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SENSORY AND BIOLOGICAL EVALUATION OF CHIA AND QUINOA- FORTIFIED GLUTEN FREE- BISCUIT PRODUCTS ON CELIAC DISEASE IN RATS

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ABSTRACT

Celiac disease (CD) is a chronic inflammatory disease of the upper small intestine triggered by gluten protein intolerance, which is prevalent in genetically predisposed persons. The present study was aimed to explore the sensory and biological evaluation of chia and quinoa-fortified gluten - free biscuit products on CD in rats. Sensory evaluation of prepared biscuit products supplemented with chia, quinoa and their combination was performed. Results revealed that incorporation of chia and quinoa flour with rice flour improved sensory properties of prepared biscuit products. Thirty-five male Sprague Dawley rats were used and allocated into five equal groups; Group1: negative control, group 2: positive control with CD and groups 3, 4 and 5: with CD and were fed on chia, quinoa and their combination, respectively. Feed intake (FI), body weight gain (BWG %), and feed efficiency ratio (FER) were calculated. Blood samples were collected for determination of parameters of liver & kidney function, total cholesterol (TC) , triglyceride (TG) , lipoprotein fractions, glutathione (GSH), malondialdehyde (MDA) and lactate dehydrogenase (LDH). Histopathology of small intestine was also carried out. Feeding of chia, quinoa and their combination to rats decreased BWG%, FER, TC, TG and parameters of hepatorenal function. Histopathological examination of small intestine demonstrated that feeding combination of chia and quinoa ameliorated lesions of CD and intestinal inflammation. It could be concluded that fortification of rice flour with quinoa and chia flour improve the sensory properties of prepared biscuit products and when fed to rats may be effective as curative for celiac disease.

Key Words: Celiac disease, Gluten- Chia , Quino, Sensory evaluation, Biochemical analysis, Histopathology.

INTRODUCTION:

Celiac disease (CD) is a chronic inflammatory disease of the upper small intestine triggered by gluten protein intolerance, which is prevalent in genetically predisposed individuals. The prevalence of the celiac disease in Arab countries varies with sex and age. However, It was found that CD presented similar clinical characteristics independent of the geographic region. **(Paivi *et al.*, 2020).** The classical manifestation of CD is often present with all related signs and symptoms of malabsorption. Moreover, patients also experience diarrhea, steatorrhea, and loss of weight or growth failure. Meanwhile, in children, the classical characteristics are diarrhea, failure to thrive, muscle wasting, poor appetite, abdominal distension, and sometimes emotional distress and lethargy **(Paivi *et al.*, 2020).** Currently the only effective treatment for CD is the gluten free diet (GFD), which is extremely difficult to adhere to and significantly reduces the patients' quality of life. Therefore investigations are in progress to find new therapies varying from production of genetically modified wheat to blockade of inflammatory cytokines. Meanwhile, the discovery of new endogenous immunoregulatory substances suggests new therapeutic approaches **(Rashtak and Murray, 2012).**

Gluten is the wheat grain protein richly consumed in Western countries with an average daily intake of 10 to 20 grams/person/day **(Cohen *et al*., 2019)**. It is comprised of prolamin and glutelin proteins. Both proteins abundantly possess glutamine and proline residues, which defy gastrointestinal digestion and promote the deamination process through the tissue transglutaminase (tTG) enzyme. It may lead to mucosal inflammation and villous atrophy, thus causing malabsorption **(Assa and Frenkel-Nir , 2017)**.

Chia is commonly known as *Salvia hispanica* L., an oilseed plant, and is native from southern Mexico and northern Guatemala. It is a traditional food in Central and South America. Chia seed contains 25 to 40% oil with high essential fatty acids (omega) ω-3 alpha-linolenic acid (60%) and (omega) ω-6 linoleic acid (20%). It is also high in protein (19-23%), dietary fiber (18-30%), vitamins, minerals and antioxidants **(Norlaily *et al*., 2012).** Due to its unique nutritional composition, especially its high unsaturated fatty acid composition, dietary fiber and antioxidant activities its consumption helps to increase satiety index and decreases the risk of various types of diseases such as cardiovascular diseases, cancer, diabetes, inflammatory and autoimmune diseases

(Munoz *et al.*, 2013). A number of studies have investigated the inclusion of different seeds into gluten-free breads in order to increase their nutritional value. Because of its nutritional composition, particularly the omega-3 fatty acid, fiber and antioxidant content, Chia is an ideal seed for the enrichment of cereal products, and there has been an increase in the number of commercial products that incorporate chia in their formulation in recent years **(Eugenia *et al* ., 2014).**

Quinoa, a pseudo cereal that belongs to the *Chenopodiaceous* family has a high nutritive value than traditional cereals. It has high protein content (10-18%) with balanced amino acid composition, supplying high contents of lysine and methionine **(Nowak *et al*., 2016).** The fat content of raw quinoa seeds was 9.7% (dry-weight basis) and it has similar fatty acid composition with soybean oils with high amounts of essential fatty acids linoleic (52.3%) and linolenic acids (3.9%). These essential fatty acids required for good health, cannot be synthesized in human body and must be obtained from the diet **(Costantini *et al*., 2014).** It contains a significant amount of fiber (2.1-4.9%), more calcium, magnesium, potassium, iron, copper, riboflavin (B2), α-Tocopherol (vitamin E), β-Carotene and ascorbic acid (vitamin C) than wheat, barley and rice. It is also a rich source of other bioactive compounds (polyphenols, phytosterols, etc.) **(Aktaş and Levent, 2018).** Quinoa used in the bakery industry because the starch present in the seeds has properties similar to those found in wheat. In addition to augmenting the nutritional value, it is free of gluten, so it can be eaten by people who have CD as well as by those who are allergic to wheat **(Stikic *et al*. 2012)**

MATERIALS AND METHODS:

Materials

Raw material chia seeds, whole quinoa flour, rice flour, fine granulating sucrose, whole egg, oil, cinnamon, salt, baking powder and ethyl vanillin were obtained from Agricultural Research center in Cairo.

Basal diet was prepared according to the method of **Reeves *et al.* (1993).** It was consisted of 20 % protein (casein), 10 % carbohydrate, 4.7% fat (corn oil), 2% choline chloride, 1% vitamin mixture, 3.5 % salt mixture and 5% fibers. The remainder was corn starch up to 100 %. Kits for blood analysis were purchased from local distributer of (Sigma Chemical), Cairo, Egypt. Gliadin (G-3375; Sigma chemical substance to induction of celiac disease obtained from El-Gomhoryia Company, Cairo, Egypt.

Experimental Animals:

A total number of thirty-five rat (Sprague Dawley strain) weighing (220 to 210 g) body weight, were purchased from the Agriculture Research Center, Giza, Egypt.

Methods:

Preparation of Flour Formulas:

The free gluten flour formula consists of (rice flour), chia flour (CF) and quinoa flour (QF) were mixed together for preparation the biscuits by replacement as recorded in Table 1.

Table (1): Flour formula for preparation of free gluten bakery products (biscuits).

Formula	Rice flour (g)	Chia flour(g)	Quinoa flour(g)
Control	200	-	-
Sample 1	190	10	-
Sample 2	180	20	-
Sample 3	160	40	-
Sample 4	190	-	10
Sample 5	180	-	20
Sample 6	160	-	40
Sample 7	190	5	5
Sample 8	180	10	10
Sample 9	160	20	20

Preparation of Bakery Products (Biscuits):

Preparation of the different types of free gluten (biscuits). Control gluten-free biscuits sample was prepared using the following recipe: Gluten free flour (rice flour) 200g, fine granulating sucrose (40 g), whole egg (50 g), salt (0.5 g), baking powder (5 g), ethyl vanillin (0.1 g) and sunflower oil (40)g (**AOAC. 1995).** The replacement by chia and quinoa flour with the percentage of chia flour (5, 10, 20 %), quinoa flour (5, 10, 20 %) and mixture of chia: quinoa flour (1:1) as (5, 10, 20%).

Evaluation of products quality:

The bakery products that were prepared underwent sensory evaluation in order to determine their texture quality and to select the appropriate flour formulas that should be used for the preparation. Each type of baked products with the most acceptable characteristics was then subjected to further investigation, which included a biological evaluation study.

Sensory Evaluation:

The Sensory characteristics, including appearance of crumb, mouth feel of crumb, flavour intensity, firmness of crust, colour (crust and crumb) and general acceptability. This evaluation was carried out by trained panelists using a score sheet according to **Penfield and Campbell (1990).**

Biological Evaluation:

Daily feed intake (FI) was recorded day after day throughout the experimental period (3 weeks). Body weight gain (BWG) was calculated. Determination of body weight gain per cent and feed efficiency ratio (FER) were assessed according to the method described by **Chapman *et al.*, (1959)** using the following equations

BWG % = final weight (g) – Initial weight (g) / Initial weight (g) ×100

Feed efficiency ratio (FER) = Weight gain (g) / feed consumed (g)

Induction of Celiac Disease (CD):

To induce celiac disease, Gliadin (G-3375; Sigma) was dilute in 0.02 M acetic acid to form 10% solution. The prepared solution was given intragastrically by gavage at a dose of 1.5 mg/g body weight for five days as reported by **Nikoukar *et al.*, (2014).**

Experimental Animal Design:

Thirty-five male rats, Sprague Dawley strain ,were housed in well-aerated cages under hygienic conditions, and fed on basal diet for one week for adaptation.

After the adaptation period, rats were divided into two main groups, as follows:

First group: negative control group, rats (n=7) were fed on basal diet only during the experimental period.

Second group: all remaining rats (n=28), were given intragastrically (1.5 mg/g body weight) from Gliadin diluted in 0.02 M acetic acid to form 10% solution for 5 days to induced celiac disease, and they were divided as follows:

Subgroup (1): rats serve as a positive control group fed basal diet only.

Subgroup (2):rats were fed basal diet (with bakery product containing chia seeds).

Subgroup (3): rats were fed basal diet (with bakery product containing quinoa seeds).

Subgroup (4): rats were fed basal diet (with bakery product containing chia and quinoa).

Biological Evaluation:

Daily feed intake (FI) was recorded day after day throughout the experimental period (3 weeks). Body weight gain (BWG) was calculated. Determination of body weight gain percent and feed efficiency ratio (FER) were assessed according to the method described by **Chapman *et al.* (1959)** using the following equations

BWG % = final weight (g) – Initial weight (g) / Initial weight (g) ×100

Feed efficiency ratio (FER) = Weight gain (g) / feed consumed (g)

Blood Collection and Serum Separation:

At the end of the experimental period (2 weeks), rats were fasted overnight and authorized by ether, intestinal was dissected out and kept in 10% neutral buffered formalin for histopathological examination and blood samples were collected from each rat and centrifuged at 3000 rpm for 15 min to obtain the serum for biochemical analysis.

Biochemical Analysis:

Total cholesterol (TC) was determined according to **Richmond, (1973)**. Triglyceride (TG) was determined according to **Wahlefeld, (1974)**. High density lipoprotein cholesterol (HDL-c) was determined according to **Albers *et al*., (1983)**.Low density lipoprotein cholesterol (LDL-c) and very Low density lipoprotein cholesterol (VLDL-c) were estimated according to the equation described by **Friedewald *et al*., (1972)**. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) concentration were determined according to **Young and Friedman (2001)**. Alkaline phosphatase (ALP) concentration was determined according to **Roy, (1970)**. Serum uric acid and creatinine levels were estimated as described by **Lorentz and Brendt (1967)**. Glutathione peroxidase (GPx) was determined according to **Hissin and Hilf, (1976)** . Lactate dehydrogenase was determined according to **Vassault *et al*., (1986)**. Serum malondialdehyde (MDA) was determined by the method of **Ohkawa *et al*., (1979).**

Histopathological Examination:

Immediately after scarifying of rats, intestinal dissected out and kept in 10% neutral buffered formalin for histopathological examination according to **Bancroft and Stevens (1996)**. Histopathological examination was carried out at the Department of Pathology, Faculty of Veterinary medicine, Cairo University, Egypt.

Statistical Analysis:

The obtained results were analyzed using Statistical Package for the Social Sciences (SPSS) for Windows, version 20 (SPSS Inc., Chicago, IL, USA). Collected data was presented as mean± standard deviation (SD). Analysis of Variance (ANOVA) test according to **Armitage and Berry (1987)**.

RESULTS AND DISCUSSION:

It is clear from Table (2) that Chia fortified product at 10%, Quinoa fortified product at 10% and Chia + Quinoa fortified product at 10 produced the best sensory characteristic recorded by trained panelists. These sensory characteristics included appearance, color, uniformity, taste, odor and overall acceptability. These findings were similar to those of **Sadeek *et. al*., (2021**) who concluded that the incorporation of chia and quinoa flour with rice flour have beneficial effects for improving the chemical, nutritional, rheological, and sensory properties of food.

Table (2): Sensory evaluation of prepared products supplemented with chia and quinoa seeds on celiac disease in rats

Characteristics	Samples									
	CO	C 5%	C 10%	C 20%	Q 5%	Q 10%	Q 20%	C+Q 1:1 5%	C+ Q 1:1 10%	C+Q 1:1 20%
Appearance (5)	4.16	3.84	4.1	4.43	4.54	4.4	3.98	4.04	4.28	4.16
Color: Internal (5)	4.4	4.2	4.28	3.94	3.96	4.3	4	3.83	3.86	4.02
Color: External (5)	4.12	4.04	3.8	4.38	4.48	4.2	3.84	3.67	3.96	3.9
Cell Uniformity(5)	3.9	3.92	3.86	3.7	3.38	3.54	3.74	3.72	4.04	4.18
Taste (5)	4	4.08	4.08	3.72	3.02	3.66	3.6	3.7	4	3.98
Odor (5)	4.08	3.96	4	3.98	4.08	3.94	3.78	3.6	4.04	3.92
Overall Acceptability (5)	3.8	3.96	3.84	3.82	3.72	3.82	3.64	3.4	3.86	3.9

CO = Normal control group C= Chia Q = Quinoa

However, overall acceptability is given scores from (5) as following:

Less than 1 = very very bad	**1 less than 1.5 = very bad**
1.5 less than 2 = bad	**2 less than 2.5 = acceptable**
2.5 less than 3 = good	**3 less than 3.5 = very good**
3.5 less than 4 = very very good	**4 less than 4.5 = excellent**
4.5 less than 5 = very excellent	

Table (3) shows that feeding of rats with Chia and Quinoa-fortified gluten free biscuit products decreased FI, BWG% and FER in the positive group (rats with celiac disease) as compared to the normal control rats. Feeding Chia, Quinoa and their combination to rats significantly increase. FI, BWT% and FER.

These findings are similar to those reported by **Sadeek *et.al*., (2021**) who concluded that the incorporation of chia and quinoa flour with rice flour have beneficial effects for improving the chemical, nutritional, rheological, and sensory properties of food product pasta.

Table (3): Effect of Chia and Quinoa-fortified gluten-free biscuit products on feed intake (FI), body weight gain (BWG %) and feed efficiency ratio (FER) in rats

Group	FI (g/day/rat)	BWG (%)	FER
Control (-ve)	10.0±0.71a	48.56±2.71a	0.230±0.009a
Control (+ve)	9.0±0.67c	24.07±2.67c	0.120±0.003b
Chia	12.0±0.34bc	30.35±2.34bc	0.121±0.007b
Quinoa	12.5±0.10bc	32.88±2.10bc	0.128±0.006b
Chi and Quinoa	13.0±0.71b	36.28±2.71b	0.132±0.008b

Means in the same column with different letters are significantly different at P≤0.05

Results in Table (4) revealed that feeding of rats with celiac disease significantly increased TC and TG in the positive group as compared to the normal control group. Rats fed on chia, quinoa and their combination had a significant decrease in TC and TG.

These results agree to those reported by **Eugenia *et al.* (2014), Nowak *et al.* (2016) & Aktaş and Levent (2018).**The previous investigators reported that chia, quinoa lowered TC and TG in rats with celiac disease.

Table 4. Effect of Chia and Quinoa-fortified gluten-free biscuit products on total cholesterol (TC) and triglycerides (TG) in rats. (n=7 rats)

Group	Total Cholesterol (mg/dL)	Triglycerides mg/dL
Control (-ve)	96.14±1.07b	98.42±2.12b
Control (+ve)	122.42±1.43a	122.71±2.47a
Chia	92.28±1.68bc	83.71±2.14cd
Quinoa	91.42±1.35bc	86.57±1.60c
Chi and Quinoa	88.71±1.83c	74.28±1.83d

Means in the same column with different letters are significantly different at P≤0.05

As shown in Table (5), celiac diseases in rats significantly decreased HDL-c, and increased LDL-c and VLDL-c. Rats fed Chia, Quinoa and their combination had a significant increase in HDL-c and a decrease in LDL-c and VLDL-c.

These findings are similar to those of **Norlaily *et al.* (2013); Nowak *et al.* (2016) and Khatri *et al.*, (2023).** Moreover, many studies have described chia and quinoa as protecting against a variety of diseases, particularly cancer, allergies, inflammatory diseases, and they may reduce the risk of cardiovascular diseases (**Sadeek *et al.*, (2021).**

Table (5). Effect of Chia and Quinoa-fortified gluten-free biscuit products on lipoprotein fraction (high density lipoprotein (HDL-c), low density lipoprotein (LDL-c) and very low density lipoprotein (VLDL-c). (n=7 rats)

Group	HDL-c (mg/dL)	LDL-c (mg/dL)	VLDL-c (mg/dL)
Control (-ve)	50.57±1.23a	25.88±1.65b	19.68±0.42b
Control (+ve)	42.14±0.50c	55.74±1.77a	24.54±0.69a
Chia	46.57±1.49b	28.79±2.07b	16.47±0.62cd
Quinoa	46.58±0.93b	27.25±1.99b	17.31±0.32c
Chi and Quinoa	49.57±0.57ab	24.28±1.79b	14.85±0.16d

Means in the same column with different letters are significantly different at P≤0.05.

Table (6) shows that Celiac diseases in rats significantly increased liver enzymes AST, ALT and ALP. Rats fed on chia, quinoa and their combination had a significant decrease in the levels of elevated liver enzymes.

The present results agree with those of **Rashtak & Murray (2012) Muñoz *et al*., (2013) and Khatri, *et al*., (2023).** The previous researchers concluded that feeding chia and quinoa to the rats lowered the level of liver enzymes.

Table (6). Effect of Chia and Quinoa-fortified gluten-free biscuit products on liver enzymes aspartate aminotransferase (AST); alanine aminotransferase (ALT) and alkaline phosphates (ALP) in rats.(n=7 rats)

Group	AST (U/L)	ALT (U/L)	ALP (U/L)
Control (-ve)	14.71±0.42c	28.28±0.86d	115.00±1.38d
Control (+ve)	39.57±0.57a	32.57±0.64a	126.71±1.20a
Chia	19.71±0.42b	29.28±0.80bc	118.42±1.48b
Quinoa	19.57±0.42b	26.57±0.97b	117.58±1.12c
Chi and Quinoa	16.14±0.63c	25.00±0.81cd	116.57±1.84c

Means in the same column with different letters are significantly different at P≤0.05.

As shown in Table (7), Celiac diseases in rats significantly increased kidney function parameters uric acid (UA) and creatinine (Creat.) in control positive groups. . Rats fed on chia, quinoa and their combination had a significant decrease in the levels of elevated kidney parameters (uric acid and creatinine).

These results are in agreement with those of **Mohd *et al.* (2012) Muñoz *et al.*, (2013) and Costantini *et al.*, (2014).**

Table (7). Effect of Chia and Quinoa-fortified gluten-free biscuit products on kidney function parameters uric acid (UA) and creatinine (Creat.) in rats. (n=7 rats)

Group	UA (mg/dL)	Creat. (mg/dL)
Control (-ve)	16.71±0.56c	0.78±0.036c
Control (+ve)	24.71±0.68a	1.79±0.058a
Chia	19.14±0.50bc	1.13±0.087b
Quinoa	19.42±0.64b	1.05±0.46b
Chi and Quinoa	17.14±0.63bc	0.82±0.043c

Means in the same column with different letters are significantly different at P≤0.05.

The current results revealed that Celiac diseases in rats significantly increased LDH and MDA but decreased GTH in the positive control group as compared to the negative control group. Rats fed on chia, quinoa and their combination had a significant decrease in LDH and MDA and a significant increase in GTH.

These findings are nearly similar to those of **Muñoz *et al.*, (2013) ; Aktaş and Levent (2018).** The previous researchers reported that feeding of rats with chia, quinoa and their combination had a significant decrease in LDH and MDA and a significant increase in GTH.

Table (8). Effect of Chia and Quinoa-fortified gluten-free biscuit products on glutathione (GSH); malondialhyde (MDA) and lactate dehydrogenase (LDH) in rats. (n=7 rats)

Group	GSH (mg/dL)	MDA (mg/dL)	LDH (U/L)
Control (-ve)	5.09±0.023a	2.60±0.018c	118.28±3.44c
Control (+ve)	3.43±0.119d	3.67±0.103a	316.14±4.33a
Chia	4.80±0.020b	2.83±0.064b	144.57±2.71b
Quinoa	4.50±0.038c	2.73±0.073bc	139.00±2.41bc
Chi and Quinoa	4.74±0.034bc	2.28±0.040d	129.00±2.60bc

Means in the same column with different letters are significantly different at P≤0.05.

Histopathology Examination

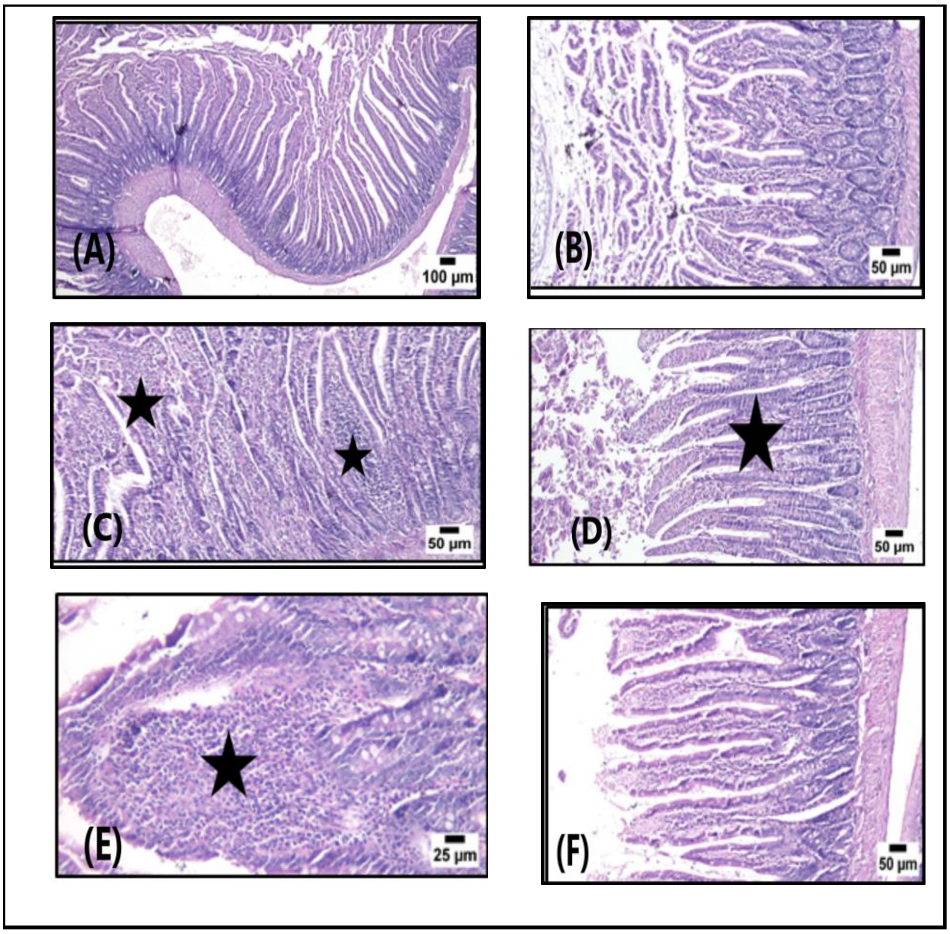

Fig (1): Cross sections of small intestine of rats:

(A) Normal control group showing normal histological structure all layers (H&E), **(B)** Positive control group showing marked atrophied intestinal villi with hyperplasia of crypts (H&E), **(C)** Positive control group showing expansion of the lamina propria with numerous infiltrated inflammatory cells (stars) (H&E), **(D)** Group fed on chia-fortified gluten free biscuit product showing moderate atrophy of the intestinal villi associated with hyperplasia of the crypts (Star) (H&E), **(E)** Group fed on quinoa -fortified gluten free biscuit product showing variable number of inflammatory cells infiltration in the intestinal mucosa (Star) (H&E) and **(F)** Group fed on chia and quinoa -fortified gluten free biscuit product showing apparently normal histological structure.

The histopathological alterations seen in small intestine in rats with CD rats, in this study, were parallel with the reported biochemical parameters. These histopathological alterations in the present study are similar to those demonstrated by **Muñoz *et al*., (2013)**, **Khatri *et al*., (2023)** who reported that chia and quinoa would be an effective curative for celiac disease- induced histopathological changes in the small intestine.

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التقييم الحسى والبيولوجى لمنتجات البسكويت المدعمة بالشيا والكنوا والخالية من الجلوتين على مرض السيلياك فى الفئران

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مرض السيلياك هو مرض مزمن يصيب الجزء العلوى من الامعاء الدقيقة بالالتهاب وتزداد حدته فى الأشخاص الذين يعانون من الحساسية لبروتين الجلوتين . وتهدف هذه الدراسة الى معرفة التقييم الحسى والبيولوجى لمنتجات البسكويت المدعمة بالشيا والكنوا والخالية من الجلوتين على مرض السيلياك فى الفئران. وتم إجراء التقييم الحسي للمنتجات المحضرة من البسكويت والتي تم تعزيزها بالشيا والكينوا وتركيباتهما. وقد تم استخدام خمسة و ثلاثون فأر ذكر وتم توزيعهم إلى خمس مجاميع متساوية؛ المجموعة 1: مجموعة السيطرة السلبية، المجموعة 2: مجموعة السيطرة الايجابية التي تعاني من مرض السيلياك، والمجموعات 3 و 4 و 5 : تعاني من السيلياك وتم تغذيتها بالشيا والكينوا وتركيباتهما على التوالي. تم حساب معدل استهلاك

الغذاء ونسبة زيادة وزن الجسم ونسبة كفاءة تحويل الغذاء. وتم سحب عينات الدم لفصل المصل وذلك لقياس معايير وظائف الكبد والكليتين ومستوى الكوليسترول الكلي والدهون الثلاثية والجلوتاثيون بيروكسيداز والمالونآلدهيد وانزيم لكتات دى هيدروجينيز .تم أيضاً إجراء الفحص النسيجي للأمعاء الدقيقة .

وأظهرت النتائج أن إضافة طحين الشيا والكينوا إلى طحين الأرز قد حسن من الخصائص الحسية لمنتجات البسكويت المحضرة وأيضاً قلل تغذية الفئران علي الشيا و الكينوا وتركيبتهما نسبة زيادة وزن الجسدم ونسبة كفاءة تحويل الغذاء ومستوى الكوليسترول الكلي والدهون الثالثية ومعايير وظائف الكبد والكليتين. وقد أظهر الفحص النسيجي للأمعاء الدقيقة أن تغذية التركيبة المكونة من الشيا والكينوا قد حسنت من التلف الناتج عن مرض السيلياك والتهاب الامعاء الدقيقة. و يمكن الاستنتاج أن إضافة طحين الشيا والكينوا إلى طحين الأرز يحسن من الخصائص الحسية لمنتجات البسكويت المحضرة، وعند تغذية الفئران على التركيبة المكونة من الشيا والكينوا يمكن أن تكون فعالة في علاج مرض السيلياك، حيث تقلل من الاضرار الناتجة عن المرض والالتهاب وتحسن من وظائف الكبد والكليتين ومستويات الدهون في الدم .