Mutah University
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Enrichment Taboun Bread with Quinoa Seeds as a Functional Ingredient

By:
Ahmad Riziq Al-Maayta

Supervisor:
Dr. Khaled Abu-Alruz

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الآراء الواردة في الرسالة لا تُعبر
بالضرورة عن وجهة نظر جامعة مؤتة

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أ.د عبدالله ياسين عبدالفتاح الرواشده	عضوا	
د. ابراهيم رجب ابراهيم دبور	عضوا	
د.رانيه محمد عطا الله القروم	عضو خارجي	

عميد كلية الدراسات العليا

أ.د مخلد سليمان الطراونة

Dedication

الى القلب الكبير الذي لولاه لم أكن هنا اليوم يا من أحمل اسمك بكل فخر.. مهجة قلبي أبي.

الى التي حملت عني يأسي وحزني وصبرت على مشاكلي..تلك التي نادتني امل المستقبل ها أنا أهدي أملي الاول إليك.. بسمة أيامي أمي.

الى من كانت ملامحنا واحدة وبحة صوتنا واحدة.. الى كتفي حين أنهار وسندي حين أتعب.. الى من آثروني على نفسهم..الى من حولوا لحظات حزني الى مرح ..الى ذلك الجبل الذي اسند نفسي عليه وقت الشدائد.. سعادة قلبي إخوتي.

الى من رافقني بالطريق حتى عبرته.. الى من كانوا ملاذي وملجئي ..الى من تحلو بالاخاء وتميزوا بالعطاء.. أصحاب قلبي ورفقاء الدرب.

الى من علمني كل ما تعلمته لليوم.. من يسّر علي الوصول.. أساتذتي.

الى المكان الذي احتواني مخابز السفراء متمثلة بصاحبها السيد مروان الحموي ابو حسن المحترم الذي لم يتوانى بتقديم اي مساعدة.

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"يَرْفَعِ ٱللَّهُ ٱلَّذِينَ ءَامَنُواْ مِنكُمْ وَٱلَّذِينَ أُوتُواْ ٱلْعِلْمَ دَرَجَٰتٍۚ وَٱللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ"

اللهُمَّ لكَ الحمدُ حمداً كثيراً طيباً مباركاً فيهِ...

حمداً ملىءَ السَّماواتِ والأرضِ وملىءَ ما بينَهُما وملىءَ ما شئتَ من شيءٍ بعدهُ...

لكَ الحمدُ كلَّهُ ولكَ الملكُ كلَّهُ وإليكَ يرجعُ الأمرُ كلَّهُ علانيَّتُهُ وسرَّهُ...

بهذهِ المناسبةِ الجميلةِ أودُّ تقديمَ الشكرِ الجزيلِ للدكتور خالد أبو الرز مشرفي الرئيسي على كلِّ ما قدَّمَهُ لي من نصحٍ وإرشادٍ وتوجيه وأعانني على إتمامِ هذا العمل على أكملِ وجه...

والشكر موصول لأعضاء لجنة المناقشة الكرام على تفضلهم بقبول مناقشة رسالة الماجستير هذه.

لا يسعني كذلك سوى تقديم الشكر الجزيل إلى أقرب واصدقائي ممن دعموني.

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Abbreviation

CRD	Completely Randomized Design
RVA	Rapid Visco Analyser
SD	Standard Deviation
TPA	Texture Profile Analysis

Abstract

Enrichment Taboun Bread with Quinoa Seeds as a Functional Ingredient

Ahmad Riziq Al-Maayta

Mutah University, 2022

This study aimed to replace a part of the wheat flour with quinoa seeds flour to prepare Taboun bread due to the nutritional and functional values of quinoa seeds. The impact of physical treatments (Washing, roasting, extruding) and the different substitution levels (0, 5, 10, 15, 20, 25%) on the quinoa-wheat flour was examined. The quinoa-wheat flour was assessed by testing pasting profile parameters and CIE Lab color parameters, and the final samples of bread were assessed by texture parameters, CIE Lab color parameters, and sensory characteristics. The composite flour with washed quinoa seeds was the best formula prepared which increased the substitution levels significantly affected the texture parameters (hardness, cohesiveness, chewiness, and resilience), and sensory properties. The results indicated that it is possible to use quinoa seeds as an ingredient in the preparation of Taboun bread with a high nutritional value in terms of minerals, proteins, and dietary fibers.

Keywords: quinoa, bread, Taboun, flour, color**.**

الملخص

إثراء خبز الطابون بحبوب الكينو كمكون وظيفي

أحمد رزق معايطة

جامعة مؤتة، 2022

هدفت هذه الدراسة إلى استبدال جزء من دقيق القمح بدقيق بذور الكينو لتحضير خبز الطابون نظرًا لما تمتلكه بذور الكينو من قيم غذائية ووظيفية. تمَّ قياس تأثير المعالجات الفيزيائية (الغسل و التحميص و البثق الحراري)، ومستويات الاستبدال المختلفة (0 و 5 و 10و 15و20و 25%) على جودة خبز الطابون. تمَّ تقييم العينات النهائية من الطحين المُركب (المُحتوي على دقيق بذور الكينو ودقيق القمح الأبيض) من خلال قياس قيم اللزوجة وخصائص اللون، أما عينات خبز الطابون تمَّ تقييمها من خلال فحص القوام وخصائص اللون والخصائص الحسية. كانت أفضل عينة تم الحصول عليها هي الدقيق المُركب المُحتوي على دقيق بذور الكينو المغسولة ودقيق القمح الأبيض حيث أثرت الخلطة المُطورة التي تحتوي على بذور الكينو المغسولة مع زيادة مستويات الاستبدال معنويًا على قيم الصلابة (hardness) و التماسك (cohesiveness) و المضغ (chewiness) و المرونة اللحظية (resilience) و خصائص اللون و والخصائص الحسيَّة. كما أشارت النتائج إلى أنه من الممكن استخدام دقيق بذور الكينو كمكون وظيفي لتحضير خبز الطابون بقيمة غذائية مُرتفعة من حيث المعادن و البروتينات والألياف الغذائية.

الكلمات المفتاحية: الكينو، الخبز، الطابون، الدقيق، اللون.

Chapter One
Introduction

1.1 Theoretical background

Functional foods are definite as any component or ingredient of food that gives health benefits, containing the avoidance and treatment of diseases. The main functional ingredients of foods are fibers, proteins, polyunsaturated fatty acids, phenolic compounds, prebiotics, and probiotics (El-Sohaimy et al., 2019).

A functional food can be: a natural food, a food with a component added, a food with a component removed, a food with one or more components changed, a food with modified bioavailability, or any combination of these (Henry, 2010).

A food product become functional by using eliminating a component that is known to cause or has been identified as causing a negative effect when consumed, Increasing the concentration of a naturally occurring component in food, Adding a ingredient that is not normally present in food, Increasing the bioavailability or stability of a component recognized to have a functional benefit or to lessen the food's disease-risk potential (Henry, 2010).

Quinoa is a pseudo-cereal with high-quality protein, and this cereal has high fatty acid levels and strong oxidative stability (Ng et al., 2007). Quinoa grains are covered by an epicarp that holds glycoside compounds called saponins showing a characteristic bitter or astringent taste (Tarade et al., 2006).

Quinoa has well-balanced protein and amino acid content that could improve dietary protein balance when used by itself or mixed with cereal grains. Nowadays, quinoa is gaining attention because of its high nutritional quality, protein content, and as a valuable source of micronutrients. Quinoa includes a well-balanced set of necessary amino acids, making it a complete plant protein source for humans. Furthermore, quinoa is an excellent source of phosphorus and dietary fiber. It is high in magnesium, iron, and vitamins such as vitamin E and those of the group B. Quinoa is considered simple to digest (El-Sohaimy et al., 2019).

Quinoa and quinoa products are rich in polyphenols, including phenolic acids, flavonoids, and tannins that make up the bioactive secondary plant metabolites that contribute to diverse physiological properties such as antimicrobial, antioxidant, anti-inflammatory, antitumor, and anti-carcinogenic effects (Tang et al., 2015). Quinoa seeds' compounds possess additional health benefits beyond the high nutritional value, especially the antioxidant and anti-inflammatory activities, which are critical in reducing the risk of oxidative stress-related chronic diseases, including cancer, cardiovascular diseases, diabetes, and aging and quinoa are generally safe for people with celiac disease (Tang & Tsao, 2017).

On the other hand, there are many antinutritional substances in quinoa, such as saponins. Saponins are considered an antinutritional factor, which must be eliminated before the seeds are consumed (El Hazzam et al., 2020). Most quinoa saponins are polar saponins soluble in water (Xue et al., 2019) and tend to foam in aqueous solutions (Vilche et al., 2003). Saponins are present in the outer layer of glycoside compounds. These compounds possess pharmacological properties but impart a bitter taste to the grain, which must be reduced by grinding and/or washing before consumption. The amount of saponins in quinoa grains depends on the variety and can be classified as sweet (<0.11% saponins) or bitter (>0.11% saponins) (Nickel et al., 2016).

All of these nutritional and health properties will make quinoa a potential functional food that can be incorporated with different food products, and one of these products is Taboun bread. The Taboun bread is a flatbread type, classified as a single-layer bread. Cereal flours, particularly wheat, are the world's most popular fortified food. The purpose of fortifying wheat flour is to enhance produced bread's nutritional and sensory values (Sayed-Ahmad et al., 2018). One of the important challenges to consider was reducing the saponin contents of quinoa seeds before utilizing it in Taboun bread preparation.

1.2 Problem Statement

Replacing part of the flour used in the preparation of Taboun bread with Quinoa flour will improve its nutritional and health properties, providing it will not negatively affect its sensory properties. To the best of our knowledge, no studies have been carried out to investigate the effect of substituting wheat flour with different levels of quinoa flour on the Taboun bread quality.

1.3 Research questions

The current study questions were:

1. What is the maximum wheat flour substitution level with quinoa flour that can be used without negatively affecting Taboun bread quality?
2. What are the effects of substituting wheat flour with quinoa flour on Taboun bread's sensory, color, and textural properties?
3. What are the best pretreatment that could be used to reduce saponine content without negatively affecting Taboun bread quality.

1.4 Study Purposes

This study aimed to achieve the following objectives:

1. To develop Taboun bread supplemented with quinoa flour.
2. To select the best pretreatment that could be used to reduce saponine content without negatively affecting Taboun bread quality.
3. To determine the optimal proportions of wheat flour to quinoa flour to produce Taboun bread with good quality.

1.5 Relevance and importance of the study

The results of this study will return the benefits on the following:

- Bakeries: The result will assist the bakeries in reaching the consumers' demand for more nutritional and healthy bread.
- Consumer: The availability of more nutritional bread will benefit the consumer in making healthful choices.

1.6 Research Hypotheses

- Adding quinoa flour will not negatively affect the texture of Taboun bread.
- The addition of quinoa seeds will negatively affect the Taboun bread's color and sensory attributes.

Chapter Two
Review of Literature

2.1 Characteristics of Taboun Bread:

Taboun is uncomplicated bread composed of flattened dough of flour, water, salt, yeast, and other optional ingredients. The manufacturing of flatbread requires special characteristics for flour and dough. Additional (optional) components can be used for processing aids that are important in particular in the bread-making process, for improving the quality of bread, and for making bread more nutritious. Milk, eggs, other cereals, legumes, dates or date syrup, and dried fruit can be added to the bread recipe (Al-Dmoor, 2011).

Taboun bread has a round shape and lower specific volumes than pan bread. If taboun bread is leavened with yeast, it is prepared with a shorter fermentation period in comparison to pan bread. Higher baking temperatures are used for baking of taboun compared to pan bread. The crust of Taboun bread is thick with brown or dark spots. The crust: crumb ratio in Taboun bread is higher than in pan bread (Pahwa et al., 2016).

2.2 Quinoa seeds

The botanical name of Quinoa is Chenopodium quinoa Willd and belongs to the Goosefoot family "Chenopodiaceae". Quinoa has been cultivated for thousands of years in the Andean region of Bolivia and Peru (E & DA, 2016). There are a six genotype of quinoa seeds that Ancovinto, Cancosa, Cáhuil, Faro, Regalona and Villarica (Miranda et al., 2011).

2.2.1 Saponine

Saponins are an important group found in Chenopodium quinoa. They represent a barrier to the use of quinoa as food and animal feed because of their bitter taste and toxic effects, which necessitates their elimination (el Hazzam et al., 2020). Saponins are being studied for their insecticidal, antibiotic, fungicidal, and pharmacological properties, but appear to be devoid of significant oral toxicity in humans. And must be removed from the quinoa seeds to reduce possible biological negative effects and bitterness (Pappier et al., 2008). There are some bioactive effects of saponine in quinoa like inti-inflammatory effects and inhibit bacterial growth (Xue et al., 2019).

2.2.2 Quinoa seeds nutritional profile

2.2.2.1 Protein

The protein biological value measures the percentage of protein absorbed from food, which then becomes merged with the proteins of the body. Quinoa has a high biological value (73%), similar to that of beef

(74%), and higher than those of white rice (56%), wheat (49%), and corn (36%). Quinoa also contains all ten essential amino acids, and its protein content ranges from 12.9 to 16.5% (Vega-Gálvez et al., 2010). Of primary interest is the high lysine value, an essential amino acid that is deficient in many grains. Quinoa is also high in the essential amino acid met, which is deficient in many legumes (Yang & Ludewig, 2014).

2.2.2.2 Carbohydrate

Starch, as a carbohydrate, supplies the major source of physiological energy in the human diet. The content of starch in quinoa ranges from 58.1% to 64.2% of dry matter, of which 11% is amylose. Furthermore, quinoa has a high content of D-xylose and maltose and low content of glucose and fructose (E & DA, 2016).

2.2.2.3 Lipids

The total lipid content of quinoa is 14.5%, with approximately 70%-89.4% being unsaturated (38.9%-57% of linoleic acid, 24.0%-27.7% of oleic acid, and 4% of α linolenic acid). The unsaturated fatty acid content is protected by vitamin E in this plant. The ratio between omega-6 and omega-3 in quinoa is about 6:1 (Tang et al., 2015).

2.2.2.4 Fiber

A greater intake of fiber-rich whole grains is related to a lower risk of type 2 diabetes (Maki & Phillips, 2014) and cardiovascular disease (Wu et al., 2015). Quinoa is an excellent source of dietary fiber, comprising about 2.6%-10% of the grain's total weight; about 78% of its fiber content is insoluble and 22% soluble (Fardet, 2010).

2.2.2.5 Vitamins

Vitamins are compounds essential for the health of humans. Quinoa has many vitamins, with 100 g of this grain containing: 0.4 mg of thiamine, 78.1 mg of folic acid, 1.4 mg of vitamin C, 0.20 mg of vitamin B6, and 0.61 mg of pantothenic acid (Vega-Gálvez et al., 2010). Its vitamin E content ranges from 37.49-59.82 μg/g. Tocopherol isoforms have also been detected in this seed: γ-tocopherol (47-53 μg/g), α-tocopherol (17-26 μg/g), and β- and δ-tocopherol (<5 μm/g) (Tang et al., 2015).

2.2.2.6 Minerals

The mineral content of quinoa (mg) per 100 g flour. Potassium was found to be the most abundant mineral with a value of 714.0 mg/100 g, while iron was the least abundant with the value 2.6 mg/100 g. Magnesium is the next highest mineral in quinoa (232.0 mg/100 g). Potassium and sodium, which are abundant minerals present. The value of calcium in quinoa (86.0 mg/100 g) is adequate for infant development of bones and teeth. This suggests that quinoa is good for human food formulations (Ogungbenle, 2003).

2.2.2.7 Polyphenols

Quinoa presents at least 23 phenolic compounds. The total phenolic content is 466.99 mg/kg, 634.66mg/kg and 682.05mg/kg for white, red and black quinoa, respectively. The most abundant phenols are ferulic acid and quercetin (Repo-Carrasco-Valencia et al., 2010). Quinoa contains more phenols than whole cereals, including wheat, barley, millet, rice, and buckwheat (Morrison & Laeger, 2015).

2.2.3 Clinical Evidence of Health Benefits of Quinoa-Derived Products

- The effects of dietary quinoa on parameters for risk of cardiovascular diseases were evaluated and found reduced blood pressure and body weight (Tang & Tsao, 2017).
- The hypolipidemic potential of quinoa products has been demonstrated in human trials. Daily consumption of a quinoa cereal significantly lowered triglyceride, total cholesterol, and LDL levels. At the same time, blood glucose levels, body weight, and blood pressure each decreased (Netzel & Sultanbawa, 2020).
- Quinoa has been evaluated for potential in lowering risk of type 2 diabetes by assessing the antihyperglycemia and antihypertension activities using in vitro enzyme assays and the anti-obesity effect (Tang & Tsao, 2017).
- The use of quinoa seeds as a safe, gluten-free alternative to cereal grains was assessed in a human clinical trial among celiac patients. Gastrointestinal parameters and serum lipid levels were evaluated before and after the intervention. The study showed that gastrointestinal parameters enhanced following the quinoa diet, while serum lipid levels remained within a normal range, with small decreases observed in total cholesterol, LDL, HDL, and triglycerides (Netzel & Sultanbawa, 2020).

2.2.4 Application of Quinoa in processing, formulation and packaging

The small size and thermostability of quinoa starch granules create them useful in frozen food packaging, emulsion type products (thickeners), and malted beverages (Netzel & Sultanbawa, 2020). Quinoa proteins with reasonable concentrations of essential amino acids and their variable applicability in food and pharmaceutical industries are capable to provide a complete diet to mitigate the global food crisis. These emerging proteins are considered as an alternative for animal sources possessing appropriate functional properties to be used in food applications. Quinoa protein with suitable foaming capacity can be used in gluten-free products such as gluten-free breads, crackers, biscuits and gluten-free beer or milk for patients with celiac disease. Due to the high water and oil absorption capacity playing an important role in the mouth feel, Quinoa protein isolate may be used in the formulation of sausage, soup and bakery products (Dakhili et al., 2019).

2.2.5 Uses

Quinoa can be eaten as a rice replacement, as a hot breakfast cereal, or can be boiled in water to make infant cereal food. The seeds can even be popped like popcorn. Seeds can be ground and used as flour, or sprouted. The sprouts need to get green before they can be added to salads. Quinoa flour can be mixed with maize or wheat flour. Several levels of quinoa flour substitution have been reported, for instance, in bread (10–13% quinoa flour), noodles and pasta (30–40% quinoa flour), and sweet biscuits (60% quinoa flour) (Valencia-Chamorro, 2003). Quinoa Protein Isolates (QPI) due to its functional and physicochemical properties, which can be used in food industry. Emulsifying, foaming properties and solubility are some functional properties (Dakhili et al., 2019).

There is no research studied adding quinoa seeds in taboun bread. Many other research studies focused on adding quinoa seeds in flatbread and observed the result that effect quinoa seeds in the rheology of dough include water absorption significantly increased with the increasing of quinoa flour, Dough development time increased with the increasing the quinoa flour percent, Stability value indicating stronger dough and Stability time was significantly increased with the increasing of quinoa flour up to 20%. Adding quinoa seeds also effect in the chemical composition of product flatbread which include the protein content in quinoa-based bread was increased gradually with increasing the percentage of quinoa flour, Lipids in quinoa bread being higher than wheat bread and minerals content of sodium, potassium, magnesium, calcium, iron, copper, manganese, and zinc were higher than 100% wheat flour. Phosphorus was the only element to decrease gradually when quinoa flour increased (El-Sohaimy et al., 2019).

Chapter Three
Design and Methodology

3.1 Material

The following ingredients were used: quinoa flour (Alsufara Bakery, Amman, Jordan), Baladi wheat flour (Aljwaideh mills, Amman, Jordan), and Zero wheat flour (Alghazal modern flour mills & Macaroni factories, Amman, Jordan).

3.2 Methods

In this study, two experiments were performed to answer the research questions:

1. What is the best pretreatment to reduce saponin content?
2. Effects of using composite flour containing wheat flour with different proportions of quinoa seeds flour on the quality of Taboun bread.

3.2.1 First experiment

Effects of quinoa seed physical modifications on the pasting profile of composite flour containing wheat flour with different proportions of quinoa flour.

3.2.1.1 Pretreatments of quinoa seeds and preparation of quinoa flour

The following pretreatments were used to reduce saponin content: washing, roasting and extruding. Quinoa seeds portions of 200g were used with two replicates for each treatment. For washing, Quinoa seeds were washed ten times using 10L of water for each 1Kg of quinoa seeds (VEGA-GÁLVEZ et al., 2010). After that, quinoa seeds were dried at 55C for 6 hours using lab dehydrator (Excalibur, USA). In roasting, the quinoa seeds were milled hammer mill (Alsufara Bakery, Amman, Jordan). Then, the flour was roasted in a vacuum oven at 200^0 C for 10min. (JE IO TECH (OV12), Korea). For extrusion, the quinoa seeds were extruded in (Alsufara Bakery, Amman, Jordan) (Manual design) at 150^0C and 14% moisture content using a locally designed extruder. After that, the extruded quinoa was milled using a hammer mill. All samples were numbered and coded appropriately.

3.2.1.2 Preparation of the composite flour containing wheat flour and quinoa flour with different proportions

Pretreated Quinoa seeds flour was mixed with wheat flour in the following proportions: 0, 5, 10, 15, 20, and 25%. Composite flour was prepared just before testing and evaluation. The composite flour was mixed manually and packed in plastic bags.

3.2.1.3 Evaluation of the composed flour: two methods were used to evaluate the different quinoa flour blends

1. Flour pasting profile

The general pasting method (AACC International Method 76-21.01) was used to determine the composite flour's pasting profile. The process in brief: 25ml of distilled water was filled into a canister. After that, 3.5 g of the composite flour at 14% moisture content was added to the canister. The blade was placed in the canister and vigorously moved ten times up and down to ensure no lumps remained. The canister was inserted into the Rapid Visco Analyser device (RVA) (Perten, Australia). The Rapid Visco Analyser (RVA) was programmed using Thermocline software (Perten, Australia). The profile used to program the Rapid Visco Analyser (RVA) is summarized in Table (3.1).

Table (3.1)

Rapid Visco Analyser heating profile according to the general pasting method

Time	Type	Value
00:00:00	Temp	50 ^{O}C
00:00:00	Speed	960 RPM
00:00:10	Speed	160 RPM
00:01:00	Temp	50 ^{O}C
00:04:42	Temp	95 ^{O}C
00:07:12	Temp	95 ^{O}C
00:11:00	Temp	50 ^{O}C
00:13:00	End	
	I dle Temperature:50±1^{o}c	
	Time Between Readings: 4s	

The software drew the pasting curve as the program started. At the end of the program, the software calculates the following parameters: peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature. A typical pasting curve is shown in Figure (3.1). The calculation method used for each parameter is summarized in Table (3.2).

Table (3.2)

Pasting profile parameters definition

Parameter	Definition
Peak viscosity	The maximum paste viscosity is reached during the heating stage of the profile.
Trough	The minimum paste viscosity was obtained during the holding stage at the highest temperature.
Breakdown	(Peak viscosity) – (trough viscosity)
Final viscosity	The viscosity at the end of the profile
Set back	(Final viscosity) – (trough viscosity)
Peak time	The time corresponded with the peak viscosity
Pasting temperature	The temperature at the onset of the rise in viscosity.

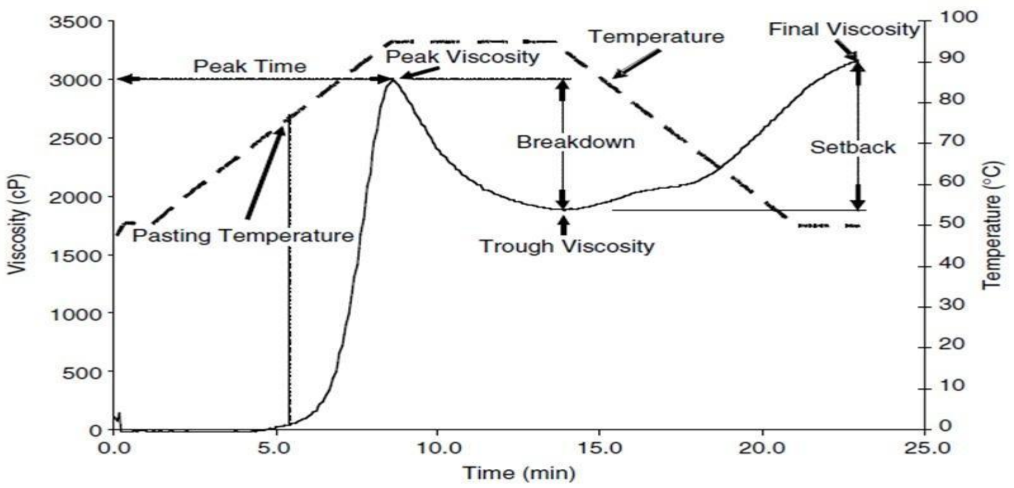

Figure (3.1)
Typical Rapid Visco Analyser pasting profile

2. Flour color

Composite flour color was evaluated using a non-contact spectrophotometer (VS-450, UK) according to the manufacturer's recommendations. The CIE Lab values and color difference values were calculated using Oncolor software (CyberSoft, UK).

3. Statistical analysis

Completely Randomized Design-factorial design (CRD) (4x6) with two replicates was used to analyze the data using Minitab system (version 19.20.20). The statistically significant effect of the parameters was determined by a two-way analysis of variance with Tukey's test ($P < 0.05$).

3.2.2 Second experiment

Effects of using composite flour containing wheat and quinoa flour in different ratios on Taboun bread quality during three days of storage

A completely randomized design was used to evaluate the quality of Taboun bread formulated from three types of composite flour containing wheat flour with different quinoa seed flour: 0, 10, and 20%.

Based on the first experiment's results, the previous substitution ratio was selected.

3.2.2.1 Taboun bread preparation

Six composite flour recipes were used to prepare Taboun bread. In addition to composite flour, recipes contain salt, sugar, yeast, sodium bicarbonate, and water (Table 3.3). An expert worker determined the required amount of water as the amount of water required to give the dough's optimal viscosity. The straight-dough method was used to prepare the dough. Ingredients were weighed and mixed; water was gradually added to give the dough the required viscosity. The dough was mixed. Then divided and rounded the dough into balls weight 185g and put it in wood boarding then, the dough was left to ferment for 50 minutes at room temperature. After that, the dough was manually formed to the desired diameter and baked. After baking, the loaves were left to cool down for 15 min. Finally, the loaves are packed in plastic bags and left for evaluation for three days of storage.

Table (3.3)
Taboun bread formulas using different composite flour containing wheat flour with different proportions of quinoa seed flour

Wheat flour%	Quinoa flour%	Baldi flour(g)	Zero flour(g)	Quinoa (g)	Salt (g)	Sugar (g)	Sodium bicarbonate (g)	Yeast (g)	Water (ml)
100%	0%	1000	500	0	15	30	10	100	1360
90%	10%	900	450	150	15	30	10	100	1305
80%	20%	800	400	300	15	30	10	100	1305

3.2.2.2 Taboun bread evaluation
3.2.2.2.1 Physical measurements
1. Baking loss

The baking loss is calculated by this equation:

$$\text{baking loss} = \frac{\text{dough weight before proving} - \text{loaf weight after cooling}}{\text{dough weight before proving}} \quad *100\%$$

2. Color measurement:

The bread upper surface and bottom surface color were measured at three different locations in the bread loaf, and then averaging the values. The color was measured using a non-contact spectrophotometer (X-rite VS-450, UK) equipped with Oncolor software (CyberSoft, UK). The CIE Lab color values and color difference were calculated where: L* represents the reflection of light; a* values represent the red/green colors (+ values for red color and – values for green color); b* values represent the yellow/blue colors (+ values for yellow color and – values for blue color).

3.2.2.2.2 Instrumental texture evaluation
1. Texture profile analysis (TPA)

TPA was measured using a texture analyzer (TVT6700, Perten, Sweden) using TVT methods (01-03.2). The texture analyzer was equipped with a 5 kg load cell and stainless steel cylinder probe (45mm height and 25mm diameter). Test profile was: staring distance from sample=5mm, sample compression=20%, pause between cycles=15 s, initial probe speed=1mm/s, probe test speed=1mm/s, probe retract speed=1mm/s, and trigger force=5g. The program drew the distance/time and force curve from which the following parameters were calculated: firmness, cohesiveness, chewiness, resilience, and springiness. In Figure (3.2), a typical Texture Profile Analysis (TPA) curve is illustrated. The maximum peak force was calculated as firmness. The resilience was Areaa2/Area a1. Cohesiveness was the total area of the second peak divided by the area of the first peak. The chewiness was calculated by multiplying firmness, cohesiveness, and springiness.

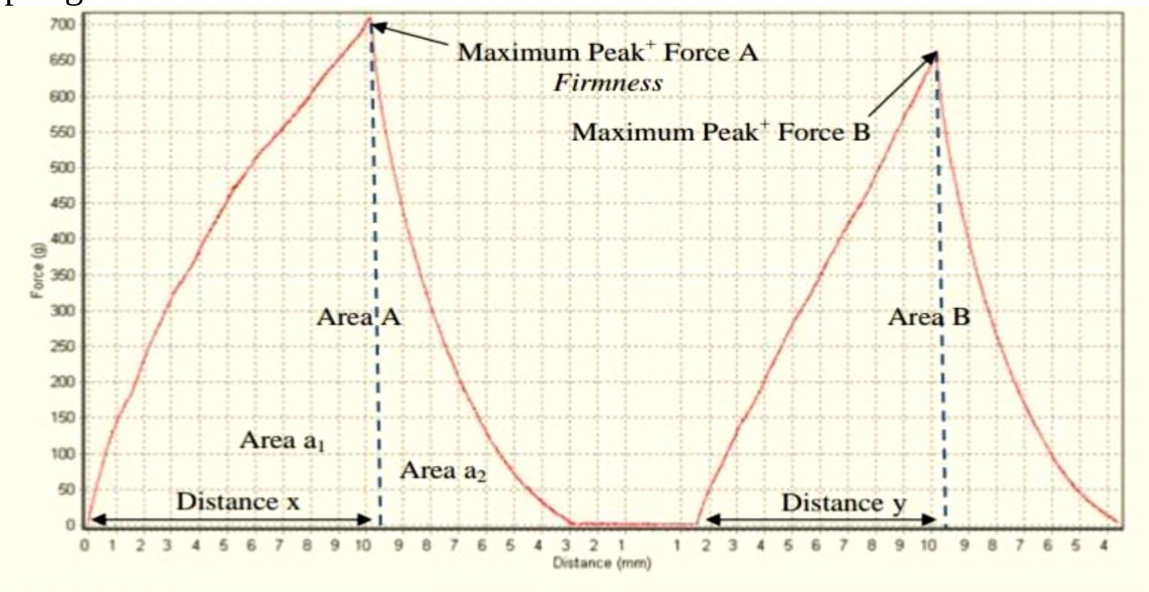

Figure (3.2)

A typical Texture profile analysis curve

2. Bread stretchability

Bread stretchability was tested using a texture analyzer (TVT6700, Perten, Sweden). 5kg load cell was used, and stainless steel cylinder probe (3 mm diameter). The bread loaf was placed under the probe. The program records the measurement once the probe reaches the pre-set trigger force. The probe will then puncture the sample to a pre-defined distance. After the puncture, the probe returns to its starting position (AIB method, 2017). The test profile used was: starting distance from the sample: 5mm, sample compression: 15 mm, initial probe speed: 2 mm/s, probe test speed: 1.7mm/s, probe retract speed: 10mm/s, and trigger force: 10 g. Three measurements were taken from each loaf and averaged for statistical analysis.

3.2.2.2.3 Sensory analysis

1. Untrained Sensory analysis

The bread samples were cut from each loaf looks like a circular sector. Samples were placed on plates and displayed to my family member and my friends. We instructed the panelists to evaluate the bread using a nine-point hedonic scale, where 1 denotes dislike very much, and nine denotes like very much. Twenty panelists evaluated the bread.

3.2.2.3 Statistical analysis

Completely Randomized Design- factorial design (CRD) with two replicates was used to analyze the data using the Minitab system (version 19.20.20). Tukey's test determined the statistically significant differences effect of the parameters ($P< 0.05$).

Chapter Four
Results and Discussion

4.1 First experiment: Effect substitution level of wheat flour and type of pretreatment on the composite flour

A 4×6 factorial experiment was applied to examine the main effects of the two factors and their interaction. The first factor was the pretreatment of Quinoa seeds which contained four levels: Quinoa seeds without pretreatment, washed Quinoa seeds, roasted Quinoa seeds, and extruded Quinoa seeds. The second factor was the levels of substitution of wheat flour with Quinoa seeds flour which contained six levels: 0, 5, 10, 15, 20, and 25%. When the interaction effect was significant, only the results of the interaction effects were presented. When the interaction effect was not significant, significant main effects were presented.

4.1.1 Pasting profile

Pasting temperature

The pasting temperatures of the composite flour were not significantly ($P>0.05$) affected by the pretreatment type of Quinoa seeds, levels of substitution of wheat flour, and interaction between them. The pasting temperatures for different composite flour ranged between 73.8℃ and 87.68℃ (Table 4.2).

Peak time

The values of peak time were significantly affected ($P\leq0.05$) by the type of pretreatment and the levels of substitution of wheat flour, with no interaction between them. Only the roasting treatment was significantly ($P\leq0.05$) lower than the control treatment (Figure 4.1). Regarding the effect of flour substitution level, above 5% substitution level the peak time values decreased significantly (Table 4.1).

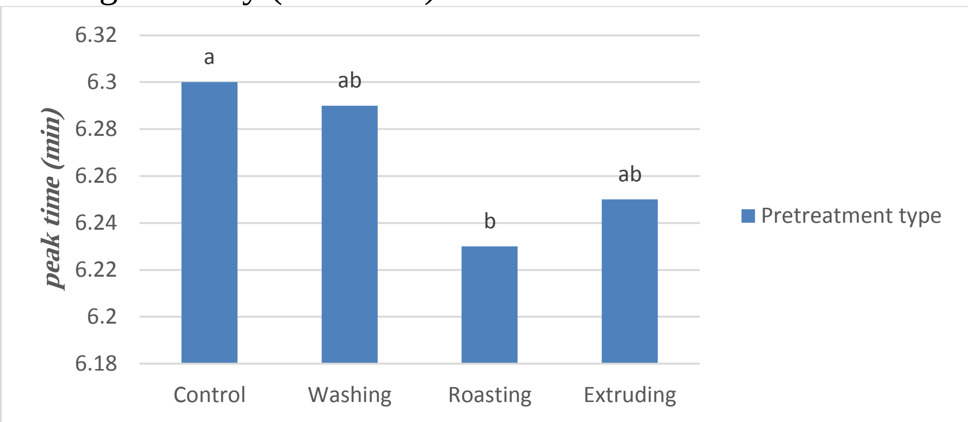

Figure (4.1) Effect of the type of pretreatment on the peak time values. (The arithmetic means within the same letter are not significantly different at a 0.05 probability level).

Breakdown

The values of breakdown were significantly affected ($P \le 0.05$) only by the pretreatment type and the substitution levels. No significant differences existed between the pretreatments used and the control (Figure 4.2). Only the 25% substitution level was not significantly different from the control, whereas other treatments were significantly higher than the control (Table 4.1).

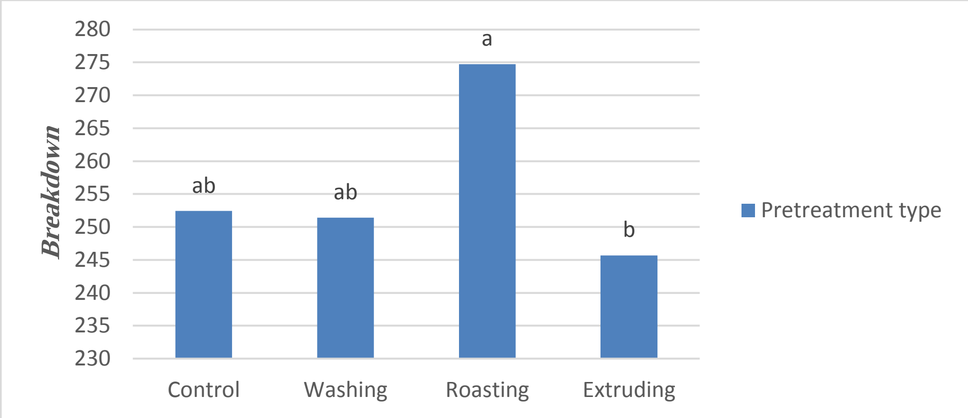

Figure (4.2) Effect of the type of pretreatment on the breakdown values. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

able (4.1)

Effect of the substitution levels of wheat flour with quinoa seeds flour on pasting profile parameter**

	Pasting Profile Parameters						
Substitution* Levels	**Pasting. Temp**	**Peak Viscosity**	**Time to peak (min)**	**Breakdown**	**Trough**	**setback**	**Final Viscosity**
0%	86.68±0.29a	1568±9.27^{a}	6.54±0.025^{a}	229.13±3.76^{b}	1338.25±5.78^{a}	427.25±9.63^{d}	1766.13±15.17^{a}
5%	84.01±8.79a	1535.38±49.17^{a}	6.46±0.042^{a}	268±19.26^{a}	1267.38±51.84^{a}	479.62±23.75^{c}	1747±61.57^{ab}
10%	86.93±0.59a	1449.13±69.59^{b}	6.33±0.11^{b}	266.88±32.44^{a}	1182.25±73.63^{b}	512.13±52.05^{bc}	1694.38±95.35^{b}
15%	86.69±0.6a	1348±142.86^{c}	6.21±0.11^{c}	268.5±26.46^{a}	1079.5±136.39^{c}	537.5±58.86^{ab}	1617±173.46^{c}
20%	86.79±0.48a	1243.5±166.81^{d}	6.07±0.1^{d}	262.75±19.46^{a}	1014.75±137.85^{c}	559.88±61.24^{ab}	1541.38±218.39^{d}
25%	83.71±9.29a	1149.13±202.76^{e}	6±0.072^{d}	241.13±29.71^{ab}	908±189.67^{d}	562±89.66^{a}	1470±276.45^{e}

*Data were expressed by Means±Standard Deviation (SD), ** The arithmetic means within the same column followed by the same letter are not significantly different at a 0.05 probability level.

Peak viscosity

The peak viscosity values of composite flour were significantly affected ($P \le 0.05$) by the pretreatment type, the substitution levels, and the interaction between them. Composite flour with extruded Quinoa seeds and with increased substitution levels had the highest effect in decreasing the values of peak viscosity compared to other types of pretreatments. The composite flour with extruded quinoa seeds with levels above 5% did significantly affect the peak viscosity compared to the wheat flour. The composite flour with washed quinoa seeds with levels up to 20% did not significantly affect the peak viscosity compared to the control. (Table (4.2) and Figure (4.3)).

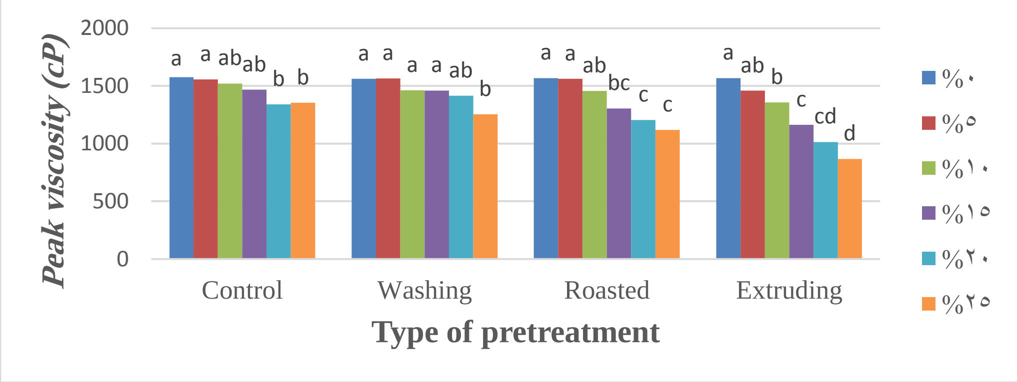

Figure (4.3) Effect of the interaction between type of pretreatment and wheat flour substitution levels with quinoa seeds flour on the peak viscosity values. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

Trough

There were main effects of pretreatment type and levels of substitution with a significant (P≤0.05) interaction between them on the trough values. Composite flour with washed Quinoa seeds had the lowest effect in decreasing the trough values compared to other types of pretreatments, and composite flour with extruded quinoa seeds and with a 25% substitution level had the highest significant impact on the trough values compared to the control (Table (4.2) and Figure (4.4)).

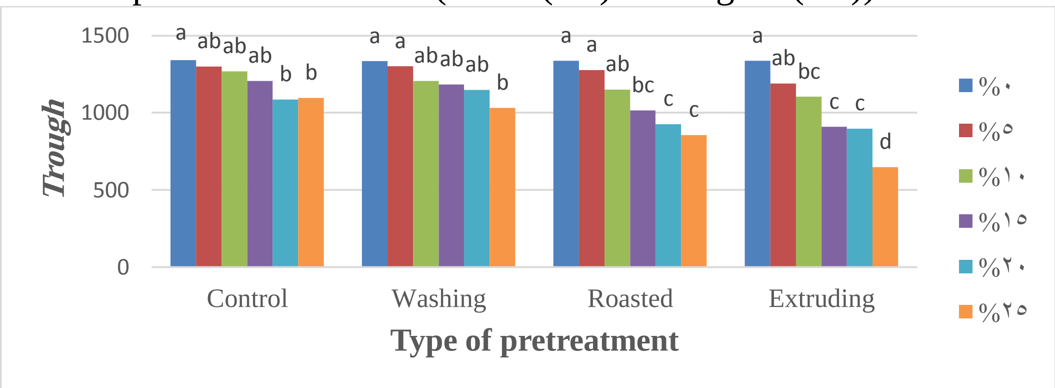

Figure (4.4) Effect of the interaction between type of pretreatment and wheat flour substitution levels with quinoa flour on the trough values. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

Setback

The type of pretreatment, the levels of substitution, and the interaction between them significantly (P≤0.05) affected the values of the setback. As shown in Table (4.2) and Figure (4.5), the roasting and extruding pretreatments were not significantly affected the setback values, as washing pretreatment and quinoa seeds without pretreatment had the highest effect in increasing the setback values. The composite flour with quinoa seeds without pretreatment with the substitution level up to 15% did not significantly affect the setback values compared to control.

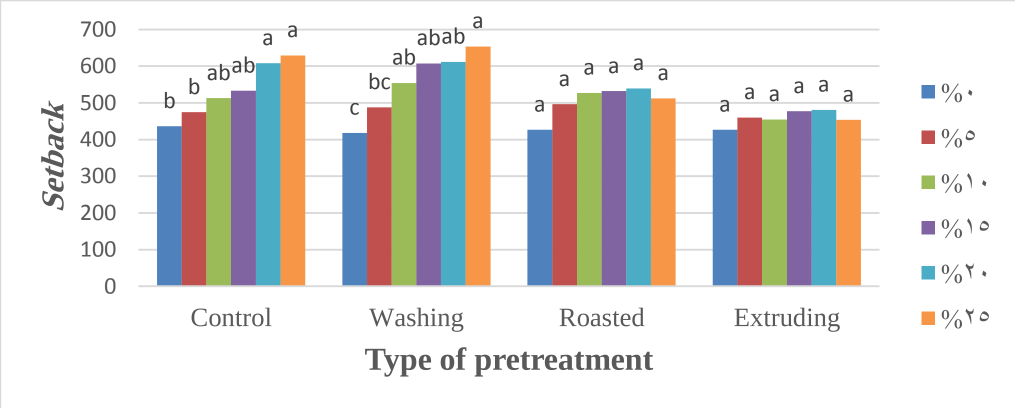

Figure (4.5) Effect of the interaction between type of pretreatment and wheat flour substitution levels with quinoa seeds flour on the setback values. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

Final viscosity

The final viscosity values were significantly affected by the pretreatment type, the substitution levels, and the interaction between them. The composite flour with extruded Quinoa seeds with a 20 and 25% substitution level of wheat flour had the highest effect in decreasing the final viscosity values compared to other pretreatments. Only the washing pretreatments and the control (Quinoa without pretreatments) were not significantly affected the final viscosity values (Table (4.2) and Figure (4.6)).

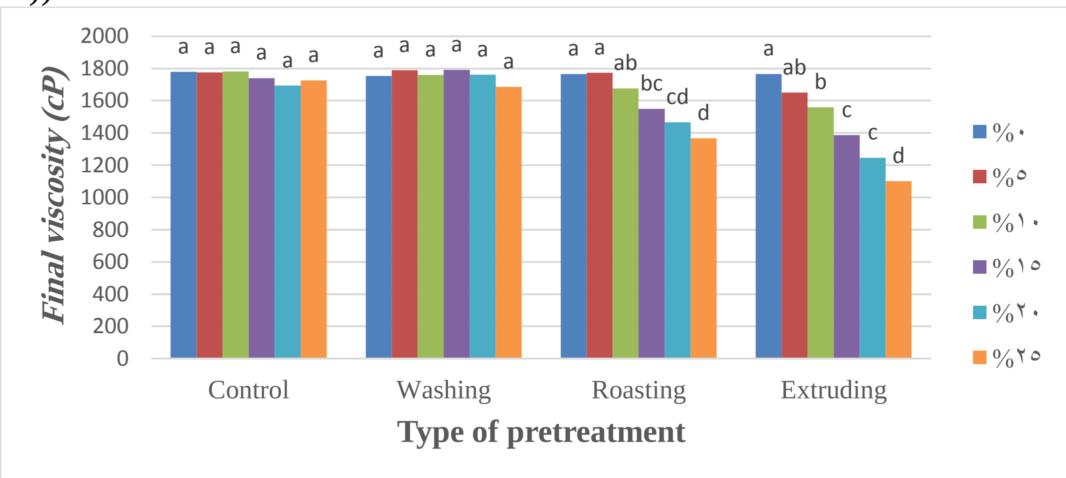

Figure (4.6) Effect of the interaction between type of pretreatment and wheat flour substitution levels with quinoa seeds flour on the final viscosity values. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

Table (4.2)

Effect of the interaction between pretreatment type and substitution level with quinoa flour on pasting profile parameters*

Interaction effect Pre.	Sub.	Pasting. Temp	Peak Viscosity	Time to peak	Breakdown	Trough	Setback	Final Viscosity
Control	0%	86.48±0.53	1575.5±16.26^{a}	6.52±0.014	233±4.24	1342.5±12.02^{a}	436.5±13.44^{de}	1779±25.46^{a}
Control	5%	87.38±0.67	1557±8.49^{a}	6.5±0.04	256±2.83	1301±11.31^{ab}	474.5±0.71^{de}	1775.5±10.61^{a}
Control	10%	87.05±0.14	1521±50.91^{ab}	6.37±0.049	252±16.97	1269±33.94^{ab}	513±8.49^{bcde}	1782±42.43^{a}
Control	15%	86.48±0.6	1466.5±62.93^{abc}	6.3±0.14	259±14.14	1207.5±77.07^{abc}	533±72.12^{abcde}	1740.5±4.95^{a}
Control	20%	86.53±0.53	1339.5±30.41^{bcdef}	6.07±0.00	256.5±12.02	1086±22.63^{bcde}	608±1.41^{abc}	1694±21.21^{ab}
Control	25%	86.9±0.07	1355±21.21^{bcdef}	6.07±0.00	258±2.83	1097±24.04^{bcde}	629±2.83^{ab}	1726±21.21^{a}
Washing	0%	86.89±0.29	1560.5±10.61^{a}	6.57±0.04	225.5±4.95	1334.5±4.95^{a}	418.5±12.02^{e}	1753.5±17.68^{a}
Washing	5%	86.9±0.07	1564.5±2.12^{a}	6.44±0.05	262.5±0.71	1302±1.41^{ab}	487.5±7.78^{cde}	1789.5±9.19^{a}
Washing	10%	86.53±0.6	1461.5±58.69^{abc}	6.27±0.19	255.5±2.12	1206±56.57^{abc}	554±56.57^{abcd}	1760±0.00^{a}
Washing	15%	86.45±0.49	1459.5±102.53^{abc}	6.27±0.09	275±46.67	1184.5±55.86^{abc}	607.5±24.75^{abc}	1792±31.11^{a}
Washing	20%	86.48±0.46	1415±60.81^{abcd}	6.2±0.1	266.5±9.19	1148.5±70^{abcd}	612±43.84^{abc}	1760.5±26.16^{a}
Washing	25%	86.48±0.67	1255.5±45.96^{defg}	6.04±0.05	223.5±34.65	1032±11.31^{cdef}	653.5±17.68^{a}	1685.5±28.99^{abc}
Roasting	0%	86.68±0.00	1568±0.00^{a}	6.54±0.00	229±0.00	1338±0.00^{a}	427±0.00^{e}	1766±0.00^{a}
Roasting	5%	86.8±1.13	1561±26.87^{a}	6.44±0.05	284.5±36.06	1276.5±9.19^{ab}	496.5±37.48^{cde}	1773±28.28^{a}
Roasting	10%	86.48±0.46	1456±21.21^{abc}	6.27±0.00	306±28.28	1150±7.07^{abc}	527±19.8^{bcde}	1677±12.72^{abc}
Roasting	15%	86.5±0.57	1304±14.14^{cdefg}	6.12±0.07	287.5±21.92	1016.5±7.78^{cdef}	532±26.87^{abcde}	1548.5±19.09^{cd}
Roasting	20%	86.88±0.11	1205.5±61.52^{efgh}	6±0.1	278.5±30.41	927±31.11^{def}	539±15.56^{abcde}	1466±46.67^{de}
Roasting	25%	87.68±0.18	1118.5±126.57^{gh}	6±0.00	263±42.43	855.5±84.14^{fg}	512±41.01^{bcde}	1367.5±125.16^{ef}
Extruding	0%	86.68±0.00	1568±0.00^{a}	6.54±0.00	229±0.00	1338±0.00^{a}	427±0.00^{e}	1766±0.00^{a}
Extruding	5%	74.98±17.93	1459±22.63^{abc}	6.47±0.00	269±19.8	1190±42.42^{abc}	460±31.11^{de}	1650±11.31^{abc}
Extruding	10%	87.65±0.21	1358±8.49^{bcde}	6.44±0.049	254±46.67	1104±55.15^{bcde}	454.5±68.59^{de}	1558.5±13.44^{bcd}
Extruding	15%	87.35±0.64	1162±46.67^{fgh}	6.17±0.049	252.5±23.33	909.5±23.33^{ef}	477.5±24.75^{de}	1387±48.08^{ef}
Extruding	20%	87.28±0.53	1014±29.7^{hi}	6±0.00	249.5±23.33	897.5±194.45^{ef}	480.5±23.33^{de}	1245±29.7^{f}
Extruding	25%	73.8±18.46	867.5±36.06^{i}	5.9±0.04	220±11.31	647.5±24.75^{g}	453.5±2.12^{de}	1101±26.87^{g}

***Data were expressed by Means±Standard Deviation (SD); The values within the same column followed by the same letter are not significantly different at a 0.05 probability level.**

4.1.2 CIE Lab color values

***L**values**

The *L** values of composite flour were significantly affected by the pretreatment type and the substitution level of wheat flour, with a significant interaction between them. Figure (4.7) and Table (4.3) show that the control (quinoa seeds without pretreatment) and washing pretreatments did not significantly affect the *L** values with all levels of substitution. In contrast, with roasting and extrusion pretreatments, the *L** values decreased with increased substitution levels above 5%.

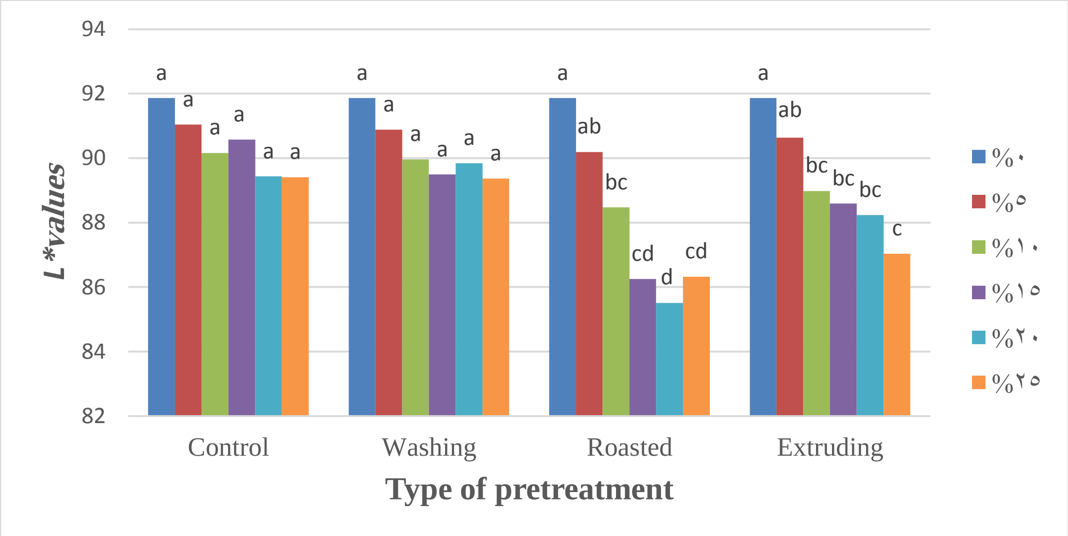

Figure (4.7) Effect of the different quinoa seeds pretreatment and wheat flour substitution levels with quinoa flour on composite flour *L*values*. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

***a**values**

*a** values were significantly affected by the pretreatment type and the substitution levels, with a significant interaction between them. As seen in Figure (4.8) and Table (4.3), the roasting treatment had the highest effect in increasing the *a** values with increasing substitution levels, followed by extrusion pretreatment. In contrast, the washing pretreatment and the control treatment (quinoa seeds without pretreatment) did not significantly affect the *a** values with all substitution levels.

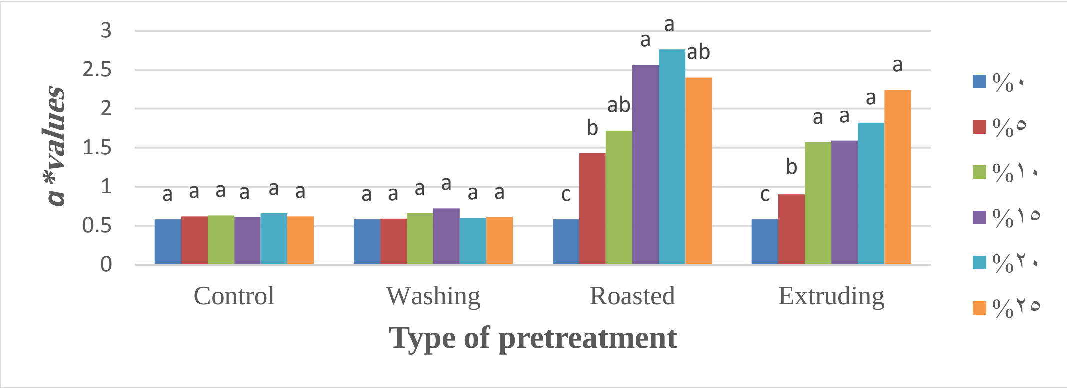

Figure (4.8) Effect of different quinoa seeds pretreatment and wheat flour substitution levels with quinoa flour on composite flour *a*values*. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

bvalues**

There were main effects by the pretreatment type and the substitution level of wheat flour, with a significant interaction between them on the *b** values. Figure (4.9) and Table (4.3) show that roasting and extrusion pretreatments significantly affect the *b** values, where the *b** values increased with increasing the substitution level. In contrast, the control treatment (quinoa seeds without pretreatment) and washing pretreatment did not significantly affect the *b** values with all levels of substitution used.

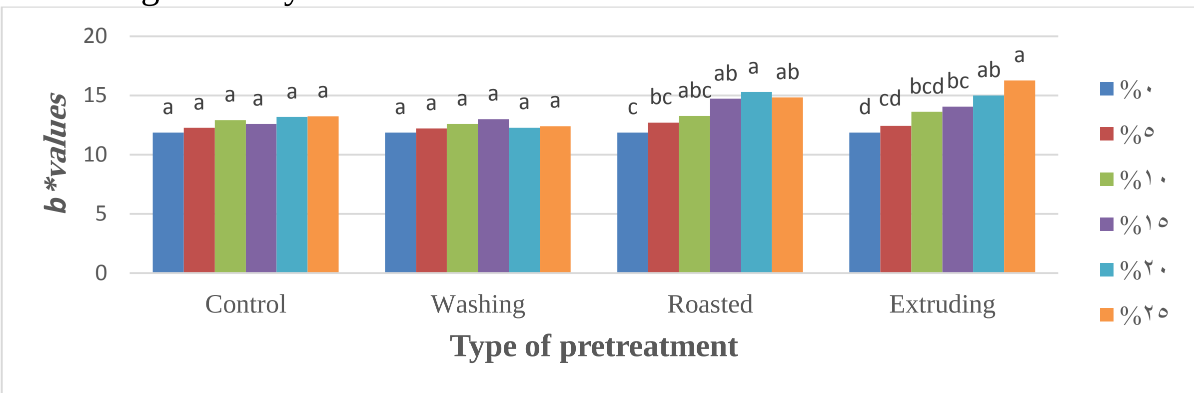

Figure (4.9) Effect of different quinoa seeds pretreatment and wheat flour substitution levels on composite flour *b*values*. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level).

ΔEab* **values**

There were main effects by the pretreatment type and the substitution level of wheat flour, with a significant interaction between them on the *ΔEab** values. Figure (4.10) and Table (4.3) show a significant interaction between the main effects of pretreatment type and wheat flour substitution level on the *ΔEab** values, which *ΔEab** values of composite flour with extruded and roasted Quinoa seeds significantly increased by increasing the substitution levels compared to other pretreatments. The *ΔEab** values of composite flour with washed quinoa seeds and quinoa seeds without pretreatment did not significantly affect for all levels of substitution used.

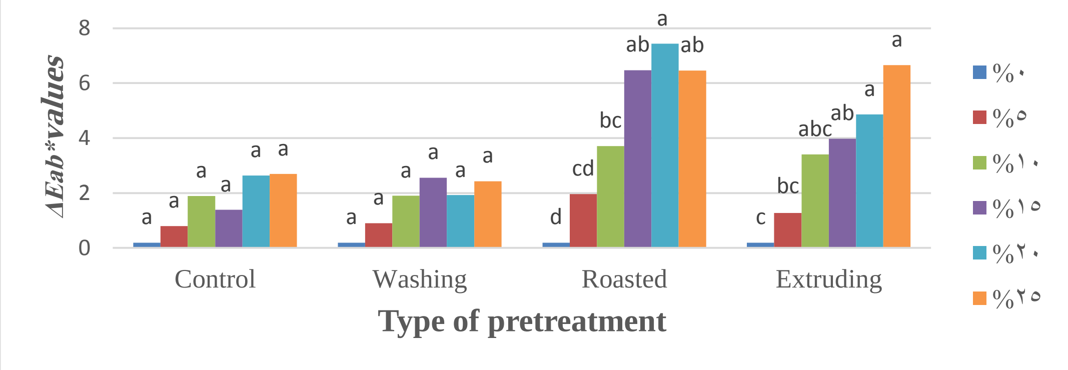

Figure (4.10) Effect of different quinoa seeds pretreatment and wheat flour substitution levels on composite flour *ΔEab*values*. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level)

Table (4.3)

Effect of interaction between the type of pretreatment and levels of substitution on CIE lab color*

*Data were expressed by Means±Standard Deviation (SD); The values within the same

Interaction effect Pre.	Sub.	*L* value*	*a*value*	*b*value*	*ΔEab* value*
Control	0%	91.86 ± 0.48^{a}	0.58 ± 0.03^{d}	11.86 ± 0.37^{f}	0.19 ± 0.58^{e}
Control	5%	91.04 ± 0.48^{ab}	0.62 ± 0.03^{d}	12.26 ± 0.37^{ef}	0.8 ± 0.58^{de}
Control	10%	90.16 ± 0.48^{abc}	0.63 ± 0.03^{d}	12.91 ± 0.37^{cdef}	1.89 ± 0.58^{cde}
Control	15%	90.57 ± 0.48^{abc}	0.61 ± 0.03^{d}	12.59 ± 0.37^{ef}	1.39 ± 0.58^{de}
Control	20%	89.43 ± 0.48^{abcd}	0.66 ± 0.03^{cd}	13.18 ± 0.37^{cef}	2.64 ± 0.58^{cde}
Control	25%	89.4 ± 0.48^{abcd}	0.62 ± 0.03^{d}	13.24 ± 0.37^{bcdef}	2.69 ± 0.58^{cde}
Washing	0%	91.86 ± 0.48^{a}	0.58 ± 0.03^{d}	11.86 ± 0.37^{f}	0.19 ± 0.58^{e}
Washing	5%	90.88 ± 0.48^{abc}	0.59 ± 0.03^{d}	12.2 ± 0.37^{ef}	0.9 ± 0.58^{de}
Washing	10%	89.96 ± 0.48^{abc}	0.66 ± 0.03^{cd}	12.58 ± 0.37^{ef}	1.9 ± 0.58^{cde}
Washing	15%	89.49 ± 0.48^{abcd}	0.72 ± 0.03^{cd}	12.99 ± 0.37^{cdef}	2.56 ± 0.58^{cde}
Washing	20%	89.84 ± 0.48^{abc}	0.6 ± 0.03^{d}	12.27 ± 0.37^{ef}	1.92 ± 0.58^{cde}
Washing	25%	89.36 ± 0.48^{abcd}	0.61 ± 0.03^{d}	12.4 ± 0.37^{ef}	2.43 ± 0.58^{cde}
Roasting	0%	91.86 ± 0.48^{a}	0.58 ± 0.03^{d}	11.86 ± 0.37^{f}	0.19 ± 0.58^{e}
Roasting	5%	90.19 ± 0.48^{abc}	1.43 ± 0.03^{b}	12.69 ± 0.37^{cef}	1.96 ± 0.58^{cde}
Roasting	10%	88.47 ± 0.48^{bcde}	1.72 ± 0.03^{ab}	13.25 ± 0.37^{bcef}	3.71 ± 0.58^{bcd}
Roasting	15%	86.25 ± 0.48^{ef}	2.56 ± 0.03^{a}	14.71 ± 0.37^{abc}	6.47 ± 0.58^{ab}
Roasting	20%	85.51 ± 0.48^{f}	2.76 ± 0.03^{a}	15.3 ± 0.37^{ab}	7.44 ± 0.58^{a}
Roasting	25%	86.32 ± 0.48^{f}	2.4 ± 0.03^{ab}	14.83 ± 0.37^{abc}	6.46 ± 0.58^{ab}
Extruding	0%	91.86 ± 0.48^{a}	0.58 ± 0.03^{d}	11.86 ± 0.37^{f}	0.19 ± 0.58^{e}
Extruding	5%	90.63 ± 0.48^{abc}	0.9 ± 0.03^{c}	12.43 ± 0.37^{ef}	1.27 ± 0.58^{de}
Extruding	10%	88.98 ± 0.48^{bcde}	1.57 ± 0.03^{ab}	13.6 ± 0.37^{bcef}	3.41 ± 0.58^{bcde}
Extruding	15%	88.59 ± 0.48^{bcde}	1.59 ± 0.03^{ab}	14.04 ± 0.37^{bce}	3.98 ± 0.58^{bcd}
Extruding	20%	88.23 ± 0.48^{cdef}	1.82 ± 0.03^{ab}	14.98 ± 0.37^{abc}	4.86 ± 0.58^{abc}
Extruding	25%	87.03 ± 0.48^{def}	2.24 ± 0.03^{ab}	16.26 ± 0.37^{a}	6.66 ± 0.58^{ab}

column followed by the same letter are not significantly different at a 0.05 probability level.

4.2 Second Experiment: Effect of composite flour that contains wheat flour with different proportions of Quinoa seeds on the bread quality

A Completely Randomized Design (CRD)-factorial design was used to examine the effect of composite flour containing wheat flour with different proportions of 0, 10, and 20% of washed Quinoa seeds on the bread quality during storage at room temperature for three days.

4.2.1 CIE Lab color values for the top layer of bread

*L** values, *a** values, *b** values, and *ΔEab** values for the top layer of bread were not significantly affected by the two factors of the storage time and levels of substitution with no significant interaction between them. Values of CIE Lab color for the top layer of bread were presented in Appendix II.

4.2.2 CIE Lab color values for the bottom layer of bread

*L** values, *a** values, and *b** values for the bottom layer of bread were not significantly affected by the storage time and levels of substitution, and interaction between them. Values of CIE Lab color for the bottom layer of bread were presented in Appendix II.

ΔEab* **values**

*ΔEab** values of the bottom layer of bread were significantly affected only by the storage time with no significant interaction effect. Figure (4.11) shows *ΔEab**value of the bottom of the bread significantly differed on the third day compared to the first and second day.

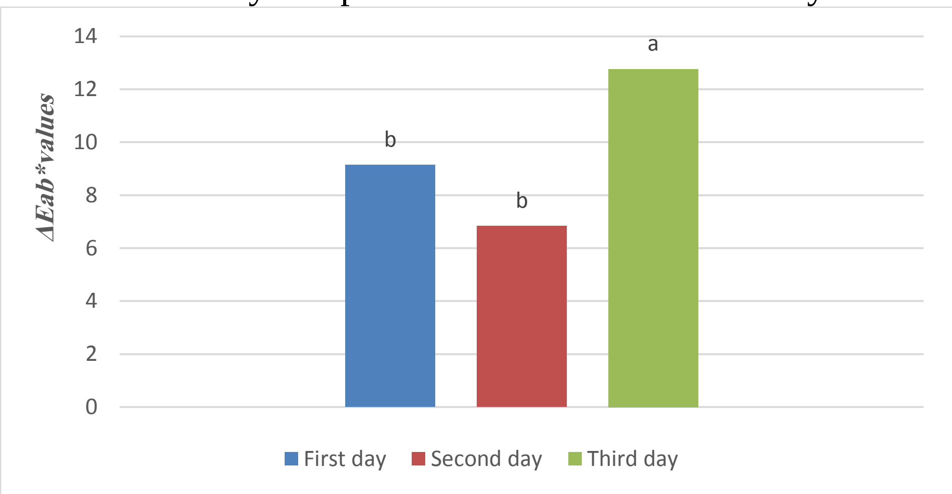

Figure (4.11) Effect of the difference of days on the *ΔEab*values* of the bottom layer of bread. (The arithmetic means within the same group followed by the same letter are not significantly different at a 0.05 probability level

4.2.3 Texture analysis

4.2.3.1 Double cycle compression (Texture Profile Analysis TPA)

Chewiness

The values of chewiness were significantly affected by the storage time, the different levels of substitution, and the interaction between them. As shown in Figure (4.12) and Table (4.4), the values of chewiness increased significantly by increasing the substitution levels with varying days, and the composite flour with a 20% substitution level had the highest value of chewiness on the third day (8234.2 g).

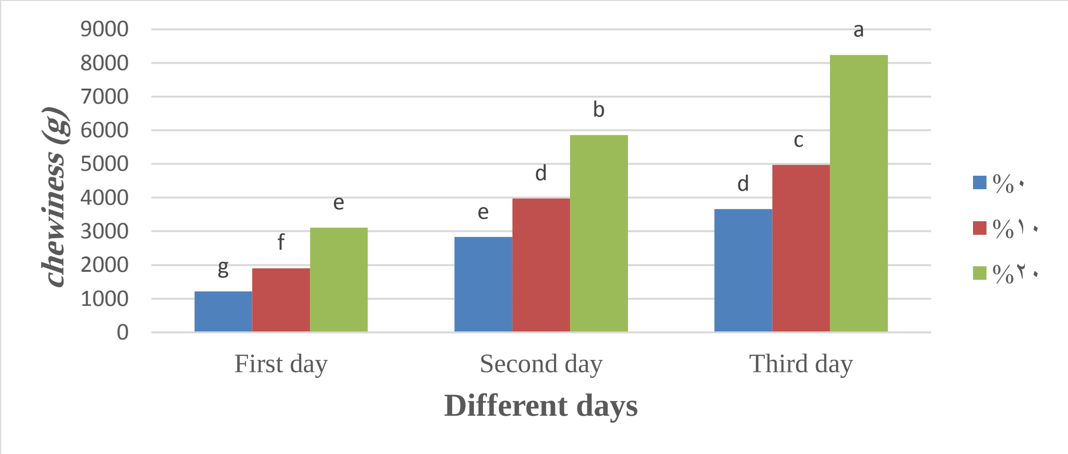

Figure (4.12) Effect of the interaction between different days and levels of substitution on values of chewiness. (The bar within the same letter is not significantly different at a 0.05 probability level).

Hardness

The storage time, the different levels of substitution, and the interaction between them had a significant impact on the values of hardness. The values of hardness significantly increased by increasing the substitution levels with varying days, and the composite flour with a 20% substitution level had the highest value of hardness on the third day (Figure (4.13) and Table (4.4)).

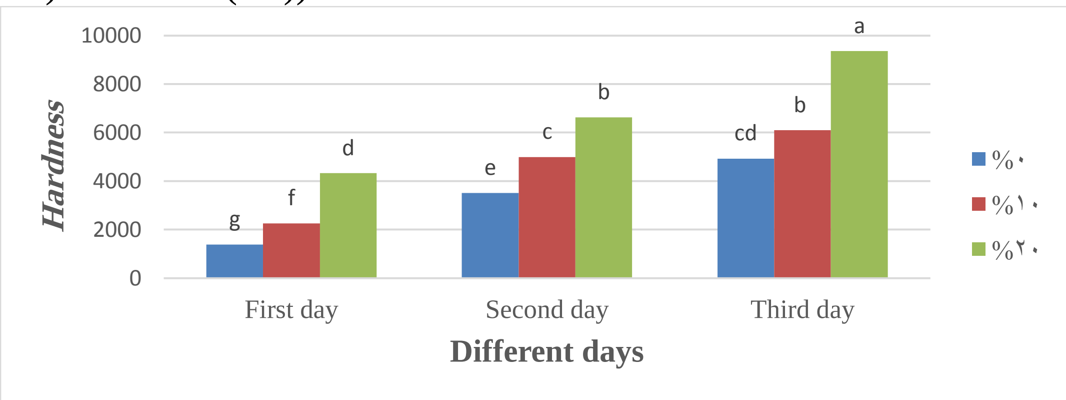

Figure (4.13) Effect of the interaction between different days and levels of substitution on values of hardness. (The bar within the same letter is not significantly different at a 0.05 probability level).

Springiness

The values of Springiness were not significantly affected by the storage time, the different levels of substitution, and the interaction between them.

Resilience

The values of resilience were significantly affected by the storage time, the different levels of substitution, and the interaction between them. The values of resilience were not significantly different on the second day compared to the first day, and the composite flour with a 20% of substitution level had the highest value of resilience on the third day (Figure (4.14) and Table (4.4)).

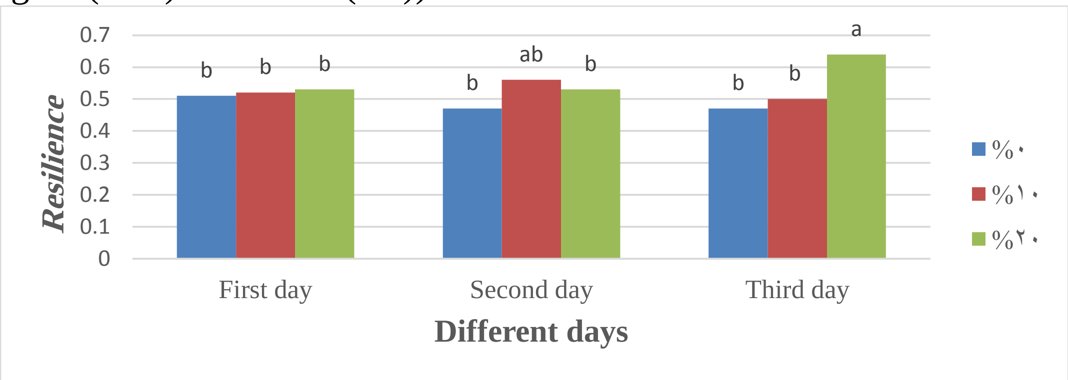

Figure (4.14) Effect of the interaction between different days and substitution levels on resilience values. (The bar within the same letter is not significantly different at a 0.05 probability level).

Cohesiveness

The storage time, the different levels of substitution, and the interaction between them significantly affected the values of cohesiveness. The values of cohesiveness did not significantly affect by increasing the substitution levels on the first day, while the values of cohesiveness were most affected by an increase in the substitution level on the second and third day (Figure (4.15) and Table (4.4)).

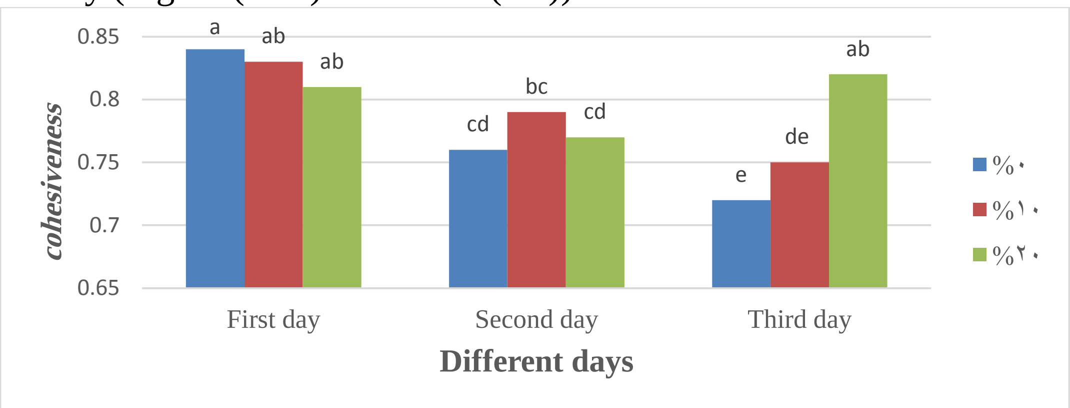

Figure (4.15) Effect of the interaction between different days and levels of substitution on values of cohesiveness. (The bar within the same letter is not significantly different at a 0.05 probability level).

Bread Stretchability

The storage time, the different levels of substitution, and the interaction between them significantly impacted the values of stretchability. The values of stretchability with increasing concentrations of quinoa seeds flour were significantly affected on the second and third days compared to the first day (Figure (4.16) and Table (4.4)).

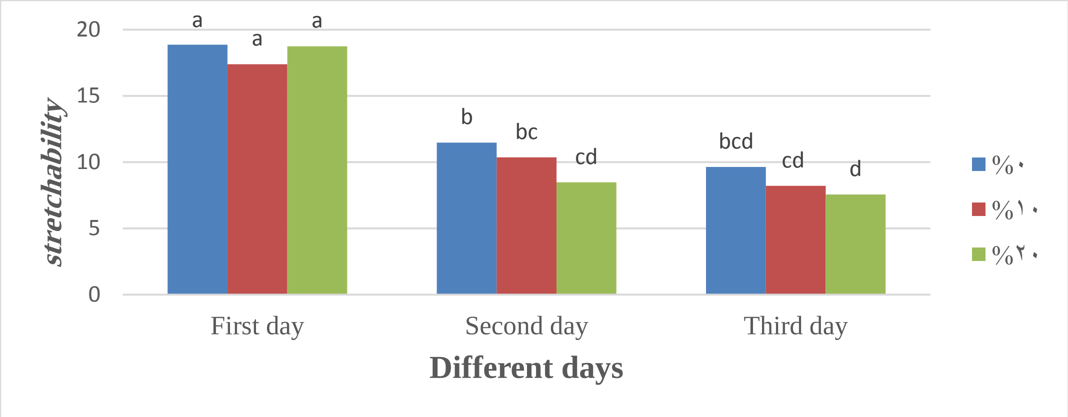

Figure (4.16) Effect of the interaction between different days and levels of substitution on values of stretchability. (The bar within the same letter is not significantly different at a 0.05 probability level).

Breakpoint

The breakpoint values were significantly affected by the storage time, the different levels of substitution, and the interaction between them. The values of the breakpoint were significantly decreased on the second and third day, and the highest value of the breakpoint was for composite flour with a 20% on the first day (Figure (4.17) and Table (4.4)).

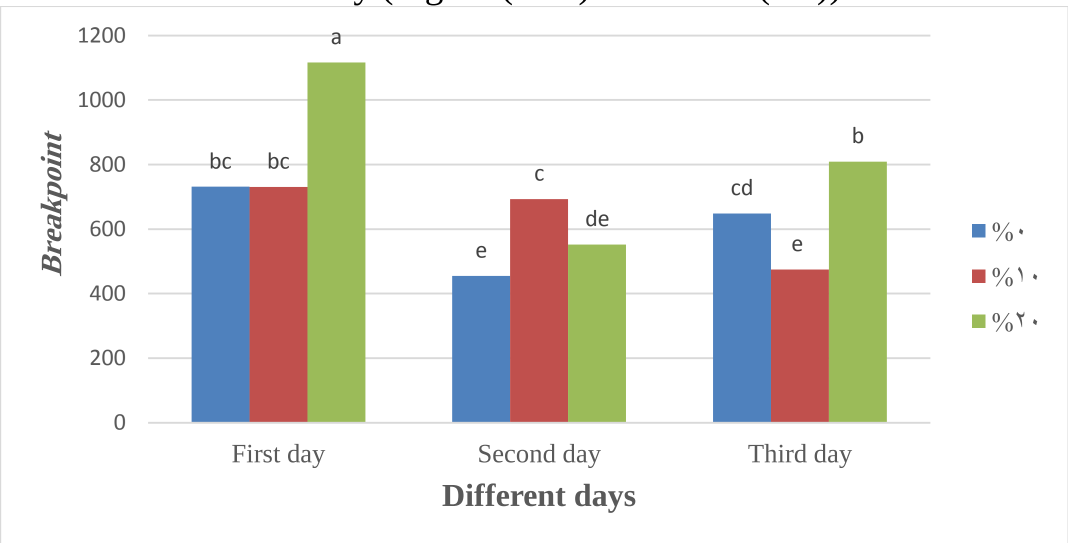

Figure (4.17) Effect of the interaction between different days and levels of substitution on values of the breakpoint. (The bar within the same letter is not significantly different at a 0.05 probability level).

Table (4.4)
Effect of the interaction between storage days and the substitution levels on Texture Profile Analysis (TPA) parameters*

Interaction effect Day	Sub.	Chewiness (g)	Hardness	Springiness	Resilience	Cohesiveness	Stretchability	Breakpoint
1	0%	1212±76.4^{g}	1377±113^{g}	0.99±0.01	0.51±0.02^{b}	0.84±0.01^{a}	18.85±0.47^{a}	731.2±20.2^{bc}
1	10%	1901.5±76.4^{f}	2253±113^{f}	0.99±0.01	0.52±0.02^{b}	0.83±0.01^{ab}	17.39± 0.47^{a}	730.6±20.2^{bc}
1	20%	3107±76.4^{e}	4322±113^{d}	0.96±0.01	0.53±0.02^{b}	0.81±0.01^{ab}	18.74±0.47^{a}	1116.4±20.2^{a}
2	0%	2830.1±76.4^{e}	3515±113^{e}	0.97±0.01	0.47±0.02^{b}	0.76±0.01^{cd}	11.48±0.47^{b}	455.1±20.2^{e}
2	10%	3977.4±76.4^{d}	4994±113^{c}	0.99±0.01	0.56±0.02^{ab}	0.79±0.01^{bc}	10.36±0.47^{bc}	693.2±20.2^{c}
2	20%	5856.9±76.4^{b}	6633±113^{b}	0.99±0.01	0.53±0.02^{b}	0.77±0.01^{cd}	8.48±0.47^{cd}	552.3±20.2^{de}
3	0%	3658.1±76.4^{d}	4929±113^{cd}	0.97±0.01	0.47±0.02^{b}	0.72±0.01^{e}	9.63±0.47^{bcd}	648.7±20.2^{cd}
3	10%	4969±76.4^{c}	6092±113^{b}	0.99±0.01	0.5±0.02^{b}	0.75±0.01^{de}	8.21±0.47^{cd}	475.1±20.2^{e}
3	20%	8234.2±76.4^{a}	9363±113^{a}	0.99±0.01	0.64±0.02^{a}	0.82±0.01^{ab}	7.57±0.47^{d}	809±20.2^{b}

***Data were expressed by Means±Standard Deviation (SD); The values within the same column followed by the same letter are not significantly different at a 0.05 probability level.**

4.2.4 Sensory analysis

The effect of the storage time and substitution level of wheat flour on the sensory scores of the final product of bread was studied.

Color

The sensory scores of the color of bread pieces were significantly affected only by the storage time and substitution levels of wheat flour, with no interaction between them (Figure (4.18) and Table (4.5)). The highest score of sensory evaluation for the color of bread was on the first day compared to the third day (Figure 4.18). There was a significant decrease in color score with increased substitution level regarding substitution level.

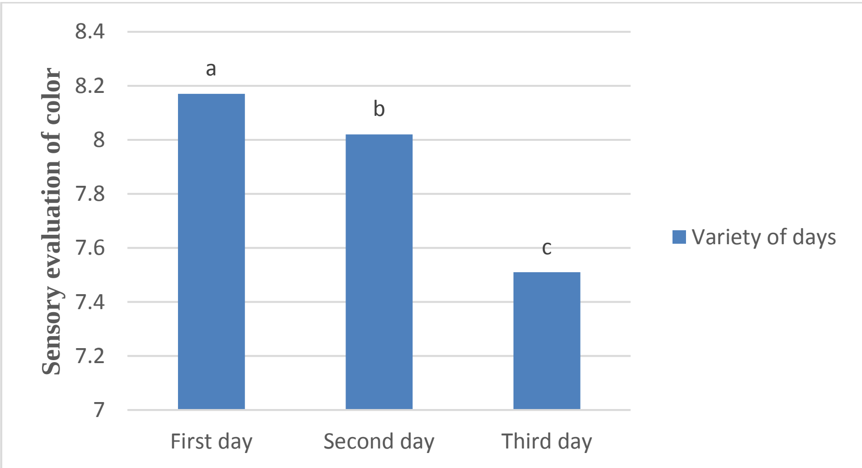

Figure (4.18) Effect of the storage time on the sensory evaluation of color. (The arithmetic means within the same letter are not significantly different at a 0.05 probability level).

Texture

The sensory scores of the texture of bread pieces were significantly affected by the storage time, substitution levels of wheat flour, and the interaction between them (Figure (4.19) and Table (4.6)). The final product of bread containing composite flour with 20% of quinoa seeds flour on the third day had the lowest texture evaluation scores. The texture of the bread was acceptable on the first day although substitution levels of wheat flour differed.

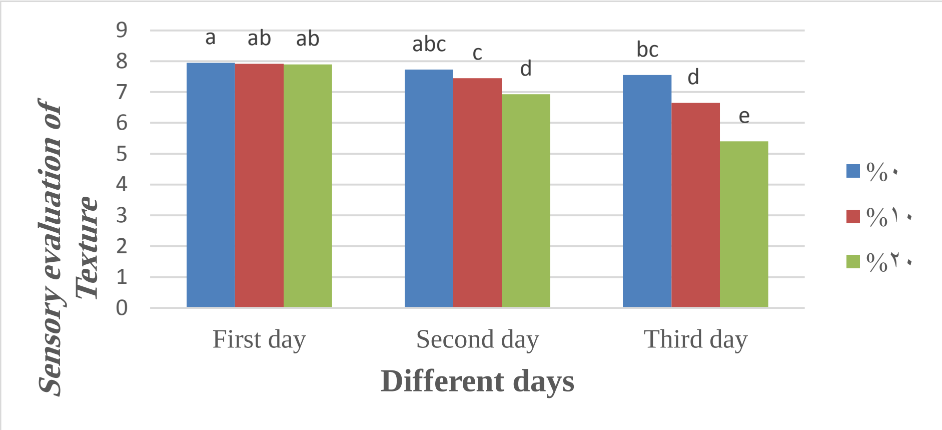

Figure (4.19) Effect of the interaction between different days and levels of substitution on the sensory evaluation of texture. (The bar within the same letter is not significantly different at a 0.05 probability level).

Taste

There were main effects by the different days and substitution levels with significant interaction between them on the sensory scores of the taste of bread pieces (Figure (4.20) and Table (4.6)). Even after 24 hours, the final product of bread was acceptable up to 20% of quinoa seeds flour in the composite flour with no significant differences with the control treatment. The bread taste acceptance score decreased on the third day when the proportion of quinoa seeds flour reached 10% or more compared to the previous days.

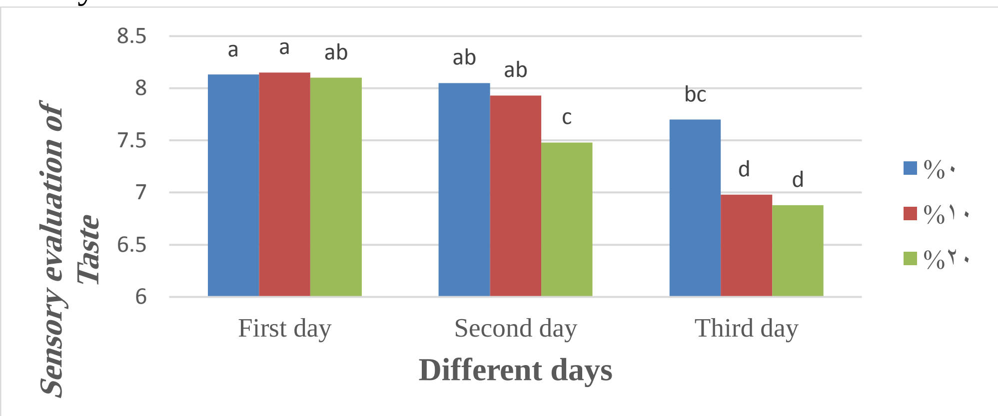

Figure (4.20) Effect of the interaction between different days and levels of substitution on the sensory evaluation of taste. (The bar within the same letter is not significantly different at a 0.05 probability level).

Overall quality

The sensory scores of the overall quality of bread pieces were significantly affected by the different days and substitution levels of wheat flour with the interaction between them (Figure (4.21) and Table (4.6)). The final product of bread had the highest score of sensory evaluation of overall quality on the first day, regardless of substitution level. The composite flour with 10% and 20% of quinoa flour on the third day differed from the control treatment.

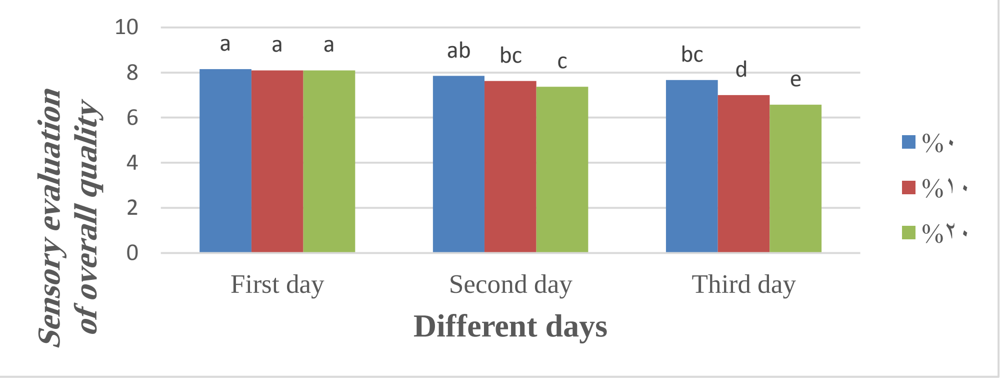

Figure (4.21) Effect of the interaction between different days and levels of substitution on the sensory evaluation of overall quality. (The bar within the same letter is not significantly different at a 0.05 probability level).

Table (4.5)

Effect the substitution levels on sensory analysis scores of the Taboun bread*

Substitution level	Color	Texture	Taste	Overall quality
0%	8.07±0.40^{a}	7.74±0.39^{a}	7.96±0.45^{a}	7.89±0.33^{a}
10%	7.90±0.49^{b}	7.34±0.66^{b}	7.68±0.60^{b}	7.58±0.57^{b}
20%	7.73±0.43^{c}	6.74±1.10^{c}	7.48±0.71^{c}	7.35±0.71c

***Data were expressed by Means±Standard Deviation (SD); The values within the same column followed by the same letter are not significantly different at a 0.05 probability level.**

Table (4.6)

Effect of storage days and substitution levels on sensory analysis scores of the Taboun bread*

Interaction Effect		Color	Texture	Taste	Overall quality
Day	**Substitution level**				
1	**0%**	8.28±0.34	7.95±0.28^{a}	8.13±0.48^{a}	8.15±0.24^{a}
1	**10%**	8.20±0.30	7.93±0.29^{ab}	8.15±0.37^{a}	8.10±0.21^{a}
1	**20%**	8.05±0.28	7.90±0.26^{ab}	8.10±0.35^{ab}	8.10±0.21^{a}
2	**0%**	8.20±0.25	7.73±0.38^{abc}	8.05±0.39^{ab}	7.85±0.24^{ab}
2	**10%**	8.05±0.28	7.45±0.46^{c}	7.93±0.24^{ab}	7.63±0.48^{bc}
2	**20%**	7.83±0.29	6.93±0.37^{d}	7.48±0.53^{c}	7.38±0.39^{c}
3	**0%**	7.75±0.38	7.55±0.39^{bc}	7.70±0.38^{bc}	7.68±0.34^{bc}
3	**10%**	7.45±0.48	6.65±0.43^{d}	6.98±0.34^{d}	7.0000±0.28^{d}
3	**20%**	7.33±0.34	5.40±0.50^{e}	6.88±0.63^{d}	6.58±0.41^{e}

***Data were expressed by Means± Standard Deviation (SD); The values within the same column followed by the same letter are not significantly different at a 0.05 probability level.**

4.3 Discussion

First Experiment

Due to its poor baking quality, which is caused by the absence of gluten, quinoa flour can only partially replace wheat flour in bread making, so the possibility of using quinoa flour inclusion in baked products up to 20-30% was mentioned (Stikic et al., 2012). In this experiment, there were three types of pretreatments for quinoa seeds and three levels of substitution. Quinoa seeds had bitter-tasting and toxic compounds (chiefly saponins) in the hull (Nowak et al., 2015), this can be removed by dehulling/polishing and washing in most cases (Lopez-Garcia, 2007). Three pretreatments of quinoa seeds flour were used with different levels of substitution of wheat flour ranging from 0% to 25% to prepare composite flour. The Process of roasting and extrusion can be able to lessen the bitter flavor imparted by saponins, and nutraceutical properties can be reduced by extrusion and roasting processes (Brady et al., 2007). Quinoa seeds must be polished and washed before applying the process method to increase the acceptability of the finished product (Ruales, 1993). It was difficult to prepare and evaluate bread from each composite flour due to cost, time, and effort. Rapid evaluation techniques of pasting profiles using Rapid Visco Analyser (RVA) and color evaluation using a spectrophotometer were applied. The Rapid Visco Analyser (RVA) was widely used to assess the pasting characteristics of flour or starch (Martinez, 2015). The pasting parameters include pasting temperature, peak viscosity, trough, breakdown, set back, peak time, and final viscosity. The gelatinization of the starch granule occurs by an increase in viscosity and the variation in the composition of the starch and protein in the flour leads to a difference in the peak viscosity (Roa-Acosta, 2020).

The significant effect of the interaction between pretreatment type and levels of substitution was observed, as increasing the levels of substitution for the different pretreatments decreased the L^*parameter and increased the a^*, b^*, and ΔEab parameters. A decrease in NaOH and temperature lead to a reduction in lightness (L^*), resulting in a quinoa co-product with a lower starch content and a higher protein content (Gómez, 2022). These results are very close to the investigation of wheat-quinoa flour by Coţovanu, Ungureanu & Mironeasa (2021), in which the L^* values significantly decreased and the a* values significantly increased in all composite flour when the level of quinoa flour increased.

Second Experiment

There were many studies investigating the impact of substitution levels of quinoa flour on the quality of bread. A study by stikic (2012) investigated the impact of the substitution of quinoa flour on the nutritional and functional properties of resulting products and it showed the addition 20% of quinoa flour increased the contents of protein, essential amino acids lysine, methionine, and histidine in the resulting bread compared to wheat flour. In this experiment, the effect of incorporating of the different concentrations of quinoa seeds flour with wheat flour and the storage days on the quality of Taboun bread was studied.

Instrumental color analysis

Instrumental color analysis of the top layer of taboun bread showed that the substitution of wheat flour with quinoa flour was not affected significantly the total color. *ΔEab** values of the bottom layer of Taboun bread were significantly affected only by the passage of days, and the *ΔEab** values of the bottom layer of taboon bread were significantly higher on the third day compared to the first and second days.

Instrumental texture analysis

Increasing levels of substitution of wheat flour and differing days resulted in significantly increased Texture Profile Analysis (TPA) parameters including resilience, hardness, and chewiness, and the values of cohesiveness were significantly decreased. A study by Wang et al., (2015) showed the same results, which increased the levels of quinoa flour to various certain extents and caused a change in texture profiles (hardness, cohesiveness, and chewiness) of the bakery products.

Sensory Analysis

The results showed that the level of acceptance of sensory characteristics was good up to 20% of quinoa seeds flour in the composite flour. Stikic et al. (2012) reported sensory characteristics of evaluated bread were excellent up to 20% substitution level of wheat flour. Another study conducted by Calderelli et al. (2010) showed that quinoa bread was well accepted as evaluated by sensory panelists. Additionally, the results of the current study showed that composite flour containing 20% quinoa flour had the lowest significant taste compared to other treatments. The proportion of 20-30% quinoa seed flour is possible in baked products, and the bitter taste recorded at high levels of quinoa flour is likely due to a lack of processing of the seeds leaving some of the hull (Stikic et al., 2012).

4.4 Conclusions

The incorporation of pre-processed quinoa seeds with different levels of wheat flour substitution significantly affected the pasting parameters and color parameters. Rapid Visco Analyser (RVA) was used as a tool to evaluate composite flour that contains different levels of quinoa flour. On the other hand, the CIE lab color and texture profile analysis for the composite flour with washed quinoa seeds was not significantly affected compared to the control and this makes the washing treatment the best formula prepared.

Composite flour with increasing the substitution levels of wheat flour has significantly affected the Texture Profile Analysis (TPA) parameters (hardness, cohesiveness, resilience, and chewiness). 10% substitution level had no significant affect more than 20% substitution level with the control in some parameters like resilience, cohesiveness and stretchability. In addition, 10% substitution had higher sensory accepted.

Up to 48 hours, the composite flour up to 10% of quinoa seeds flour had no significant affected with the control.

Values of CIE Lab color ($a*$, $b*$, $L*$, ΔEab) for the top layer of Taboun bread were not significantly affected by the storage days and different concentrations of quinoa seeds but the value of ΔEab for the bottom layer of Taboun bread was significantly affected only by the storage of days.

4.5 Recommendations

1. Further studies to understand the qualities of quinoa may help to make the desired nutritious foods of quinoa that meet consumers' needs.
2. Further studies to investigate chemical parameters of wheat-quinoa flour such as protein content, ash, fat, and dietary fibers.
3. The study recommends that studies be carried out to further verify the role of physical treatments of quinoa seeds in improving the characteristics of the finished product of Taboun bread.

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Appendices

Appendix I
Calculated F. values for different effects in the first and second experiment

Table

Calculated F values for the main and interaction effects in the first experiment

	Parameters	F. value	P>F
Pasting temperature			
	Effect of pretreatments	1.56	0.2253
	Effect of substitution level	0.56	0.6612
	Effect of the interaction	0.56	0.6177
Peak Time			
	Effect of pretreatments	3.44	0.0328
	Effect of substitution level	80.77	<0.001
	Effect of the interaction	1.88	0.0805
Peak viscosity			
	Effect of pretreatments	59.21	<0.001
	Effect of substitution level	97.08	<0.001
	Effect of the interaction	6.51	<0.001
Trough			
	Effect of pretreatments	36.49	<0.0001
	Effect of substitution level	69.48	<0.0001
	Effect of the interaction	3.83	0.0017
Breakdown			
	Effect of pretreatments	3.57	0.0290
	Effect of substitution level	4.08	0.0080
	Effect of the interaction	0.56	0.8773
Setback			
	Effect of pretreatments	21.58	<0.0001
	Effect of substitution level	22.82	<0.0001
	Effect of the interaction	3.15	0.0060
Final viscosity			
	Effect of pretreatments	202.82	<0.0001
	Effect of substitution level	89.61	<0.0001
	Effect of the interaction	20.79	<0.0001
L*value			
	Effect of pretreatments	29.05	<0.0001
	Effect of substitution level	38.61	<0.0001
	Effect of the interaction	3.15	0.006
a*value			
	Effect of pretreatments	302.49	<0.0001
	Effect of substitution level	63.80	<0.0001
	Effect of the interaction	16.07	<0.0001
b*value			
	Effect of pretreatments	25.34	<0.0001
	Effect of substitution level	24.28	<0.0001
	Effect of the interaction	4.14	0.001
⊿Eab*value			
	Effect of pretreatments	33.31	<0.0001

	Effect of substitution level	35.89	<0.0001
	Effect of the interaction	3.81	0.002
Chewiness			
	Effect of days	1639.05	<0.0001
	Effect of substitution level	1335.49	<0.0001
	Effect of the interaction	86.10	<0.0001
Hardness			
	Effect of days	1011.48	<0.0001
	Effect of substitution level	741.22	<0.0001
	Effect of the interaction	19.08	<0.0001
Resilience			
	Effect of days	1.32	<0.313
	Effect of substitution level	16.85	<0.001
	Effect of the interaction	8.99	<0.003
Cohesiveness			
	Effect of days	62.12	<0.0001
	Effect of substitution level	10.65	0.004
	Effect of the interaction	24.12	<0.0001
Stretchability			
	Effect of days	374.87	<0.0001
	Effect of substitution level	11.01	0.004
	Effect of the interaction	3.63	0.050
Breakpoint			
	Effect of days	168.96	<0.0001
	Effect of substitution level	102.40	<0.0001
	Effect of the interaction	61.24	<0.0001

Appendix II
Effect the storage time, substitution levels, and interaction between them on the CIE Lab color for top and bottom layers of bread

Table
Effect the storage time, substitution levels, and interaction between them on the CIE Lab color for the bottom layer of bread

	L*values	**a*values**	**b*values**	**Eab* values**
Factor				
Days				
First day	38.05±2.81	4.157±0.334	16.23±1.02	9.14^{b}±1.30
Second day	38.25±2.81	3.972±0.334	15.94±1.02	6.83^{b}±1.30
Third day	35.47±2.81	3.373±0.334	14.75±1.02	12.76^{a}±1.30
Substitution level				
0%	38.19±2.81	3.974±0.334	16.33±1.02	7.95±1.30
10%	35.53±2.81	3.644±0.334	15.04±1.02	11.00±1.30
20%	38.04±2.81	3.883±0.334	15.55±1.02	9.78±1.30
Day*substitution level				
1*0%	37.56±4.86	4.627±0.578	17.04±1.76	7.71±2.25
1*10%	38.59±4.86	3.472±0.578	15.71±1.76	10.51±2.25
1*20%	37.99±4.86	4.373±0.578	15.95±1.76	9.22±2.25
2*0%	40.03±4.86	3.698±0.578	16.48±1.76	5.11±2.25
2*10%	33.88±4.86	3.895±0.578	14.34±1.76	8.77±2.25
2*20%	40.84±4.86	4.322±0.578	16.99±1.76	6.61±2.25
3*0%	36.98±4.86	3.598±0.578	15.46±1.76	11.04±2.25
3*10%	34.13±4.86	3.567±0.578	15.06±1.76	13.71±2.25
3*20%	35.29±4.86	2.955±0.578	13.71±1.76	13.52±2.25

Table
Effect the storage time, substitution levels, and interaction between them on the CIE Lab color for the top layer of bread

	L*values	**a*values**	**b*values**	**Eab* values**
Factor				
Days				
First day	34.34±2.86	5.972±0.357	18.62±1.56	10.17±1.28
Second day	35.61±2.86	5.159±0.357	17.77±1.56	8.34±1.28
Third day	31.42±2.86	5.184±0.357	16.08±1.56	14.73±1.28
Substitution level				
0%	34.86±2.86	5.263±0.357	18.44±1.56	8.92±1.28
10%	32.15±2.86	5.687±0.357	18.30±1.56	11.45±1.28
20%	34.37±2.86	5.365±0.357	15.72±1.56	12.88±1.28
Day*substitution level				
1*0%	33.59±4.96	5.560±0.618	18.29±2.70	8.02±2.21
1*10%	33.70±4.96	6.175±0.618	20.02±2.70	11.51±2.21
1*20%	35.74±4.96	6.180±0.618	17.54±2.70	10.98±2.21
2*0%	36.16±4.96	5.237±0.618	18.86±2.70	7.97±2.21
2*10%	31.46±4.96	5.650±0.618	17.51±2.70	8.58±2.21
2*20%	39.20±4.96	4.592±0.618	16.93±2.70	8.47±2.21
3*0%	34.82±4.96	4.993±0.618	18.18±2.70	10.76±2.21
3*10%	31.28±4.96	5.237±0.618	17.38±2.70	14.25±2.21
3*20%	28.17±4.96	5.323±0.618	12.68±2.70	19.18±2.21

Appendix III
Sensory evaluation form

نموذج التقييم الحسي لخبز الطابون

التاريخ ....

لديك 3 عينات مُختلفة، أرجو منك تقييم صفات خبز الطابون المُوضحة بالجدول ووضع الرقم المناسب بناء على مما يأتي:

1. لا أرغب بشدة/ Dislike extremely

2. أرغب بشدة/ Like extremely

الصفة	العينة (1)	العينة (3)	العينة (4)
Texture القوام			
Bread color لون الخبز			
Flavor (taste+odor) الطعم			
Overall quality **الجودة**			

Appendix IV
Taboun bread photos


0% Quinoa
10% Quinoa
20% Quinoa

المعلومات الشخصية

الاسم: احمد رزق المعايطة

العنوان: الكرك

الكلية : الزراعة

التخصص: علم الغذاء والتغذية