C18:2 Linoleic
C18:3 Linolenic	-	C18:3 Linolenic
C20:4 Arachidonic	-	-

Table 4 shows the effects of substituting wheat flour with sesame flour in different proportions on the chemical composition of laboratory biscuits. It is noticed that the moisture ratios in the studied treatments are comparable in each BS25% and BS20%, with a ratio of 6.33% for each of them, followed by the sample BW with a moisture ratio of 6.27%. As for the BS10% treatment, the moisture ratio is about 5.90%. Regarding the ash ratio, the findings showed that there were some variances across the treatments, as the highest ratio of ash was in BS25%, which amounted to about 1.70%, whereas they were 1.5, 1.33, and 1.37%, for BS20%, BS10%, and BW respectively. It is noted from the table that there are significant differences in the protein ratio. The protein ratio increased with the increase in the proportion of replacement, with the highest protein ratio in the BS25% treatment, which was about 14.43%, followed by BS20% (14.07%), BS10% (13.4%), and BW (12.1%). As for fat, its ratio increased by increasing the replacement ratio, with the highest fat ratio in the BS25% treatment, which was about 10.33%, followed by BS20% (7.1%), BS10% (4.34%), and BW (2%).

Regarding fiber percentages, the results for BS10%, BS20%, and BS25% were about 12.20%, 12.17%, and 12.10%, respectively. The results revealed statistically significant variations in the carbohydrate ratios of the examined therapies. The proportion of carbohydrate declined as the replacement ratio increased, with the greatest value of carbohydrate at BW, which was around 68%, and the percentages of carbohydrate in the treatments BS10%, BS20%, and BS25% being 62.73%, 58.93%, and 55.10%, respectively. Gandhi and Srivastava (2007) discovered that the addition of 20%, 30%, and 40% sesame seeds to biscuit mixture led to an increase in the percentages of moisture, ash, protein, fat, and fiber and a decrease in the percentage of carbohydrates. The results of the chemical analysis of sesame-seed-treated biscuits were consistent with their findings.

Table 4: The impact of replacing wheat flour (WF) with sesame flour (SF) on the chemical composition of different biscuit treatments

Chemical composition	Treatments			
	BW	BS10%	BS20%	BS25%
Moisture %	6.27 ± 0.07 a	5.90 ± 0.06 b	6.33 ± 0.07 a	6.33 ± 0.03 a
Ash%	1.37 ± 0.03 c	1.33 ± 0.03 c	1.50 ± 0.06 b	1.70 ±0.06 a
Protein%	12.10 ± 0.06 d	13.40 ± 0.15 c	14.07 ± 0.03 b	14.43 ± 0.09 a
Fats%	2.00± 0.06 d	4.34 ± 0.13 c	7.10 ± 0.12 b	10.33 ±0.09 a
Fiber%	9.93 ± 0.12 c	12.20 ± 0.10 a	12.17 ± 0.09 a	12.10 ± 0.06 a
Carbohydrate%	68.33 ± 0.15 a	62.73 ± 0.38 b	58.93 ± 0.13 c	55.10 ± 0.10 d

* The different lowercase letters within the same row indicate that there are significant ($p \leq 0.05$) differences between the treatments.
BW= Biscuits made from wheat flour only, BS10%= Biscuits made from 10% replacement of sesame flour, BS20%= Biscuits made from 20% replacement of sesame flour, BS25%= Biscuits made from 25% replacement of sesame flour.

Table 5 demonstrates the impacts of substituting wheat flour with flax flour at various ratios on the chemical composition of laboratory biscuits. The table shows that the results were comparable; the highest moisture ratio in the treatment was BF25% with about 6.57%, followed by BF20% with about 6.47%. For BW and BF10%, the moisture ratios were the same and equaled 6.27%. Regarding the ratio of ash, there were no significant variations between them; BF25% (1.40%) and BW (1.37%) had the greatest ratio of ash, while BF10% and BF20% had the same ratio at 1.27%. There are considerable changes in the ratio of protein, as shown in the table 5. As the amount of replacement rises, so does the protein ratio, with the greatest protein ratio occurring in the BF25% treatment (about 13.83%), followed by BF20% (13.20%). The protein ratios for BF10% and BW were around 13.07% and 12.10%, respectively. Increasing the replacing ratio increased the ratio of fats, with the greatest ratio of fat in the BF25% treatment (10%), followed by BF20% (9.53%), while the ratios of fat for BF10% and BW were 9.23% and 2.00%, respectively. Regarding the ratio of fibers, the sample BF25% and BF20% had the greatest ratio of fibers, at about 10.77% and 10.40%, followed by BW, at around 9.93%, and BF10%, at approximately 8.67%. The greatest ratio of carbohydrates was found in the control sample BW, which was 68.33%, followed by the sample BF10%, which was about 61.50%, BF20%, which was about 59.03%, and the sample BF25%, which was approximately 57.43%.

The results of the chemical composition of biscuits made with flax grain replacement are in agreement with what was found by Rahangdale *et al*. (2021), who found that mixing flax grains with the biscuit manufacturing mixture in proportions (5, 10, 15, 20, 25, 35, 40) led to an increase in the proportions of moisture, ash, protein, fiber and a decrease in the proportion of carbohydrates as well as its content of oil, which makes it a good choice in the manufacture of bread and functional foods.

Table 5: The impact of replacing wheat flour (WF) with flax flour (FF) on the chemical composition of different biscuit treatments

Chemical composition	Treatments			
	BW	BF10%	BF20%	BF25%
Moisture %	6.27 ± 0.07 b	6.27 ± 0.09 b	6.47 ± 0.03 ab	6.57 ± 0.09 a
Ash%	1.37 ± 0.03 a	1.27 ± 0.03 a	1.27 ± 0.03 a	1.40 ± 0.06 a
Protein%	12.10 ± 0.06 d	13.07 ± 0.03 c	13.20 ± 0.12 b	13.83 ± 0.03 a
Fats%	2.00 ± 0.06 c	9.23 ± 0.09 b	9.53 ± 0.09 b	10.00 ± 0.21 a
Fiber%	9.93 ± 0.12 b	8.67 ± 0.09 c	10.40 ± 0.12 a	10.77 ± 0.21 a
Carbohydrate%	68.33 ± 0.15 a	61.50 ± 0.12 b	59.03 ± 0.30 c	57.43 ± 0.33 d

* The different lowercase letters within the same row indicate that there are significant ($p \leq 0.05$) differences between the treatments
BW = biscuits made from wheat flour only, BF10% = biscuits obtained from replacing 10% flax flour, BF20% = biscuits obtained from replacing 20% flax flour, BF25% = biscuits obtained from replacing 25% flax flour.

The antioxidant activity of biscuit produced with different replacement ratios of sesame and flax grains was estimated by adopting the method of estimating the inhibitory effect of free radicals using 1,1-diphenyl-2-picrylhydrazyl (DPPH). The results from Figure 1 show that there is an increase in the samples substituted with sesame and flax in comparison to the control sample BHT, where the highest inhibitory ability to inhibit free radicals was for the BW treatment, which reached 58%, followed by the BS25% treatment, which amounted to 55%, whereas the lowest level of antioxidants was in the treatment BF25%, which reached 24% compared to the synthetic antioxidant (BHT), which reached 30%.

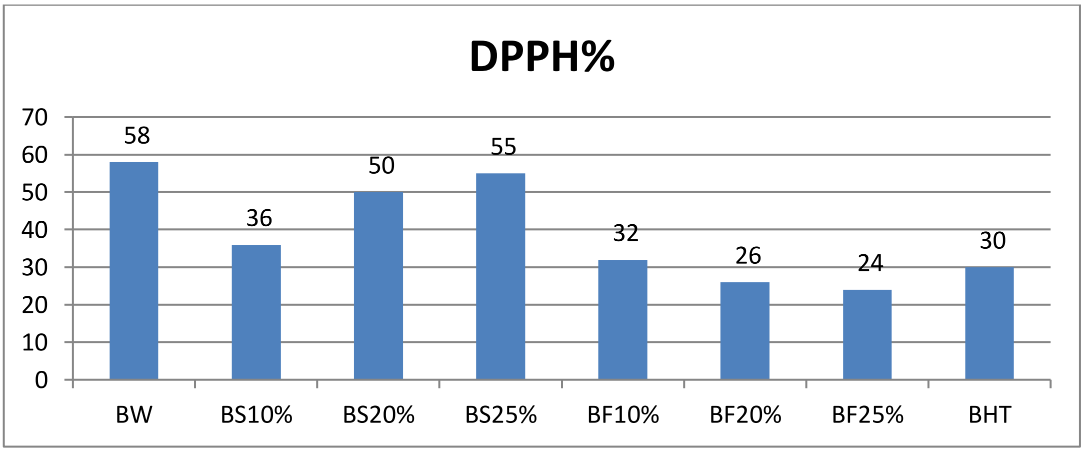

Figure 1: Antioxidants activity in the biscuit samples

As they highlighted that the whole wheat kernel includes vitamin E, which functions as an antioxidant, the findings of calculating the antioxidant content of biscuits made with whole wheat flour matched those of Leonard *et al.* (2004). Moore *et al.* (2005) said that the antioxidant activity of wheat relies on the kind of wheat and the environment in which it is grown, in addition to the use of whole grain flour in manufacturing and the lack of shortening chemicals. The results corroborated these findings. Other results concurred with Kahyaoglu and Kaya (2006) assertion that roasted sesame grains had antioxidant properties that limit the formation of free radicals. The results of the estimation of antioxidants in biscuits made from replacing flax grain flour agreed with those of Man *et al.* (2021), who discovered an increase in the antioxidants ratio with the increase in the ratio of replacement from flax grains to the produced biscuits, and this result can be explained by the fact that flax grains have a strong antioxidant activity, particularly in the crusts that contain compounds that resist oxidation (Akl *et al.*, 2020).

CONCLUSIONS

This study aimed to better understand the chemical composition of different grains by comparing the fatty acid and antioxidant content of biscuits manufactured with zero, ten, twenty, and twenty-five percent replacement ratios of sesame and flax flour. The chemical analysis of the biscuits made using sesame flour and flax flour as replacements revealed a variation in the percentage of moisture for the different biscuit types. As the ratios of replacement increased, the percentage of ash rose sharply. The highest concentration of proteins was found in the BS25% treatment. Higher rates of replacement were associated with higher protein concentrations. Replacement rates for the treatments studied were likewise related to the amount of fats, with the greatest percentage of fats being 10.33%. fiber content was highest in the BS20% treatment (12.20%). With increasing replacement rates, the highest carbohydrate percentages (55.10-68.33%) were indicative of a falling carbohydrate ratio. Results also revealed that all grain varieties analyzed had detectable levels of both necessary and non-essential fatty acids. Antioxidant levels in the original biscuits reached 58%, the highest of all of the tested varieties.

REFERENCE

A.O.A.C. (2005). Official Methods of Analysis, 18th ed. Association of Official Analytical Chemists, Washington, D.C.

A.O.A.C. (2008). Official Methods of Analysis. 18th ed. Association of Official Analytical Chemists International. Arlington, Virginia, USA.

Abo El-Maati, A. F., Samir, A. M., Salah, M. L., Ali M. A. & Al-Gabya, M. F. R. (2016). Phenolic extracts of clove (*Syzygium aromaticum*) with novel antioxidant and antibacterial activities. European Journal of Integrative Medicine, 8: 494-504.

Akl, E. M., Mohamed, S. S., Hashem, A. I. & Taha, F. S. (2020). Biological activities of phenolic compounds extracted from flax grain meal. Bulletin of the National Research Centre, 44(1): 1-8.

Alpaslan, M., & Hayta, M. (2006). The effects of flax grain, soy and corn flours on the textural and sensory properties of a bakery product. Journal of Food Quality, 29(6): 617-627

Asuman, K. (2012). Chemical and elemental characterization of wheat germ oil (*triticum spp. L.*) cultivated in Turkey. African Journal of Agricultural Research, 7(35): 4979-4982.

Belitz, H. D., Grosch, W. & Schieberle, P. (2009). Grains and grain products. Food chemistry, 670-745.

Dalatu, I.S., Mohammed, B. & Umar, A. (2019) Determination of Relationship b Characteristics and Grain Yield o indicum L. In Sokoto, Nigeria.

Dashak, D. A. & Fali, C. N. (1993). Chemical composition of four varieties of Nigerian bennigrain (*Sesamum indicum*). Food chemistry, 47(3): 253-255.

Doğmuş, D. & Durucasu, İ. (2013). Keten tohumu çeşitlerinin n-bütanol fraksiyonlarinin fenolik bileşenlerinin antioksidan aktivitesi-antioxidant activity of phenolic components from n-butanol fraction of flax grain varieties. Celal Bayar University Journal of Science, 9(1): 47-56.

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C. & Attia, H. (2007). Quality characteristics of Sesame grains and by-products. Food chemistry, 103(2): 641-650.

Gandhi, A. P. & Srivastava, J. (2007). Studies on the production of protein isolates from defatted sesame grain (*Sesamum indicum*) flour and their nutritional profile. ASEAN Food Journal, 14(3): 175.

Gandhi, A. P. & Taimini, V. (2009). Organoleptic and nutritional assessment of Sesame (*Sesamum indicum L.*) biscuits. Asian journal of food and Agro-Industry, 2(2): 87-92.

Ganorkar, P. M. & Jain, R. K. (2014). Effect of flax grain incorporation on physical, sensorial, textural and chemical attributes of cookies. International Food Research Journal, 21(4).

Herchi, W., Arráez-Román, D., Boukhchina, S., Kallel, H., Segura-Carretero, A. & Fernández-Gutierrez, A. (2012). A review of the methods used in the determination of flax grain components. African Journal of Biotechnology, 11(4): 724-731.

Abdul Jalill, D. JO (2014). GC-MS analysis of Calendula officinalis and cytotoxic effects of its flower crude extract on human epidermoid larynx carcinoma (HEP-2). World J. Pharm. Pharm. Sci., 3(4): 237-275.

Kahyaoglu, T. & Kaya, S. (2006). Modeling of moisture, color and texture changes in Sesame grains during the conventional roasting. Journal of Food Engineering, 75(2): 167-177.

Leonard, S. W., Good, C. K., Gugger, E. T. & Traber, M. G. (2004). Vitamin E bioavailability from fortified breakfast grain is greater than that from encapsulated supplements. The American journal of clinical nutrition, 79(1): 86-92.

Man, S. M., Stan, L., Păucean, A., Chiş, M. S., Mureşan, V., Socaci, S. A., & Muste, S. (2021). Nutritional, sensory, texture properties and volatile compounds profile of biscuits with roasted flax grain flour partially substituting for wheat flour. Applied Sciences, 11(11), 4791

Moore, J., Hao, Z., Zhou, K., Luther, M., Costa, J. & Yu, L. (2005). Carotenoid, tocopherol, phenolic acid, and antioxidant properties of Maryland-grown soft wheat. Journal of Agricultural and Food Chemistry, 53(17): 6649-6657.

Naji, E. Z. (2016). Optimum conditions for the extraction of Sesame grain (*sesamum indicum)* proteins and study some of its functional properties. J. Food and Dairy Sci., Mansoura Univ., 7(10): 427-433.

Nitrayová, S., Brestenský, M., Heger, J., Patráš, P., Rafay, J. & Sirotkin, A. (2014). Amino acids and fatty acids profile of chia (*Salvia hispanica L.*) and flax (*Linum usitatissimum L.*) grain. Slovak Journal of Food Sciences, 8(1).

Paul, P. & Bhattacharyya, S. (2015). Antioxidant profile and sensory evaluation of cookies fortified with juice and peel powder of fresh Pomegranate (*Punica granatum*). International Journal of Agricultural and food Science, 5 (3): 85-91.

Pearson, D., Harold, E., Ronald, S. K. & Ronald, S. (1981). Chemical Analysis of Food, Churchill Livingston. New York, USA.

Rahangdale, H. K., Mishra, S. P., Duggal, A., Shukla, S. S. & Rana, G. K. (2021). Assessment of nutritional and sensory properties of biscuits prepared from wheat and linseed flour.

SAS. (2001). Statistical Analysis System, SAS Institute, Inc., Cary, N.C.U.S.A.

Sharif, M. K., Butt, M. S., Anjum, F. M. & Nawaz, H. (2009). Preparation of fiber and mineral enriched defatted rice bran supplemented cookies. Pakistan Journal of Nutrition, 8(5): 571-577.

Sulaqa, A. B. (1990), Bread and Pastries, Higher Education Press, University of Mosul.

Yadav, R. K., Singh, M., Roy, S., Ansari, M. N., Saeedan, A. S. & Kaithwas, G. (2018). Modulation of oxidative stress response by flaxseed oil: Role of lipid peroxidation and underlying mechanisms. Prostaglandins and other lipid mediators, 135: 21-26.

Yi, J., Zhang, Q., Li, X., Wang, X., Li, B. & Zhu, W. (2019). Steam explosion technology based for oil extraction from Sesame (*Sesamum indicum L.*) grain. Journal of the Saudi Society of Agricultural Sciences, 18(1): 1-6.