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Erzincan Binali Yÿldÿrÿm University

INSTITUTE OF HEALTH SCIENCES

MASTER'S THESIS

DEVELOPED USING CHICKPEA AQUAFABAS INNOVATIVE BISCUIT FOR VEGANS AND EGG ALLERGIES. THE POTENTIAL OF INDIVIDUALS' NUTRITION EVALUATION

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NUTRITION AND DIETETICS

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THESIS ACCEPTANCE AND APPROVAL

AN INNOVATIVE DEVELOPMENT USING CHICKPEA AQUAFABAS
BISCUITS FOR VEGANS AND INDIVIDUALS WITH EGG ALLERGIES
ASSESSMENT OF POTENTIAL RELATED TO NUTRITION

This was prepared by Elif POLAT under the supervision of Dr. Nazife YILMAZ, Assistant Professor.

The study was reviewed by the jury on 25/06/2026 by the Department of Nutrition and Dietetics.

It was unanimously accepted as a Master's thesis.

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SUMMARY

Master's Thesis

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Objective: With the increasing interest in plant-based nutrition, the development of alternative products to animal components has gained importance. This study aimed to determine the feasibility of using chickpea boiling water (aquafaba) as an alternative to egg whites in biscuit production.
Materials and Methods: Biscuits produced using aquafaba were compared with control biscuits containing egg white in terms of physical (diameter, thickness, spreading ratio, foaming capacity and stability), chemical (color, pH, moisture, protein, fat, ash, TPA and HMF) and sensory properties.

Findings: Aquafaba-containing biscuits maintained their thickness approximately 0.2 mm better than the control in terms of spreading ratio. The foaming capacity of aquafaba was found to be 10 mL, and foam stability was 2.08% higher. The pH value of aquafaba-containing biscuits was determined to be 0.46 units, and the moisture content was 2.42% lower than the control. While no significant difference was found between the groups in fat content; HMF values were measured as 6.65 ppm and 6.81 ppm in aquafaba-containing and control samples, respectively. The carbohydrate content was 77.84% in the aquafaba group and 77.03% in the control group; energy values were calculated as 479.81 kcal and 478.52 kcal, respectively. Although the protein content was found to be 1.05% lower in aquafaba biscuits, the aquafaba biscuits received higher scores in sensory analyses.

Conclusion: It was determined that aquafaba can be successfully used in place of egg whites in biscuit production, positively affecting the physical and sensory qualities of the product; and that it offers a high-quality alternative for vegan and egg allergy-prone consumers.

2026, 103 pages
Keywords: Aquafaba, Biscuit, Chickpea Water, Vegan Diet, Egg

ABSTRACT

EVALUATING THE POTENTIAL OF AN INNOVATIVE BISCUIT DEVELOPED USING CHÿCKPEA AQUAFABA FOR THE NUTRITIONAL AID OF VEGAN AND EGG ALLERGY INDIVIDUALS

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SYMBOLS AND ABBREVIATIONS

Symbols

*A** Redness

*B** Jaundice

Ca Calcium

Cu Copper

cm Centimeter

Minute by minute

Fe Iron

G Gram

Potassium *K*

kg Kilogram

*L** Openness

Mg Magnesium

Mn Manganese

Mg Milligram

ML Milliliter

mm Millimeter

Etc And so on

Zn Zinc

µg Microgram

Abbreviations

AACC	American Association of Cereal Chemists
USA	United States
AOAC	Association of Official Agricultural Chemists
CIELAB	International Commission on Illumination
DHA	Docosahexaenoic Acid
WHO	World Health Organization
MOST	European Norm
EPA	Eicosapentaenoic Acid
FAO	United Nations Food and Agriculture Organization
H	Volume
HCL	Hydrochloric acid
HMF	5-HydroxymethylFurfural
IBM	International Business Machines
IgE	Immunoglobulin E
ISO	International Standards Organization
IP6	Inositol Hexaphosphate
kcal	Calorie
KK	Foaming Capacity
KS	Foaming Stability
NOFIMA	Center for Recirculation in Aquaculture
PA	Phytic Acid
SPSS	Statistical Package for the Social Sciences
TS	Turkish Standard
TPA	Tissue-type plasminogen activator
WHO	World Health Organization

ENTRANCE

Interest in healthy eating and consuming quality food has increased nowadays. Nutritional value
The growing interest in nutritious foods and the increasing variety of foods people consume is leading them to seek alternatives.
This drives people to find food. The quantitative expansion in the plant-based product ecosystem directly
Rising consumer demand and market for alternative consumption practices such as vegan and vegetarian.
It is related to its dynamics. An alternative to animal-derived foods such as meat, milk, and eggs.
Plant-based food ingredients and products developed with the aim of creating [a specific type of food] have become important in recent years.
This development is attracting considerable attention. Vegetarian and vegan dietary patterns...
In addition to becoming more widespread, consumers' concerns about health, environmental sustainability, and ethics have also increased.
This is supported by their increasing sensitivity towards this issue (Tufaro and Cappa, 2023; He et al., 2021).
Animal foods like eggs are both high in protein and have emulsifying properties.
Due to their capacities, they are widely used in our nutrition and the food industry.
Eggs have a high emulsifying capacity due to their phospholipids (lecithin) and lipoproteins (low
high-density lipoproteins and other proteins (livetin and
(phosphitin) is related. These proteins also have various functional roles in different food systems.
It exhibits these characteristics (He et al., 2019). Egg products are harmful to infants and young children.
It is among the basic food groups most frequently associated with cases of food allergies.
Egg whites, especially the gel, hold an important place in our nutrition and food technology .
Widely used in food processing due to its functional properties, including foam formation.
Egg white proteins are used because, in addition to having a low energy content,
It is a high-quality protein source. Egg allergens are mostly found in egg whites.
Ovalbumin, which makes up 54% of egg white protein, is one of the main egg allergens.
The high antigenic properties of egg white make it suitable as an egg in infant and young child diets.
This restricts its use. Additionally, eggs are not recommended for those with specific dietary restrictions or religious reasons.
It is also suitable for consumers who do not consume eggs due to personal lifestyle preferences.
It is not a nutritious food. In addition, cost analyses show that the cost of eggs in the cake production recipe is less than that of eggs.
This indicates that it is responsible for approximately 50%. Accordingly, the baking industry...
Partial or complete replacement of eggs for sustainable and economical production models
Researchers have focused on searching for alternative components that can provide this (Park et al., 2017; Lin et al., 2017).

Aquafaba is obtained from the boiling water used in canned chickpea production. It is also used in baking.
Using eggs in products makes them less costly and reduces waste.

It helps to reduce fat (He et al., 2021). Aquafaba contains no fat, but contains protein and...
Because it contains carbohydrates, it is an alternative ingredient for individuals with cardiovascular disease.
It stands out as such. Moreover, since chickpeas are not an allergenic food, recipes with aquafaba are suitable.
Aquafaba will also offer a protein-rich option for those with egg allergies (Yilmaz, 2024).
Its use improves the foaming, foam formation, stability, and consistency of egg whites.
This is ensured by the soaking and cooking processes of chickpeas, which utilize aquafaba for its structural and...
It contributes to the formation of the structural and functional properties of the traditional product.
The successful production of biscuits while preserving their textural and sensory properties has given impetus to
R&D studies in the field of egg substitutes (Özer et al., 2025). Furthermore, vegan
It also contributes to meeting the nutritional needs of the nourished society. Among vegans
Insufficient protein intake can lead to muscle loss. Aquafaba's protein content is similar to that of eggs.
Because of its proximity, it contributes to the production of high-nutritional value products (Jaramillo and Shin,
(2023). Alternative food sources to meet the current nutritional needs of society.
diversification and their integration into production improves nutritional quality across the population.
This will create positive projections for public health.

The aim of this thesis study is to investigate the use of aquafaba in individuals with egg allergies or vegans.
The aim is to create an alternative option to existing recipes. Aquafaba is suitable for vegans or those with allergies.
It is the most appropriate option that can be used as an egg substitute in individuals. With the use of aquafaba,
A lower-cost ingredient can be included in the product formulation instead of eggs.
Biscuits should be easily accessible, affordable, nutritious, and delicious for everyone.
The aim is to increase the consumption of healthy snacks by vegan and allergy-friendly individuals. Chickpea-based.
The hypoallergenic nature of the ingredients makes it safe for sensitive populations at risk of food allergies.
It aims to facilitate access to functional snack products and offer healthy alternatives for these individuals, especially
those who do not want to use egg whites.
Aquafaba can be added to recipes to create a soft and fluffy texture. Aquafaba, when whipped...
A stable foam forms, which gives recipes a light and creamy texture. Aquafaba
Its easy foaming property also facilitates product formation. Egg allergy, additional problems in babies.
It can occur during the transition to solid food, especially in the first year of life (Çiftçiler, 2022).
Since eggs are known as the highest quality food after breast milk, a protein deficiency can occur.
Protein should be obtained from other sources. Aquafaba reduces protein content compared to egg consumption.
While the difference is negligible, an increase in sensory characteristics is observed. As an allergen.
By providing a substitute for eggs, which are consumed in limited quantities, the taste, flavor, texture, smell, appearance, and
New products are being produced without loss of texture. Eggless biscuits are easily accessible.

Aquafaba is a good option for both infant nutrition and for vegans.

It helps in the production stages of biscuits by contributing to sustainability and at low cost.

Yes. The allergen-free, plant-based composition of the biscuit makes the product independent of dietary restrictions.

as an accessible and suitable alternative for consumption by all consumer groups

This brings about a contribution to the ready-to-eat snack product range through the production of nutritious biscuits.

It will provide.

GENERAL INFORMATION

2.1. Legumes

Legumes are plants belonging to the Fabaceae family (Martín-Cabrejas, 2019). They have been consumed by humans for many years.

The history of legumes used in the diet dates back 8-10 thousand years (Adak

(et al., 2015). While local consumption of legumes is decreasing in developing countries,

In the United States and some high-income Western European countries, there is demand for these products.

Demand is increasing. This increase in demand is due to the nutritional properties and health benefits of legumes.

It is considered to be closely related to the increased awareness of its benefits (Önder et al., 2020). Nutrients are

obtained from animal and plant sources. Animal-derived

Due to the high cost of food, individuals, especially in developing countries, cannot afford food.
It utilizes plant-based products to meet its component requirements.
(Adak et al., 2015). Plant-derived proteins have low allergenic properties.
They can be produced sustainably and at low cost in high capacity, and are of animal origin.
It highlights proteins (Esmer et al., 2024). Proteins worldwide
While approximately 70% of its needs are met from plant sources, this rate is lower in developing countries.
In many countries, this can reach up to 90%. Türkiye consumes approximately 200 kg of grain per person annually.
It ranks among the top countries in the world in terms of consumption; however, per capita annual consumption is approximately
With a meat consumption of 22 kg, it is among the countries with relatively low consumption levels.
The situation is such that in Türkiye, protein requirements are met significantly through plant-based foods.
This shows that the needs are met (Adak et al., 2015). Animal protein sources, plant-based
Higher in terms of environmental sustainability when compared to other protein sources.
It has an impact on the production of animal-derived proteins such as meat, fish, eggs, and milk.
In their processing, more water and farmland are used compared to plant-based protein sources.
and higher levels of greenhouse gas emissions occur. Furthermore, high production levels...
animal protein sources that require significant greenhouse gas emissions and extensive land use
Dietary patterns in which people consume a lot of food are associated with mortality and certain other causes.
It is reported to be associated with an increase in the incidence of cancers (Güneÿliol and Tek, 2022).
One of the most important advantages of legumes is that they are grown with a low environmental footprint.
It is associated with various climates and soil types and is more versatile than other crops.
It requires little water and fertilizer; creating a sustainable option for farmers. Nutritious and
With their physicochemical properties, the increasing demand for plant-based diets in the food industry
It meets the requirements (Çetiner and Bilek, 2018). Legume proteins, water and fat absorption,
such as solubility, gel formation, emulsification, foaming capacity and foam stability.
Thanks to its functional and technological properties, it is widely used in food formulations today.
It is considered among the important protein sources (Atalay and Gökbulut,
(2021). These functional properties make legumes a potential substitute for animal protein.
This makes it important. Additionally, low allergenicity, sustainable production, low price, and high yield are also factors.
the nutritional benefits provided by their volume, proteins obtained from legumes and pulses
It supports industrial use (Boye et al., 2010). In less developed countries, plant-based
Consumption of proteins derived from methionine, cystine, and other similar sources is more common, and these proteins generally contain methionine and cystine.
It is limited in some essential amino acids, such as tryptophan. Furthermore, lysine is the most restricted amino acid in cereal proteins.
It is considered an essential amino acid (Ton and Anlarsal, 2015). Edible legumes,
Unlike grains, it has a rich amino acid content of lysine. Therefore, grains and

Consuming legumes together provides a complementary effect thanks to the essential amino acids.
It increases the biological value of proteins. Thus, amino acids such as lysine, methionine, and threonine...
Protein synthesis and dietary protein quality can be improved by ensuring a more balanced intake of acids
(Sarwar et al., 1978). According to the World Health Organization (WHO), protein
A balanced diet requires 60% of nutritional needs to be met from plant sources and 40% from animal sources.
It is considered as a nutritional model (Atalay and Gökbulut, 2021). In Türkiye, the total
Approximately 65% of protein supply comes from plant sources and 35% from animal sources.
This shows that the daily protein consumption profile on an individual basis is significantly shaped in favor of
plant-based sources (Atalay and Gökbulut, 2021). Plant-based protein consumed in our country...
The vast majority of protein sources come from edible beans, chickpeas, and lentils.
Protein is obtained from legumes (Sarÿoÿlu and Velioÿlu, 2018). Edible legumes contain protein.
The main amino acids that limit its quality are methionine and tryptophan.
However, the levels of these amino acids can be adjusted to a certain extent through breeding programs.
It can be increased. The methionine content in legume proteins varies between 0.5–1.9 depending on the species and genotype.
The protein content of edible legumes is 0.5–1.5 g/100 g, while their tryptophan content varies between 0.5–
1.5 g/100 g protein (Kadakoÿlu and Karlÿ, 2022). The first nitrogen compounds formed are amino acids.
Nitrogen content varies among species. Legumes have a higher nitrogen content.
There is a significant variation among them, and this amount includes broad beans, lentils, peas, black-eyed peas,
It shows a decreasing trend in the order of chickpeas and beans (Elkoca and Kantar, 2011).
The nutrients contained in legumes are shown in Table 2.1 (Sarÿtaÿ, 2025).

Table 2.1. Nutrients Contained in Legumes

Nutrients	**Nutrients**
Protein	Beans, chickpeas, hazelnuts, quinoa, tofu, and other soy-based protein foods.
Iron	Dried or fortified beans and grains
Zinc	Whole grains, nuts, legumes
Calcium	Soybean

2.2. Chickpeas

Chickpea *(Cicer arietinum)* belongs to the genus *Cicer ,* the tribe *Cicereae ,* and the family *Fabaceae .*
It is a plant belonging to *the Papilionaceae* subfamily. The name *Cicer* is of Latin origin and means strength or power.
It is derived from the Greek word 'kikus', meaning chickpeas (Kumar, 2018). Chickpeas are grown worldwide.

It is one of the most consumed legumes, with more than 2.3 million tons entering the global market every year.
Some chickpea components are included in preclinical and clinical studies (Kumar et al., 2025).
antioxidant capacity, antifungal, antibacterial, analgesic, anticancer, anti-inflammatory and
including hypocholesterolemic properties and angiotensin I-converting enzyme inhibition
Chickpeas have demonstrated various health benefits (Acevedo Martinez et al., 2021).
its origins are in Türkiye's Southeastern Anatolia Region and the northern parts of Syria
It is reported that chickpeas are grown on approximately 10 million hectares worldwide (Çevik and Deÿer, 2019).
It is cultivated in an area with a production of 7.1 million tons. The world's largest chickpea-producing countries are
India (68%), Turkey (11%) and Pakistan (8%) (Doÿan and Yusuf, 2024). In our country, it is mostly grown in the Central
Anatolia region. It is also grown in the Mediterranean, Aegean, Marmara and Southeastern Anatolia regions.
Chickpea cultivation is present (Gülümser, 2016). Chickpea, an herbaceous annual plant, branches from the base.
It has the appearance of a small shrub with spreading branches. Some genotypes are covered with hairs.
Some are hairless (Moreno and Cubero, 1978). Chickpeas consist of Desi and Kabuli types. Desi
The type is characterized by relatively small, angular seeds that come in various colors and are sometimes speckled.
Kabuli type, with larger seed sizes that are smoother and generally lighter in color.
It is characterized by (Toker et al., 2014). Chickpea seeds are grown at optimum temperature (28-33°C) and humidity.
It germinates in about 5-6 days at this level. Chickpea plants have a strong root system with 3 or 4 rows of lateral roots.
It has a taproot system. Chickpea roots bear *Rhizobium* nodules. These are carotenoids.
It is of the type that is branched with laterally flattened branches and sometimes has a fan-like lobe.
Chickpeas are grown in well-drained soil where sufficient soil moisture is provided (Singh and Diwakar, 1995).
Chickpeas, a legume, can be grown in various soil types (Sofi et al., 2020).
It obtains its nitrogen through nitrogen fixation. In addition, it provides optimum amounts of phosphorus.
Chickpeas need potassium, sulfur, and other nutrients. (Nutrition (fertilization) in chickpeas)
The response to the application depends on the nutrient status of the soil, agricultural climate conditions, and genotype.
It depends on both organic and inorganic nutrient sources and *Rhizobium* inoculation of chickpeas .
It has been found to be beneficial for growth and yield (Sandhu and Chaturvedi, 2025). Chickpea
They are among the most drought and low temperature tolerant plants, and their water requirements are also low.
It is included in sustainable agriculture. Chickpeas have a high protein content ranging from 18–36%.
It is a type of legume that is also rich in vitamins and some minerals. For a long time
It can be stored easily, is transported easily, and is more economical compared to animal-derived proteins.
Due to these characteristics, it holds an important place among edible legumes. These properties make it a legume.
This is contributing to the increasing importance given to consumption. Per capita consumption worldwide.
Annual chickpea consumption is reported to be approximately 4.61 kg (Yazÿcÿ et al., 2025).
In particular, chickpea plants are resistant to drought and low temperature stress, and low

Its low water requirements make this species an important plant in terms of sustainable agricultural practices (Önder et al, 2020). Diseases and weeds in chickpea cultivation.

Delaying planting to reduce weed pressure leads to yield losses.

Failure to sow winter varieties at the appropriate time and delays in summer sowing also negatively impact production.

This affects the timing of sowing for edible legumes. Therefore, determining the correct sowing time is of great importance (Çubuk and Özgören, 2023). Chickpea seed proteins have many functional properties.

This shows that legumes are an interesting component for developing protein-rich foods.

It becomes (Cunsolo, 2025). It has the second highest protein ratio after soybeans.

Chickpeas, a type of legume, stand out for their rich dietary fiber composition.

Complex carbohydrate matrix reduces postprandial glucose fluctuations in diabetic populations.

Because it minimizes the need for saccharides, it constitutes the most physiologically suitable saccharide source for this patient group.

Chickpeas contain all essential amino acids except sulfur-containing amino acids (Shah et al., 2025).

It is a type of legume that contains significant levels of amino acids. It also contains starch, dietary fiber, and oligosaccharides.

It is a storehouse of glucose and sucrose (Jukanti et al., 2012). Found in chickpeas

ÿGalacto- oligosaccharides are indigestible and are fermented by colon bacteria in a short period of time.

They act as prebiotics because they cause the formation of chain fatty acids (Kaur and

Chickpeas, despite their low lipid content, contain unsaturated fats such as linoleic and oleic acid (Prasad, 2021).

It has a structure rich in fatty acids. The fat fraction contains ÿ-sitosterol, campesterol, and

While it contains phytosterols such as stigmasterol, its seeds contain Calcium (Ca), Magnesium (Mg), and Phosphorus.

It is also rich in minerals such as (P) and especially Potassium (K). It also contains riboflavin, niacin,

It is also an important source of vitamins such as thiamine, folate and ÿ-carotene (Jukanti and

et al., 2012). Some chickpea components have antioxidant capacity in preclinical and clinical studies.

antifungal, antibacterial, analgesic, anticancer, anti-inflammatory and hypocholesterolemic

various health features including angiotensin I-converting enzyme inhibition

Chickpea seeds have demonstrated benefits for cardiovascular health (Acevedo Martinez et al., 2021).

Chickpeas are a relatively inexpensive source of dietary fiber and bioactive compounds with a low glycemic index,

which can be beneficial in reducing the risk of disease (Çubuk and Özgören, 2023). A healthy diet includes chickpeas.

When consumed regularly as part of a diet, it can lower blood pressure and reduce the risk of type 2 diabetes.

It can help reduce the incidence and severity (Abdelsatter et al., 2025). Chickpeas,

In addition to its protein and dietary fiber properties, it contains biologically active components.

Chickpeas are considered a potential functional food. They reduce the risk of chronic diseases.

rich in various vitamins, minerals and bioactive compounds that can help reduce

It is a relatively inexpensive source. The protein content in chickpeas is similar to that in cereal grains.

The amount is at least twice that (Boye et al., 2010). Also, depending on the variety, chickpea grains can weigh 20.

Rich in dietary fiber which can exceed g/100 g, and unsaturated fatty acids such as linoleic and oleic acids.
It is rich in nutrients (Jukanti et al., 2012). Chickpea starch is responsible for the lower glycemic index.
It has a higher amylose and resistant starch content. Therefore, chickpeas are used in bread, pasta, and
It is widely used in the production of various baked goods (Kaur and Prasad, 2021).
The oligosaccharides found in chickpeas are considered a good source of prebiotics. Chickpeas
It generally has a lower glycemic index than grains and is used in the production of baked goods.
It was applied to evaluate their cooking performance and nutritional advantages (Cappa
(et al., 2020). Sustainability of all legumes, including chickpeas.
potential for optimizing environmental sustainability and supporting public health
It offers a holistic benefit matrix in its processes. High crude protein content (21.5-23.9%)
Chickpeas, which have a high digestibility rate (76-88%), contain vitamins, iron, fiber, calcium, and magnesium.
Chickpeas are also very rich in phosphorus and amino acids (Kayan and Adak, 2015). Chickpea root
By binding atmospheric nitrogen to the soil thanks to *Rhizobium* bacteria found in its nodules
It contributes to soil fertility. With its deep root system, it improves soil structure.
In addition to providing support, legume stalks and straw have a higher protein content compared to cereals.
Chickpeas also have an important use in animal feed (Dixit, 2018).
The use of boiling water in aquafaba production without waste has been increasing in recent years.
A study found that the most popular legume cooking water is for chickpeas, compared to other legumes.
Aquafaba has been used (Agregan et al, 2025). It is used as an emulsifier and enriching agent in legume cooking water.
It has been found to be a source of phenolic compounds (0.3-0.7 mg/mL) and saponins (8-12 mg/ml).
The amount of protein and saponin in the strained legume water affects the foaming and gelling of the cooking water.
It has created the capacity to produce (Topal and Bal, 2021). The frequency of chickpea consumption was examined.
In the study, individuals who consumed chickpeas, a source of plant-based protein, once a month had an increased appetite of 4–6 times a week.
It was found that individuals who consumed it several times had higher levels of depression compared to those who consumed it only once (Ertal
(et al., 2023). The nutritional content of chickpeas is shown in Table 2.2.

Table 2.2. Nutritional Value of 100 Grams of Chickpeas (Karaboÿa and Yÿldÿrÿm, 2019)

Vitamins and Minerals	**Quantity**

Protein	19.20 g
Oil	6.20 g
Calcium	134.00 mg
Iron	7.30 mg
Vitamin B1	0.46 mg
Vitamin B2	0.16 mg
Niacin	1.70 mg
Vitamin C	1.00 mg

Chickpea allergy is related to lentil or pea allergy, but it can also occur independently.
It may not occur (Bar-El Dadon et al., 2014). The allergenicity of legumes is mainly due to the seeds.
It is related to allergens originating from storage proteins (Pereira, 2002). In legumes, especially peas.
Severe allergic reactions to lupine have been described. Most allergic reactions,
from homologous proteins, for example, IgE cross-reactions between peanuts and lupins
Chickpeas are among the primary non-legume allergen sources (Abu Risha et al.,
(2024). Allergen labeling requirements vary between countries. Public opinion on this matter...
There are very few studies on the health benefits of a legume in the diet (Hildebrand et al., 2021).
Removal should be based on a positive oral food test result (Pereira, 2002). Many food products
Despite exhibiting allergenic properties, allergic reactions to chickpeas do not last for a long time.
It has not been sufficiently characterized. However, studies conducted after 2008, especially on soy,
anaphylactic shock that occurs after consuming legumes such as beans, lentils and chickpeas
It focused on the relationship between reactions and exercise, and nutrient-dependent exercise-induced reactions.
They highlighted the case of anaphylaxis (Abu Risha et al., 2024).

2.2.1. Saponins

The name 'saponin' is derived from the Latin word 'sapo', meaning soap. Containing saponin...
The plant extract has the ability to form a soapy foam when shaken in water (Kregiel and
(et al., 2017). Saponins are surfactant sterols or triterpene glycosides. They are found in many plant species.
Although widely available, only some of them are included in human nutrition.

Soybeans, chickpeas, peanuts, and spinach are among the most commonly consumed plants in this regard.
It is among them that different saponin compounds can be found even in a single plant species.
It is reported (Oakenfull, 1981). In recent years, consumer demand for natural products has increased.
Increasing evidence regarding their physicochemical (surfactant) properties and biological activities.
Saponins (with cancer-preventive properties, hemolytic and hypocholesterolemic effects, etc.) in food
Commercially important compounds with expanding applications in the cosmetics and pharmaceutical industries.
This has contributed to the expansion of its areas of use (Karnwalve et al., 2023).

Saponins have important applications in food technology. They possess surfactant properties.
They possess the ability to reduce the surface tension of liquids; foam formation and foam stability.
They are used in the food and cosmetics industries due to their emulsifying properties. As emulsifiers.
They perform the function of ensuring the mixing of oil and water phases, thereby stabilizing emulsions.
They enhance [their quality]. They can have a preservative effect and contribute to extending the shelf life of some products.
They can provide flavor. They can be used as flavor modifiers/flavor regulators. Carbonated beverages,
such as bakery products, chewing gum, confectionery, beverages, spice blends, and dietary supplements.
They are used as functional ingredients in many products. Due to their plant origin, they are not synthetic.
They are considered as natural additives as alternatives to surfactants (Ridout).
(et al., 1991; Kerwin, 2004; Karnwal et al., 2023)

Although saponins are known for their potential health benefits and functional properties, they also have some limitations.
There are. One of these limitations is the presence of proteins, lipids, and minerals such as iron, zinc, and calcium.
to form complexes with other foods (insoluble saponin-mineral complexes)
This involves their interaction with other food components. Thus, the absorption of these food components in the body is negatively affected.
It is affected in this way (Milgate and Roberts, 1995). Saponins lower blood lipids and cancer
It can help reduce risks and slow the glycemic response. In terms of saponins.
It has been suggested that a rich diet prevents tooth decay and platelet aggregation.
Saponin consumption is also used in humans for the treatment of hypercalciuria and acute lead poisoning.
It has shown promising results as a potential therapeutic agent (Shi et al., 2004). Different
In studies on hypertensive rats using saponin extracts obtained from plants
It has been determined that it significantly reduces heart rate and arterial blood pressure (Küçükkurt and
In a study examining the relationship between saponin intake and cholesterol metabolism (Fidan, 2008), excessive saponin intake was found to be beneficial.
It has been concluded that saponin intake can be used as a hypocholesterolemic agent (Milgate and
Roberts, 1995). Furthermore, saponins have high potential due to their structural diversity and different
In addition to reducing hyperglycemia through various mechanisms, it also reduces diabetic complications.

This prevents [diabetic] diseases. Thus, we can improve existing treatments and develop new drugs to treat diabetes.
It provides opportunities for development (Choudhary et al., 2021).

2.2.2. Phytic Acid

Phytic acid (PA) is the main phosphate storage compound in cereals and other plant-based matrices.
It constitutes a large part of the plant's phosphorus reserves. In food and in the human body, it contains PA, Zn, $^{2+}$ and
Fe 2+, Mg 2+, Ca 2+, and K.$^{+}$, Mn $^{2+}$ and Cu $^{2+}$ has a high affinity for chelation.
It is a compound (Brouns, 2021; Hadi and Zotz, 2014). PA constitutes approximately 1% to 7% of their dry weight.
It constitutes more than 70% of the total core phosphorus. Zinc, calcium, and
PA has a high capacity in the chelation of polyvalent metal ions, especially iron.
It has been determined that it possesses coordination and connection capacity. Connection,
This can result in very insoluble salts that are poorly absorbed from the gastrointestinal system, and
This results in poor bioavailability of minerals (Zhou and Erdman, 1995). Negatively charged
Due to the high density of phosphate groups, PA forms very stable complexes with mineral ions.
By doing this, it reduces their bioavailability (Feil, 2001). Mineral absorption
For this to occur, minerals must be present in soluble and ionic forms. The diet...
As PA content increases, the absorption of zinc, iron, and calcium from the intestine decreases. However, PA
It is not found alone in foods and is usually consumed in combination with various compounds (Wu et al. 2009).
Phytates are composed of fiber, minerals, trace elements, and other phytochemical nutrients.
It is always present in the plant matrix. Therefore, minerals can be obtained from phytate-rich products.
To assess absorption, all components of the diet and food interactions must be considered, and
Estimating mineral bioavailability in such products using only phytate content
It is difficult (Bloot et al., 2023; Lopez et al., 2002). PA is found in many plant systems and cereals.
and constitutes approximately 1% to 5% of legumes by weight. Concerns about its presence in foods,
many essential minerals by interacting with polyvalent cations or proteins
This stems from evidence that it reduces bioavailability (Cheryan and Rackis, 1980).
PA suppresses iron-catalyzed oxidative reactions by forming iron chelates, and
It can act as a powerful antioxidant in seed preservation. Dietary PA works through the same mechanism.
It may provide protection against colon cancer and other inflammatory bowel diseases (Graf and
Eaton, 1990). By binding nutrient-important cations and protein in the digestive system.
It is considered an antinutrient because it reduces the bioavailability of minerals and protein.
(Feil, 2001). Addition to foods causes lipid peroxidation and discoloration, spoilage and syneresis.
It prevents accompanying oxidative degradation. PA has many other industrial applications.
Its antioxidant function is utilized (Bloot et al., 2023). High concentrations of PA

By inhibiting polyphenol oxidase, it prevents browning and rotting of various fruits and vegetables.
It prevents. Phytate has an important antioxidant function in seeds during dormancy, and phytate...
many of them pose potential health hazards, instead of currently used protective measures
It is suggested that it can pass through (Graf et al., 1987). The IP6 compound of PA has undergone phosphorylation and
It is an inositol derivative belonging to the nutraceuticals of a high-fiber diet. This compound has broad biological activity.
It has a spectrum (Nawrocka-Musiaÿ and Latocha, 2012). Colon, breast, prostate, cervix,
in several cancer cell lines, including liver, pancreas, melanoma and glioblastoma
Inhibition of tumor growth and induction of cell differentiation in the presence of IP6.
It has been observed that the molecular effects of IP6-mediated anticancer activity are related to the effects of Pires et al., 2023).
The mechanisms are not fully specified. IP6 features include: interference with signal transmission, natural killer.
the ability to develop cells, inhibitory effect on the cell cycle, transformed
induction of differentiation in cells and activation of programmed cell death pathways are taken into consideration
(Wang and Guo, 2021). PA is a potent inhibitor of natural and supplemental iron absorption and
Low iron absorption from cereal and legume-based complementary foods can lead to iron deficiency in infants.
It is an important factor in the etiology of deficiency. The PA/iron molar ratio should be below 1:1 and preferably...
The ratio should be reduced to below 0.4:1. To lessen the negative effect of phytic acid on iron absorption, ascorbic acid
can be added to cereals consumed with milk (Hurrel, 2004). (Mining, etc.)
Mechanical processing is suitable for seeds where phytic acid tends to localize in specific areas.
It is beneficial. This can occur directly through phytase or through the action of microorganisms like yeast in bread making.
indirectly, the enzyme process, pH and other environmental conditions are suitable, if PA
It is effective in the breakdown of proteins. PA also affects the pH solubility profiles of proteins and seeds.
It can also affect certain functional properties such as cookability (Cheryan, 1980). PA's
Its ability to chelate minerals reduces the risk of iron-mediated colon cancer in experimental animals.
It has some protective effects, such as reducing and lowering serum cholesterol and triglycerides.
It has been reported that (Zhou et al., 1995).

2.3. Aquafaba

Aquafaba means legume water, derived from the words aqua/water and faba/legumes.
(Stantiall et al., 2018). The first reports regarding the history and use of aquafaba date back to 2011. Initially, it was used
in meringue making from flaxseed gelatin as an egg substitute.
Although the result was unsuccessful, this study forms the basis of the search for egg substitutes. Furthermore...
Then in 2012, saponin extract was used for another meringue production. In 2014, a French tenor...
Joël Roessel uses red bean and palm kernel aquafaba as a substitute for egg white foam.
They made a dessert using aquafaba, but it was not found to be stable. In 2015, two French people made a dessert using aquafaba.

He prepared ganache (Stasiak et al., 2023). He is also the first American to produce vegan ganache from aquafaba.
The meringue has been made. After the addition of sugar, the foam obtained from aquafaba has stabilized and
no other stabilizers were needed (He et al., 2021). The term 'aquafaba' was coined on March 13, 2015.
The term was coined by Goose Wohlt. 'Aquafaba' consists of two Latin words: 'Aqua'
'Aquafaba' means water, and 'faba' means legume. Aquafaba is the water from the seeds of edible legumes.
Aquafaba refers to water obtained by boiling (Stasiak et al., 2023).
It is prepared by taking the boiling water from the legumes. It is made using chickpeas, beans, and black-eyed peas.
In the study, the most suitable foam consistency and protective properties were obtained from aquafaba derived from chickpeas.
It has been reported to have formed (Stantiall et al., 2018).

Properties include foam formation, gel formation, thickening, and emulsion stabilization.
Therefore, the cooking water obtained from chickpeas (aquafaba) is popular with both vegan consumers and new customers.
Aquafaba is attracting the attention of researchers and manufacturers developing food products. It has a wide pH range.
and maintains its stability within the temperature range and is suitable for various food processing applications.
It exhibits high durability. Furthermore, its lack of fat and starch makes it suitable for protein isolates and
This is an important characteristic that distinguishes it from chickpea flour. Aquafaba consists of soluble polysaccharides and phenolic compounds.
compounds, saponins and low molecular weight, water-soluble proteins (mainly
Liquid aquafaba is a diluted solution consisting mostly of polysaccharides, proteins, and albumins.
5-8% organic compounds, including saponins and Maillard reaction products.
includes and contributes to its functional properties (Mustafa and Reaney, 2020; Tachie and
(et al., 2023). A low-cost, high-value-added and technologically advanced food waste.
This is important in terms of sustainability and waste management.

2.3.1. Aquafaba Production Methods

Aquafaba preparation steps: Soaking at 4°C for 8-10 hours at a ratio of 1:4 (chickpeas:water), then 2:3 (chickpeas:water)
Cook in a pressure cooker for 30 minutes and then refrigerate at 4°C for 24 hours.
It is formed (Barros et al., 2024). Aquafaba obtained from canned chickpeas is used in homemade cooking.
It has higher foaming ability and lower emulsion properties than aquafaba.
Homemade aquafaba, however, exhibits higher stability (Meurerve et al., 2020).

The optimal wetting conditions for obtaining the best emulsion properties of chickpea aquafaba are:
Soaking at 4°C for 16 hours without adding any additives to the water. Soaking removes anti-nutrient factors from legumes.
in addition to reducing the amount of dried seeds, it also softens their texture and speeds up the cooking process.
This is done for the purpose of (Semba et al., 2021). Aquafaba is cooked by boiling it in a regular pot.

There are 3 cooking methods: microwave cooking, tempering pan cooking, and pressure cooker cooking.
This can happen. Cooking in a pressure cooker results in less foam formation.
A study examined protein, tannins, phytates , and emulsion, foaming, water, and oil retention capacity.
To maximize functional properties, including, use a 1.5:3.5 (legume-to-water) ratio.
It was concluded that the ratio and 60 minutes of pressure cooking were optimal (Jaramillo and
(Shin, 2023). Chickpeas are soaked, ground in a blender, and the filtrate is used to make aquafaba.
It is being created. The main variances of aquafaba production methodologies are significantly affected.
It has been determined that extending the cooking time does not lead to a difference in chickpeas.
A positive correlation was found between the protein concentration passing from the structure to the aqueous phase.
(Jaramillo and Shin, 2023). The most striking feature of aquafaba is its foam generation.
It is a specialty of aquafaba. Its use has become particularly popular in desserts and pastries.
When whisked, foam quickly forms, and this foam helps achieve a light structure and a fluffy texture in recipes.
Aquafaba is used in recipes to increase liquid texture or achieve a moist consistency.
is being implemented (Sala et al., 2024).

2.3.2. Biological and Physical Properties of Aquafaba

Aquafaba composition occurs through the diffusion of chemical molecules from seeds into water during cooking (He
et al., 2021). Soaking and cooking legume seeds weakens the hulls, thus
Components found in the cotyledons pass into the water (Cabezas et al., 2022). Cooking by soaking,
protein hydration and denaturation, starch gelatinization, pectin polysaccharides
This leads to its dissolution, depolymerization and loss in stages (Chigwedere and
(et al., 2018). A study conducted by the Norwegian Food Research Institute (Nofima).
In the study, the chemical composition of aquafaba was examined; chickpea water's protein and carbohydrate content was investigated.
It has been reported to contain significant levels of lipids, but no lipids.
However, the amount of digestible carbohydrates in chickpea water is minimal.
It has been determined that (Esendemir et al. (2025). Aquafaba obtained from chickpeas
Its foaming is due to the saponins present in its structure (Oakenfull et al., 2023).
Aquafaba's emulsifying activity and stability index, gelling properties, and water and oil absorption
Its capacity is higher than other legumes (Oktay and Gözükÿrmÿzÿ, 2023). Similarly
Aquafaba replaces multiple functions of egg because it has multiple properties such as foaming, emulsifying
and gelling (Özer et al., 2025). In aquafaba proteins
High emulsifying power is an indication of a less compact structure and higher resolution;
This has increased the ability to form interface membranes around oil droplets. In aquafaba
Emulsifying properties depend largely on the chickpea variety, canning process conditions, and additives.

It is related to the amounts of protein, carbohydrates, saponins, and phenolic compounds, as well as their thermal properties.
The processes affect the functional properties of aquafaba (Oktay and Gözükÿrmÿzÿ, 2023).
As you whisk, aquafaba becomes frothy and provides binding properties. This way, you can make it without using eggs.
It can also provide the desired consistency to the products, as well as the cooking water for legumes.
This will contribute to its evaluation (He et al., 2021). Highest foam volume
It is stated that foam stability also reaches its highest value when mixed.
As the duration increased from 9 minutes to 12 minutes, the foam volume decreased and air...
They measured that the size of the bubbles increased as a result of their merging (Jakubczyk and Niranjan, 2006).
When the aquafaba obtained from chickpeas is compared to the cooking water of other legumes, chickpeas...
The emulsification capacity of aquafaba and whole green lentil cooking water, dried beans,
significantly more compared to the cooking water of split yellow peas and yellow soybeans
It has been observed that it is high (Sarÿoÿlu and Velioÿlu, 2018). Commonly, foam formation
Examples of proteins used for this purpose include casein, whey, lactoferrin, and egg white.
While they can be given, lentils, soy, peas, potatoes and legumes are used less frequently.
Proteins can also be given as an example (Ellis and Lazidis, 2018). A study
It shows that the viscous liquid and stable foam filtered from canned or cooked chickpeas,
Emulsions and gels can be produced (Alifaki, 2013). Obtained by heat treatment of legumes.
Aquafaba, which is obtained, plays a role as an egg substitute in vegan and vegetarian diets; it has
Due to its binding and thickening mechanisms, it is frequently used in food formulations.
It is preferred. This byproduct has become popular among food enthusiasts who identify substances that can
potentially replace eggs (He et al., 2021). Human health problems
And because of concerns (phenylketonuria, egg allergy, cholesterol, etc.), different diets,
Economic and sustainability issues are leading consumers to consider plant-based egg alternatives.
This has led to its use in terms of criteria such as volume, cooking loss, color, porosity and taste.
The aquafaba option produced from chickpeas is suitable for this (Yazÿcÿ et al., 2023). Aquafaba,
High stability against repeated freeze-thaw cycles and thermal treatments.
This shows that products made with legumes produce 35% less greenhouse gas compared to those made with eggs.
It has been reported that aquafaba produces a gas (Maphosa and Jideani, 2017). In this sense, aquafaba is a protein.
without the need for isolates, edible gums or modified starches, the next generation
Attention in the food industry to natural substitutes and egg and dairy-free labels.
It is drawing attention. While the foam density increases with the addition of aquafaba, the need for eggs decreases.
is decreasing (Aslam et al., 2024). Aquafaba protein content is lower than egg yolk.
However, aquafaba proteins aggregate at the water-oil interface and stabilize emulsions.
It forms an intermolecular cohesive film with sufficient elasticity to withstand the process (Jaramillo and

(Shin, 2023). Aquafaba has high gel-forming ability and forms stable gels.
This functional property depends on the legume's composition, genotype, cooking time, pressure, and temperature.
It depends (Barros et al., 2024).

2.3.3. Nutritional Importance of Aquafaba

Aquafaba is a sustainable rheological additive. It is specifically formulated for its functionality.
prepared plant protein, soy milk or hydrocolloids such as aquafaba, other rheological additives
Unlike these ingredients, legume preserves, boiled legumes, hummus production, and frozen legumes are used.
It is a byproduct of legume production processes. Examples include dried beans, chickpeas, and broad beans.
Legumes such as lentils and dried peas contain 20–30% protein, primarily from lysine.
It is rich in nutrients (Shim et al., 2021). The functional properties of aquafaba are mainly due to its proteins, which are soluble in water.
They originate from soluble and insoluble carbohydrates, polysaccharide-protein complexes, coacervates, saponins,
and phenolic compounds (Özer et al., 2025). Coacervates,
various organic molecules come together in an aqueous environment as a result of hydrophobic interactions
They are defined as the small droplet structures formed. In the coacervation method...
They are used, which is a physicochemical method of encapsulation technology (Köksal and
Göde, 2017). Aquafaba, 2.03-2.59 g/100 mL carbohydrates, 0.08-2.8 g/100 mL protein and 0.07-
It contains 0.1 g/100 mL of fat (Barros et al., 2024). Aquafaba is suitable for those who cannot consume eggs.
Individuals are provided with a suitable alternative that can replace eggs. Those following a vegan diet.
Since they do not consume any animal products, consuming foods containing eggs such as cakes, biscuits, and
cookies poses a problem (Özer et al., 2025). Aquafaba has many different uses.
Its product range includes bakery products, sauces, ice cream, legume-based cheeses, and
Legume-based milk substitutes exist (Wÿodarczyk et al., 2022). Chickpea aquafaba
Nutritional content is shown in Table 2.3.

Table 2.3. Aquafaba Nutritional Content of Chickpea (Jaramillo and Shin, 2023)

Component	Chickpea Aquafaba (g/100 g)
Protein	0.39
Carbohydrate	3.28
Mineral Substance	0.01
Total Polyphenols	0.03

2.4. Biscuits

The word biscuit is derived from the Latin phrase "panis biscoctus," meaning "twice-baked bread."
It means and historically refers to types of durable bread produced for sailors.
It has been used to make (Arepally et al., 2020). Today, biscuits are a staple food, a luxury item .
gifts, snacks, baby food, diet products, dog and cat food, and chocolate,
Served as products garnished with added cream, hazelnuts, and other flavors.
This is due to the evaporation of water, protein denaturation, and partial loss during the biscuit baking process.
starch gelatinization, browning events associated with Maillard reactions, and dough
Various physical and biochemical reactions, such as deformation, occur in its structure.
(Boobier et al., 2006). Sensory and chemical properties of biscuit according to TS 2383 are given in Table 2.4.
This has been demonstrated (TS 2383, 2017).

Table 2.4. Sensory and Chemical Properties of Biscuits According to TS 2383.

Features	Borders
Color, taste and smell	The biscuits should have their own characteristic color and aroma; they should not contain any foreign tastes or odors, and should not have a bitter or soapy taste.
Structure and appearance	The biscuits should have a crispy texture and a homogeneous appearance; they should not be dirty, stained, or physically damaged.
Foreign substance	It should not be there.

A biscuit recipe consists of main and secondary ingredients: flour, oil, sugar, water, and chemical leavening agents.
(sodium bicarbonate, ammonium bicarbonate) are the main components, while salt, eggs, and emulsifiers are also used.
Milk powder and flavoring compounds are used as optional by-products (Mancebo) .

(et al., 2015). Flour is the basic ingredient for bakery products such as bread, cakes, cookies and pastries.
It is one of the components and consists mainly of starch, protein and water. In biscuit production, however...
The functional properties of these components are of great importance (Pareyt and Delcour,
(2008). Wheat flour is the most important because it affects the physicochemical properties of the dough.
It is a component. The most important component of a wheat grain is protein. Storage proteins (gliadin and
Gluten is the main component that determines the viscoelastic properties of dough in the production of various food products.
These are important fractions. Glutenins, one of the main components of gluten, determine the properties of dough.
and plays an important role in determining the end-use quality. Poor gluten quality.
This is a desirable characteristic for the final biscuit product. The baking performance of bread and biscuits depends on the flour.
It depends on its quality. Biscuits are based on the composition of chemicals in the flour (Zhou et al.,
(2018). Incorrect starch and protein levels affect the water absorption properties of flour. Unlike bread,
The starch granules do not form a continuous gel network in the biscuit system; instead, they act as a filler in the matrix.
It acts as a component. Additionally, the moisture content of the flour and the water added during dough preparation also play a role.
The quantity has different effects on the rheological and physical properties of the biscuit dough.
(Pareyt and Delcour, 2008). Biscuit quality (lower thickness and hardness, higher diameter,
(Spread rate and sensory score) were improved with the addition of starch. The starch content is being increased.
The proportion of wheat flour is reduced, and since the gluten content is also reduced, the quality of the biscuits improves.
It is observed that (Liu et al., 2022). Low protein content (8-10%), low water absorption and
Low deformation resistance defines the suitability of wheat for biscuit production.
These are the properties used (Pedersen et al., 2004). The particle size of the flour is a key factor in biscuit properties.
This is an important factor, and its effects vary depending on the dough type. Excessive biscuit base
Its spreadability is related to the finer particle size of the softer flour. Finer flour results in higher spreadability.
It produces high-density biscuits (Mancebo et al., 2015). Sugar, in addition to its sweetness, has structural and
It functions as a flavor modifier and enhancer. Sugar, depending on the presence of water...
It dissolves completely or partially in the biscuit dough and reappears after baking.
It exhibits crystallization. During cooking, undissolved sugar crystals gradually form.
It melts, which makes it easier to spread the dough. During cooling, the sugar...
It contributes to the development of the biscuit's crispy texture by forming a glassy structure.
In addition, crystal size and the rate at which sugar dissolves affect the crispness of the baked biscuit (Ay
(et al., 2025). Increasing the amount of sugar improves the hardness and appearance of the biscuit.
Excessive sugar leads to a decrease in consistency and cohesion, causing the dough to soften.
The high concentration and finer particle size of the sugar significantly improves the biscuit's quality.
It contributes to the spread of sugar, by controlling hydration, protein and starch molecules.
By dispersing it and preventing the formation of a continuous mass, it makes the product brittle. Biscuit

The most commonly used sugar in cooking is sucrose, and it is used in the production of biopolymers such as starch and gluten.
It has a major influence on their transitions (Van der Sman and Renzetti, 2019). Oil, flour and
Sugar is the third largest ingredient in dough after biscuits, providing softness and mouthfeel.
It is mostly fat-dependent. During mixing, fat inhibits hydration and gluten development.
Additionally, it forms a coating layer around the flour particles, removing carbon dioxide from the dough.
It inhibits the fermentation effect of diffusion (Davidson, 2023). In addition, the oil product in the mouth
The melting, crumbly texture provides food quality and flavor. The most commonly used oils contain lauric acid.
Oils rich in these nutrients include sunflower oil and palm oil. Butter, margarine, and various vegetable oils are also good choices.
These oils belong to the group of oils generally referred to as shortening oils in the baking industry.
Shortenings prevent gluten and starch granules from sticking together and improve cooking quality.
then it forms a softer and more uniform shape (Mert and Demirkesen, 2016).
Trans fats are unsaturated fatty acids produced naturally or industrially through the partial hydrogenation of
vegetable oils . The WHO recommends limiting trans fat intake to less than 1% of total energy intake . A significant
source of trans fat in the human diet is biscuits, cakes,
These are baked goods such as cookies and bread (Wanders et al., 2017). Fat and oil are used in the dough.
It contributes to its flexibility. Sufficient fat in the dough coats the flour particles.
and by preventing the development of the gluten network, the dough becomes softer and loses its elasticity.
This causes a decrease. However, in doughs with low water content, the fat content...
Thanks to its lubricating effect, adding 15-20% oil results in a more homogeneous and smoother finish.
It ensures the formation of the dough structure. Insufficient amount of fat affects the consistency of the dough.
It enhances cohesive, elastic, and adhesive properties (Sudha et al., 2014). For the production of 100 g of biscuits.
The standard prescription is shown in Table 2.5 (Kÿzÿlaslan, 2020).

Table 2.5. Standard Recipe for Producing 100 Grams of Biscuits

Component	% Ratio
Reputation	40-45
Oil	10-15
Sugar	25-30
Embossing	5
Egg	5-10

2.4.1. Egg

An egg is a round egg produced by female animals, especially birds, for reproductive purposes.
It is a biological product with an oval shape. The eggs of different animal species are used as food.
Although edible, the term egg most often refers to chicken eggs.
It is used (Tarantul and Eliseeva, 2020). Egg; approximately 9.5% shell, 63% egg.
It consists of egg white and 27.5% egg yolk. Eggshells are a source of minerals.
Egg whites are rich in high-quality protein, while egg yolks contain fat and nutrients.
It is considered an important and functional biological component in this respect. Furthermore...
Egg components have antibacterial, antiviral, and protective effects against certain diseases.
It is reported to contain bioactive compounds that can show nutritional value.
When evaluated, one egg provides approximately 7.5% of the daily fat requirement, saturated fat.
It meets 8% of the daily requirement and 7% of the daily cholesterol intake. Vitamin content
In terms of nutritional content, egg yolks contain vitamins A, D, E, and K, while egg whites contain vitamins B1 and B12.
It contains vitamins. Vitamins B2 and B9 are found in both egg whites and eggs.
It is found in the yolk (Yüccer et al., 2012). Among the alternatives used instead of eggs...
Hydrocolloids such as xanthan, guar, and gum arabic, as well as soy, sunflower, pea, and legume oils.
proteins, as well as applesauce, aquafaba, flaxseed, tofu, ripe banana, and tapioca starch.
These alternatives mimic the functional properties of egg proteins.
because they can do this and enable the production of products with lower cholesterol.
is preferred (Kilci, 2023). Egg white proteins and their properties are shown in Table 2.6.
This has been demonstrated (Yüccer et al., 2012).

Table 2.6. Egg White Proteins and Their Properties.

Protein	Percentage of egg white (%)	Functional Properties of Protein
Ovalbumin	51-54	It is a phosphoglycanone protein.
Ovotransferrin (Conalbumin)	12.00	It binds metal ions. Enzyme It is an inhibitor.
Ovomucoid	11.00	It inhibits trypsin.
Ovomucin	3.50	It is a sialoprotein. It gives egg white its viscous structure.

Lysozyme	3.40	Lysis of the cell wall It "lyses" proteins.
Globulin	8.00	It inhibits proteases.
Ovoinhibitor	1.50	It inhibits serine proteases.
Ovoglycoprotein	1.00	It is a sialoprotein.
Ovoflavoprotein	0.80	It binds riboflavin.
Ovomacroglobulin	0.50	It possesses strong antigenic properties.
Cystatin	0.05	Thiol inhibits proteases.
Avidin	0.05	It binds biotin.

Consuming two large eggs a day provides approximately 20% of an individual's daily protein requirement.
8% of energy requirements, 10% of calcium requirements, phosphorus and iron.
It meets 20% of the requirement. Cholesterol is found only in egg yolks.
A large egg contains approximately 200–220 mg of cholesterol. Commercial eggs...
Eggs are rich in omega-6 fatty acids but have limited omega-3 fatty acid content (Açÿkgöz and Önenç, 2006).
It is reported that approximately 30% of eggs produced today are converted into processed products. Processed egg products include omelets, cooked eggs, etc.
While it is used as a basic ingredient in products such as peeled eggs and mayonnaise, ice cream,
It is also found in small amounts in confectionery, pasta and bakery products, but the final product...
It has significant effects on the characteristics of the egg (Güner and Telli, 2021).
By being used as an emulsifier, the lecithin it contains reduces the surface tension between water and oil.
By reducing the amount of emulsions, it facilitates their formation. Therefore, egg yolks, mayonnaise, salad dressings...
It is used in sauces, bread, biscuits, cakes, pastries and many other food products (Huopalahti et al., 2007).

2.4.2. Egg allergy

The United Nations Food and Agriculture Organization (FAO) and the WHO have identified immunoglobulin E (IgE) mediated
With the guidance of a specialized expert focusing on reactions, eight main categories of food allergens.
They identified the following: eggs, milk, peanuts, sesame seeds, flour, fish, and shellfish.
Egg allergy, according to some studies conducted on childhood allergies, is different from cow's milk allergy.

It ranks second, and in some studies, it is considered the most common food allergy.

(Seidita et al., 2025). Egg allergy is a condition in which the body produces a substance in both the egg white and the egg itself.

It occurs as a result of an overreaction to the proteins found in the yolk. There are four main proteins in the egg white.

Protein is a factor that causes egg allergies. Egg yolk proteins are present in egg whites.

It has been reported to be less allergenic compared to proteins (Dona and Suphioglu, 2020).

The allergenic proteins found in egg whites are ovomucoid, ovalbumin, ovotransferrin, and lysozyme.

The yolk contains alpha livetin and YGP42 proteins, which are allergenic. Egg yolk allergy.

It is more common in adults (Tan and Joshi, 2014). Intense heat during cooking

Heating reduces the allergenicity of the protein and access of the allergen through interaction with the food matrix.

By reducing the allergenicity of egg proteins, heat treatment also reduces their allergenicity (Samady and

(et al., 2020). The allergenic properties of egg white proteins are shown in Table 2.7.

Table 2.7. Characteristics of Egg White Allergens (Caubet and Wang, 2011)

Allergen Protein: Egg White %		**Heat Treatment (IgE) Attachment Activity)**	**Allergenic Activity**
Ovomucoid (Gal d 1)	11.00	Stable	High
Ovalbumin (Gal d 2)	54.00	Unbalanced	Middle
Ovotransferrin (Gal d 3)	12.00	Unbalanced	Low
Lysozyme (Gal d 4)	3.40	Unbalanced	Middle

Egg allergy should be assessed based on whether the product has undergone heat treatment or not.

Some individuals with allergies can tolerate excessively heated or cooked eggs.

It has been reported that it can affect life (Sibincic et al., 2025). In egg allergy, sudden onset and life-threatening

Clinical presentation varies widely, ranging from threatening reactions to conditions that develop in the chronic process.

Tables can be seen. In egg allergies that appear in infancy, clinical symptoms may be observed.

Symptoms usually include skin manifestations (Gallagher et al., 2025). Egg allergy

Eggs and egg products should be completely removed from the diet of patients who have received a clinical diagnosis.

Because of the potential for tolerance to allergens to develop over time, patients should have them tested at regular intervals.
Evaluation by allergy specialists, form of egg consumption (baked,
(boiled, etc.) and optimizing the quantity under expert control is of great importance (Ünsal and Soyer, 2021). In
infancy, the first presentations of patients are mostly due to urticaria and atopic dermatitis.
It manifests with dermatitis symptoms; however, anaphylactic reactions are also reported in the literature.
Cases of persistent symptoms have also been reported. Clinical features and laboratory tests of egg allergy.
Findings may vary depending on age. Respiratory symptoms are more pronounced in patients over 2 years of age. This
Therefore, clinical features and diagnostic tests should be evaluated taking age groups into consideration.
(Nacaroÿlu et al., 2016). Chicken egg allergy is the most common food allergy in Western countries.
Egg allergy is one of the allergies and its incidence is increasing. So far, egg allergy accounts for 1.6% to 1%.
It is estimated to affect 10.1% of the population and 9.5% of children. The onset of the disease is most common.
It is seen in the first year of life. Egg allergy is generally seen in 1.2-2.9% of children by the age of 2.
It has been found to have a prevalence of 80% in 3-year-olds and 5-6-year-olds.
Natural solubility is estimated in 38-90% of children. Clinically excessive egg-tolerant reactions.
Susceptibility is observed in 60% of children aged 6–12 years (Caffarelli et al.,
(2022). Tolerance to baked eggs is better than other egg cooking methods.
Egg allergy can lead to clinical conditions such as anaphylaxis and severe chronic gastroenteropathy.
It is considered a significant health problem because of its potential to cause complications. The measures to be taken...
Elimination diets can lead to inadequate and unbalanced nutrition and increase the risk of developmental delay.
It can increase. In addition, egg allergy, regardless of symptom severity, can affect children and
It reduces the quality of life by limiting the social activities of parents (Samady et al., 2020).
The contents of 1 medium-sized (44 g) hard-boiled egg are shown in Table 2.8 (Caffarelli et al.,
2022).

Table 2.8.1 Content of a Medium-Sized (44 g) Hard-Boiled Egg.

Nutrient	Amount
Protein	5.50 g
Total Fat	4.20 g (1.40 g of which is saturated fat)
Cholesterol	162.00 mg
Sodium	189.00 mg
Phosphorus	86.70 mg
Potassium	60.30 mg

Calcium	24.60 mg
Magnesium	5.30 mg
Iron	0.80 mg
Lutein and zeaxanthin	220.00 ÿg
Folate	15.40 ÿg
Selenium	13.40 ÿg

2.5. Vegan Diet

Vegetarian diets involve consuming primarily plant-based foods and limiting animal products.
Vegetarian diet is a type of diet associated with consuming or not consuming certain foods.
They are divided into different groups according to their permitted or tolerated nutritional content. These are: Lacto
vegetarian, lowland vegetarian, lacto-lowland vegetarian, polo vegetarian, pesco vegetarian, semi
Vegan diets are diversified into vegetarian and vegan options (Bakaloudi et al., 2021). Vegan diets, however...
It is based on not consuming any animal products. Within the framework of a vegan lifestyle,
In addition to rejecting the consumption of animal products; by-products of animal origin such as silk, wool, and leather.
The products and cosmetic materials with similar components are also not used (Gökçen).
(et al., 2019). A vegan diet is primarily derived from vegetables, fruits, grains, and legumes.
It consists of nutrients. However, poorly planned vegan diets often lack dietary fiber.
Imbalances in intake and food choices lead to insufficient energy and protein intake.
This can be the reason. A high-fiber diet affects macronutrient balance.
Together, they cause gastric distension (stomach tightness), delaying gastric emptying, and
It suppresses postprandial (post-meal) glycemic fluctuations (Wang et al., 2023).
A vegan diet can provide some vitamins and minerals such as vitamin B12, calcium, iron, and zinc.
The required level cannot be met. One-third of daily protein intake comes from animal sources.
Essential amino acids must be obtained from food. Fruits, vegetables, and grains are limited in essential amino acids.
(Kniskern and Johnston, 2011; Neufingerl and Eilander, 2021). Fish consumption in vegan diets.
Because of this, they are deficient in omega-3 fatty acids. Vegans, compared to non-vegans...
Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) intakes are low (Koutenakis
et al., 2023). Since vegetable oils are consumed in excess, omega-6 intake is high. Vitamin B12
It is found in animal-derived foods, but not in plant-based foods, therefore this type of diet...

Deficiency is observed in individuals. Vegans should take regular vitamin B12 supplements (Richter et al.,

(2016). In the absence of calcium obtained from milk and dairy products, there is a deficiency, which can be compensated for by green leafy vegetables.

Iron intake should be obtained from vegetables, grains, and legumes. Vegetarians need iron.

A deficiency may occur, and even if this is met from plant sources, it may not be sufficient; plant-based iron...

Its bioavailability is low (Weikert et al., 2020). Zinc is obtained from animals such as red meat, liver,

Zinc is found in fish, milk, eggs, and cheese. Zinc absorption from plant sources is due to PA (polymerase).

It is less than that from animal sources. PA is obtained through sprouting, fermentation, fermentation, and soaking.

The amount is reduced (Gökçen et al., 2019). Vegan diet models are shown in Table 2.9.

It has been shown.

Table 2.9. Vegan Diet Models (Bakaloudi et al., 2021).

Diets	Consumed
Lacto-ovo vegetarian	Apart from eggs, dairy products, and honey, no other animal products are consumed.
Lacto-vegetarian	Apart from dairy products and honey, no animal products are consumed.
Ovo-vegetarian	No animal products other than eggs are consumed.
Polo-vegetarian	Only poultry is consumed.
Pesco-vegetarian	Fish, dairy products, and eggs are consumed, while meat and chicken are not.
Vegan	No animal products are consumed or used.
Rawists	No animal products or food cooked above 46°C should be consumed.
Fruitarians/ Fruit-fed	Only unprocessed fruits and foods that are botanically considered fruits are consumed.
Flexitarian	While plant-based foods are primarily preferred, animal products are also consumed for a balanced diet.
Zen Macrobiotics	They are divided into two groups; some consume grains, legumes, fruits, and vegetables in their diets, while others consume only grain products.

Since vegans do not consume animal products, it is necessary to produce foods specifically for them. Vegan

Individuals adopting this diet produce their own food and consume animal products

Starting to prepare their food substitutes at home creates a financial advantage in food expenses.

In this context, while veganism can optimize food expenses, it also has implications for the kitchen.
It has a two-way effect, increasing labor and time costs, focusing on the time spent.
It is seen (Aksürmeli and Beÿirli, 2019). Different recipes suitable for vegans and beneficial to health.
Alternatives are being created.

MATERIALS AND METHODS

3.1. Materials

The flour, chickpeas, sugar, margarine, baking powder, and eggs used in the biscuits are locally sourced in Erzincan province.
It was obtained from markets. Aquafaba was purchased with Duru brand chickpeas, also known as Koçbaÿÿ type chickpeas.
Prepared using Sinangil brand white wheat flour. High protein content.
While softness is ensured, low-protein flours create crispness. Torku brand powdered sugar and Ülker Bizim brand
margarine were used. Kent brand baking powder was also used.
It contains leavening agents (sodium acid pyrophosphate and sodium bicarbonate) and corn starch.
Keskinoÿlu brand eggs were used.

3.2. Method

Aquafaba production was carried out using a household Arçelik RHB 6050 S brand mixer. Biscuit
Weight measurements of raw materials used in production and of biscuit samples obtained.
This was done using an Ohaus Pioneer brand precision balance.

In the study, two different types of biscuits were used, one containing aquafaba and the other containing egg whites.
The formulation has been prepared. The foaming agent component used in both formulations.
The proportion in the total formulation was determined to be 12.5%. In the formulation containing aquafaba...
12.5% aquafaba in the formula, and 12.5% egg white in the control formulation.
It has been used.

Eggs are an important ingredient in biscuit production for creating a high-quality foam structure.
Egg white is considered a component of the biscuit structure (Manley, 2011).
It is used as a component that contributes to its development (Uyar, 2021). Aquafaba
Because it exhibits foam-forming properties similar to egg white, aquafaba was used in the study.

In order to compare the biscuit sample prepared with egg whites, a control group was used.

It was prepared using [methods].

3.2.1. Creating a Biscuit Recipe

The aquafaba and control biscuit recipes were created using standard baby biscuits as a model.

Table 3.1 was created by adjusting the percentage ratios according to the standard biscuit recipe.

Table 3.1. Percentage Ratios of Aquafaba and Control Biscuit Recipes

	Flour, Sugar, Margarine, Leavening Agent, Aquafaba, Eggs				**Flux**
Aquafabalÿ (453)	49.40 21.50	16.10	0.50	12.50	-
Control (386)	48.40 22.10	16.50	0.50	-	12.50

3.2.2. Preparation of aquafaba

Preparation of aquafaba and egg (control) biscuit samples after material procurement

The process was carried out. The chickpea water required for the aquafaba biscuit was prepared. For this process, 120 g chickpeas were soaked in 800 mL of distilled water at 25 C° room temperature for 16 hours.

Afterwards, they were strained and washed twice under tap water. The chickpeas were placed in a pressure cooker at 400 mL of water was added and boiled for 30 minutes. After the boiled chickpeas cooled to standard room temperature...

Then the water was strained and it was left in the refrigerator for 12 hours (Figure 3.1). The resulting chickpea boiling water...

It basically consists of the aquafaba used. This chickpea boiling water is kept in the refrigerator at 4°C.

It was stored for 3 days and used for analysis (Bekdemir, 2023).

Shape

3.1. Aquafaba (Chickpea Cooking Water) Preparation Scheme

3.2.3. Preparation of Biscuit Samples

100 mL of the cooled aquafaba is poured into a beaker and whisked with an Arçelik RHB 6050 S whisk.

The frothing process has been carried out. There is no trace of the yellowish liquid chickpea water.

The mixture is whipped until it becomes a completely white, foamy consistency. 160 g of powdered sugar is added and mixed from bottom to top using a spatula.

It was stirred slowly without letting the foam disappear. Then 120 g of margarine was added in small pieces.

It was added in chopped pieces and the mixing process was continued. 355 g flour and 5 g

Baking powder was also added and the dough was kneaded. The resulting dough was divided into equal 30 g pieces,

The dough will be shaped into round balls, each 60 mm in diameter and 10 mm thick.

They were shaped to the desired size. The formed biscuits were placed on a baking tray and baked for 35 minutes.

It was cooked in an Arçelik AFC 331 B oven at 160°C on the middle rack.

The aquafaba biscuits were removed from the oven and left to cool. The control biscuits were prepared in the same way.

All steps for its formation were repeated. In this step, 90 mL of egg white was used instead of aquafaba.

It has been used.

(a) (b)

Figure 3.2. Appearance of Aquafaba (a) and Whipped Aquafaba (b).

3.2.4. Physical Analysis of Biscuits

3.2.4.1. Diameter and Thickness Measurement

Diameter and thickness measurements of aquafaba and control biscuit samples were taken using a caliper. The measurements were taken in triplicate. Diameter and thickness values were used to obtain the results. Four different biscuits were measured and their averages were taken (Mustafa et al., 2018).

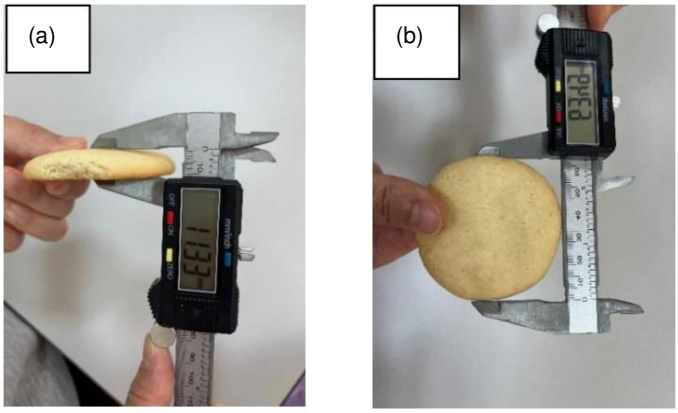

Figure 3.3. Performing (a) Thickness and (b) Diameter Measurements of Biscuits.

3.2.4.2. Measurement of Spread Rate

The spreading ratio is calculated to determine the physical properties of the formulations;
The diameter values of the biscuit samples were obtained by dividing their thickness values (Demir., 2015).

$$\text{Spread ratio} = \text{Diameter}/\text{Thickness} \quad (3.1)$$

3.2.4.3. Weight Measurement

Baking loss rate (%, wet weight), weight of dough before baking and after 30 minutes.

It is defined as the difference between the weight of the biscuit at room temperature and the weight after cooling.

(Demir, 2015). Biscuit measurements were performed in triplicate. Aquafaba and control biscuits.

The samples were weighed using a precision balance.

3.2.4.4. Measurement of Foam Capacity and Foam Stability

Foaming Capacity (FC) and Foam Stability (FS) analyses compared to egg white.

This was determined by taking 15 mL of aquafaba and 15 mL of egg white and boiling them in Arçelik for 10 minutes.

The samples were whipped with an RHB 6050 S whisk. The foam volumes of the whipped samples were determined as initial (H0) and

Calculations are made by measuring after 30 minutes (H30) (Mustafa et al., 2018). Aquafaba and control.

Biscuit measurements were taken in triplicate.

$$\%KK = (H0/\text{aquafaba ml}) \times 100 \quad (3.2)$$

$$\%KS = (H30 / H0) \times 100 \quad (3.3)$$

A 100 ml measuring cylinder was used to measure the foaming capacity. Liquid aquafaba and

Egg whites were transferred separately into 15 mL beakers. Aquafaba biscuit foam capacity

For measurement, 15 mL of aquafaba is whisked in a beaker, at the initial whisking speed.

It is whisked for 5 minutes, then the speed is reduced to level two and whisked for another 5 minutes. After a total of 10 minutes of whisking...

And after the foam consistency was achieved, it was transferred to a measuring cylinder and the value was measured, initially.

It was recorded. After waiting 30 minutes, the amount of foam remaining in mL at the end of 30 minutes was recorded.

Biscuit measurements were taken in triplicate.

(a) (b)

Figure 3.4. 10 mL Aquafaba (a) Initial Volume, (b) Initial Volume After Whipping (Hÿ) and (c) Volume 30 Minutes After Whipping

The same process was carried out on the egg white.

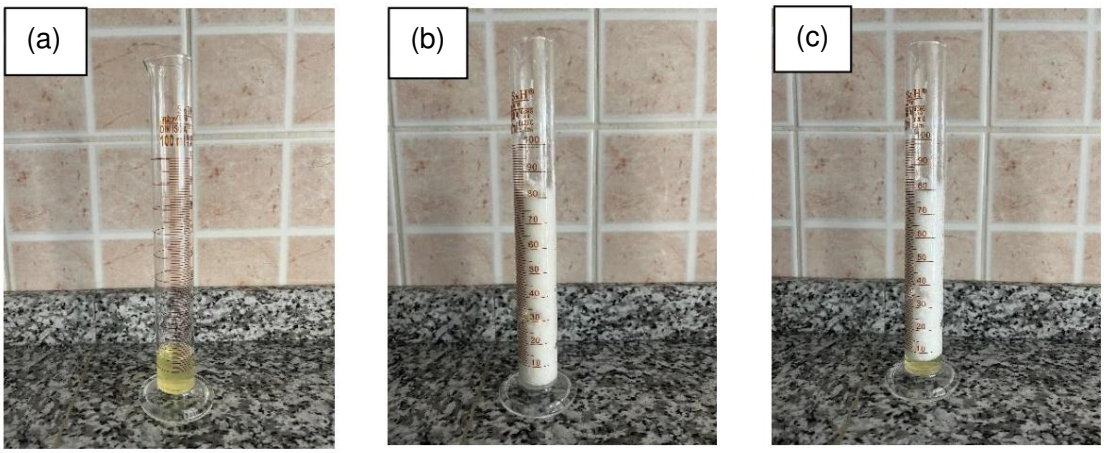

Figure 3.5. 10 mL Egg White (a) Initial Volume, (b) Initial Volume After Whipping (Hÿ) and (c) Volume 30 Minutes After Whipping

For foam stability, the foam volume after 30 minutes is divided by 100 to the initial foam volume.

It was found by multiplication. Foam capacity in aquafaba and control biscuit samples.

Measured values were used (Mustafa et al., 2018).

$$\%KS = (H30 / H0) \times 100 \quad (3.4)$$

3.2.4.5. Color Measurement

Standard, adjusted to CIELAB coordinates [L* (openness), a* (redness) and b* (yellowness)].

Illuminator A is a Hunterlab Mini Scan XE colorimeter with a standard observer angle of 10°.

Determined using Hunter Associates Laboratory (Reston, VA). The device was used for color control.

for black and white tiles (X = 79.1, Y = 83.8, Z = 89.4) and a pink tile (L = 76.2,

a = 25.7, b = 17.4) were standardized. Biscuit crumbs (30 g, 40 mm, 15 mm) were placed in the middle.

The portion was measured three times, with three repetitions for each sample and hours between readings.

It was rotated 90° in that direction (Mustafa et al., 2018).

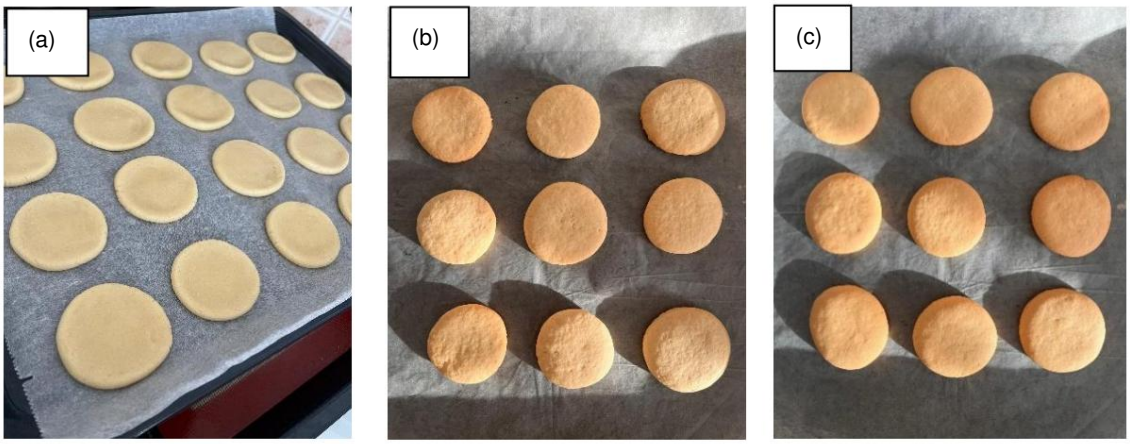

Figure 3.6. Color Appearance of Biscuits (a) Before Baking, (b) After Baking with Aquafaba and (c) After Baking Control Biscuit.

3.2.5. Proximate analyses

3.2.5.1. Moisture Content

Biscuit moisture content was determined according to the AACC method 44-19.01 (AACC, 2000) for 16-18 hours.

Biscuits before and after drying in an air oven at 100±2 C° until they reach a constant weight.

The calculation was made by taking the weight difference of the samples (Olcay and Demir, 2022).

3.2.5.2. Carbohydrate Determination

Carbohydrate determination was performed using the differential method. Protein, fat, and carbohydrate content in the food were also analyzed.

The carbohydrate content was determined by summing the ash content and subtracting it from 100 (Engi, 2024). Control

The same calculations were performed for the biscuit.

%CHO=100-(%fat+%protein+%ash+%moisture) (3.5)

3.2.5.3. Protein Determination

Protein determination was performed according to the AOAC 2001.11 analytical method. The basic principle of this method is; The organic nitrogen in the sample was burned in the presence of a copper catalyst to produce ammonium, which was then vaporized. It is collected in boric acid by distillation and titrated (Erken et al., 2020).

3.2.5.4. Fat Determination

Fat determination was determined according to the TS 6180 EN ISO 3947 analytical method. This method is particularly suitable for fat determination. It is designed for the analysis of starch samples with a content below 1.5% and is accepted as the reference method (Üzümcü and Özsisli, 2023).

3.2.5.5. Nutritional Value

The total calories (kcal) of the samples represent the carbohydrates of all raw materials included in the formulation. based on the principle of summing the caloric values from protein and fat components energy values of the control sample were calculated using the same method (Rakÿcÿoÿlu et al., 2000). It has been determined.

Energy (kcal/100g) = [9x(%fat)]+ [4x(%CHO)]+ [4x(%protein)] (3.6)

3.2.5.6. Determination of Ash Insoluble in Hydrochloric Acid (HCl)

Ash content was determined according to the TS 2383 analysis method. This method determines the total ash content in biscuits. It was used to determine the quantity and thus the quality of the food (Mut et al., 2024).

3.2.6. pH Measurement

The pH values of biscuits containing aquafaba and a control group were measured separately (Hanna Instruments, USA). Prior to measurement, pH 7.00, 4.00 and 10.00 buffer solutions were used with a pH meter. It was calibrated using three parallel pH measurements of the biscuit samples. This was carried out. Before preparing the biscuit samples, the aquafaba and The pH values of egg whites were measured. The pH values of biscuit samples containing aquafaba were also measured. In determining this, 10 g of biscuit crumbs, ground and homogenized, are taken and added to 90 mL. It was mixed with distilled water and the mixture was homogenized for 1 minute. The resulting

The mixtures were left to stand for 1 hour at 4 °C to allow for the separation of the solid and liquid phases. and then the pH value of the upper phase was measured (Aksoy, 2021). Biscuits containing egg white. The same method was applied to determine the pH values of the samples.

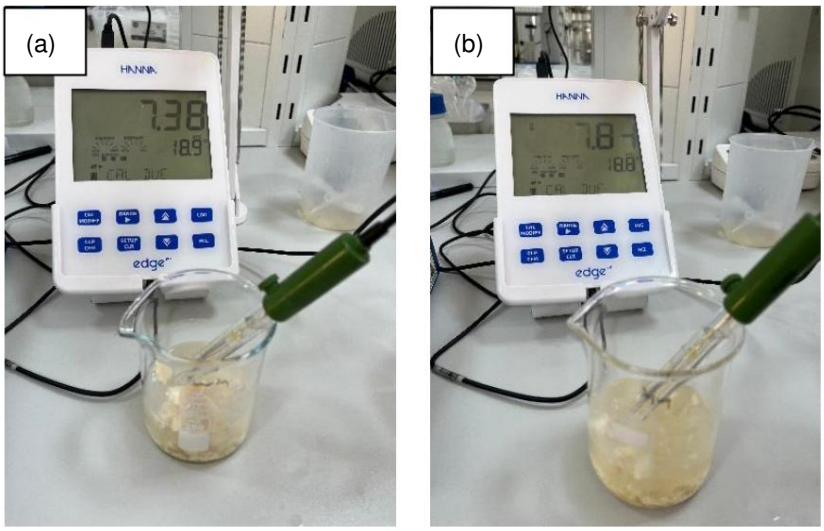

Figure 3.7. (a) Aquafaba and (b) Egg White pH Measurement.

3.2.7. Texture Profile Analysis (TPA)

The TA.XT Plus Texture Analyzer device was used for TPA analysis. Devices like the TA.XT Plus... Hardness and brittleness values of the biscuit are determined using cylindrical or blade probes. This analysis examines the hardness, stickiness, and elasticity values of the biscuits. (Tugan et al., 2022).

Figure 3.8. Biscuit Measurement with TA-XT Plus Device .

3.2.8. Determination of Hydroxymethylfurfural

To determine 5-HydroxymethylFurfural (HMF), a 6.9 g sample was taken and diluted with distilled water for 50 minutes.
The samples were diluted to ml. The samples were then filtered through a 0.45 ÿm filter to remove impurities.
The samples were passed through a membrane filter. The samples were then processed through an HPLC instrument (HPLC, Agilent).
(Technologies, California/USA) was injected. The amount of HMF in the samples varied.
Quantitative analysis using a calibration curve prepared with HMF standard at specific concentrations
The mobile phase was defined as 80% distilled water and 20% methanol at a flow rate of 1 ml/min.
It was prepared with chromatographic separation at room temperature using a DAD at a wavelength of 285 nm.
This was performed in a detector. The column specifications used are: C18, particle diameter 3 ÿm,
Column L × ID is 150 × 4.6 (Göncü, 2024).

3.2.9. Sensory Analysis

Discrimination tests have been used in product quality control research studies. Sequential scale.
The sensory analysis test was administered to 15 individuals aged 20-55, half of whom were educated.
Ten women and five men participated in the test. Biscuit samples were randomly assigned three-digit codes.
The code for aquafaba biscuits is 453, and the code for control biscuits is 386. Appearance, color, firmness, flavor,
crispness, quality, aroma, chewability, presentation, acceptability, and mouthfeel.
Each characteristic was scored. A nine-point hedonic scale was used for evaluation.
[1=Unfit for consumption, 2=Very bad, 3=Bad (Defective), 4=Borderline (Somewhat weak), 5=Average, 6=Quite good,
7=Good, 8=Very good, 9=Excellent]. (Çifçi and Eminsoy, 2024).

3.2.10. Statistical Analysis

Statistical analyses of the obtained data were performed using SPSS version 25.0 software.
The analysis was performed. In all analyses, the statistical significance level was accepted as $p < 0.05$.
Calculations are performed using analysis of variance (Ervural, 2020). Control
Biscuit and aquafaba biscuit were compared, and a pairwise comparison test was applied.

FINDINGS

4.1. Measurements of Diameter, Thickness, and Spread Rate

The aquafaba biscuit was measured to have a diameter of 60mm before baking. After baking, it measured 4mm.

The width was calculated by taking the average of the biscuits. The aquafaba biscuits purchased had a width of 65.05.

The measurements were 64.5 mm, 64.9 mm, and 65.6 mm, with an average width of 64.01 mm.

In the control biscuit sample, the diameter was set the same before baking.

The calculation was made by measuring 4 biscuits after baking and taking the average. The biscuits weighed 64.05.

The measurements were 64.5 mm, 64.3 mm, and 63.9 mm, with an average width of 64.19 mm.

The thickness measured for aquafaba biscuits before baking was approximately 10 mm.

It was measured. After baking, the average of 4 biscuits was taken to calculate the thickness. 11.3 mm,

Measurements of 11.6 mm, 11.9 mm, and 11.2 mm were taken. The average thickness was 11.5 mm.

The control biscuits were the same thickness before baking, but after baking, they were 4 biscuits thicker.

The average was used to calculate the measurements. The biscuits were 10.9 mm, 10.7 mm, 11.3 mm, and 11.5 mm.

The average thickness was calculated as 11.3 mm. For aquafaba biscuits.

The spread ratio in the biscuit was 64.01/11.5, while the spread ratio in the control biscuit was 64.19/11.3.

The measurements were taken for 4 sample biscuits: aquafaba and control biscuit diameters.

The thickness and thickness values were calculated using ANOVA analysis and are shown in Table 4.1.

Table 4.1. Diameter and Thickness Analysis

Descriptors	n	Mean ± SD	95% Confidence Interval	Minimum	Maximum
Diameter (mm)					
Control	5	63.35 ± 1.88	61.07–65.69	60.00	64.50
Aquafaba	5	64.01 ± 2.27	61.18–66.83	60.00	65.60
Total	10	63.68 ± 2.00	62.24–65.11	60.00	65.60
Thickness (mm)					
Control	5	10.88 ± 0.58	10.15–11.60	10.00	11.50
Aquafaba	5	11.20 ± 0.72	10:30–12:09	10.00	11.90
Total	10	11.04 ± 0.64	10.57–11.50	10.00	11.90

Footnote: ANOVA analysis was applied.

4.2. Weight Measurement

In this study, the baking process of aquafaba and control group biscuit doughs was investigated.

It was prepared beforehand in 30-gram portions. After the baking process...

A weight loss of 10 grams (baking loss) was detected in both biscuit formulations.

The physical properties of the biscuits are shown in Table 4.2.

Table 4.2. Physical Properties of Biscuits

Biscuit	Diameter (mm)	Thickness (mm)	Dispersion rate (D/D)	Weight (g) (first measurement, uncooked)	Weight (g) (last measurement cooked)
Aquafaba	64.01	11.50	5.56	30.00	20.00
Control	64.19	11:30	5.68	30.00	20.00

4.3. Measurement of Foam Capacity and Foam Stability

Whipping the aquafaba for 10 minutes will yield a foam volume of 90 mL.

It has been determined that the egg whites used as a control group were whipped for 10 minutes.

As a result, the foam volume was measured as 80 mL. Determination of foam stability.

For this purpose, 15 mL of aquafaba is whipped to reach an initial foam volume of 90 mL (at 0 minutes).

This was ensured. After waiting for thirty minutes, 6 mL was found at the bottom of the beaker.

It was determined that aquafaba converted to liquid form and the foam volume was 84 mL.

Similarly, whipping 15 mL of egg whites will initially produce 80 ml (at 0 minutes).

when it reaches a foam volume of mL, after waiting 30 minutes, 7 mL remains at the bottom of the beaker.

It was found that the egg white had turned into a liquid form and the foam volume had decreased to 73 mL.

It has been done.

The foam stability (KS) of aquafaba was calculated as follows:

Aquafaba KS = (84/90) × 100 = 93.33%

The foam stability of egg whites is as follows:

Egg white KS was found to be = (73/80) × 100 = 91.25%.

The results regarding the foaming properties of the biscuits are shown in Table 4.3.

Table 4.3. Aquafaba and Egg White Foam Properties.

Measurements (mL)	Aquafaba	Egg white
Foam capacity (before whipping)	15	15
Foam stability (0 min after whipping)	90	80
Foam stability (30 minutes after whipping)	84	73
Foam stability (liquid forming at the bottom of the beaker)	6	7

4.4. Color Measurement

In the laboratory color measurement, the L* (clarity) measurement of aquafaba biscuits was 3 biscuits.

The measurements were taken, the average was calculated, and the values were calculated accordingly. The L* values for the biscuits were 72.74, 72.35, and 69.14.

This was measured as follows. The average L* value for aquafaba biscuits was found to be 71.41. Control

In the biscuit, the L* value was measured as 69.54, 68.03, and 69.31. The L* value of the control biscuit...

It was found to be 68.96.

Calculations are made by measuring 3 biscuits within the a* (redness) value and taking the average.

The a* values for aquafaba biscuits were measured as 4.98, 5.37, and 6.09. Average

The a* value for the aquafaba biscuit was found to be 5.48. The a* values for the control biscuit were 8.20.

The values measured were 9.04 and 8.52. The average control biscuit a* value was found to be 8.59.

The b* (jaundice) value was calculated by measuring 3 biscuits and taking the average. For aquafaba biscuits.

b* values were measured as 34.57, 34.82, and 36.49. Average aquafaba biscuit b*

The b* value was found to be 35.3. Control biscuit b* values were 34.90, 35.74, and 35.41.

The measurements were taken. The average control biscuit b* value was calculated as 35.35.

The mean and standard deviations of the color values are shown in Table 4.4.

Table 4.4. Color Value Analysis Results

Identifiers	Example	Center ma	Standard Deflection	95% Confidence Range		Mini candle	Maxi candle	P Value
				Lower Border	Top Border			Meaningfulness
Control	3	69.54	0.01	69.54	69.54	69.54	69.54	
L*	3	71.41	1.97	66.50	76.31	69.14	72.74	
Aquafaba	6	70.47	1.61	68.77	72.17	69.14	72.74	0.17
Total								
Control	3	8.58	0.42	7.53	9.63	8.20	9.04	
a* Aquafaba	3	5.48	0.56	4.08	6.87	4.98	6.09	
Total	6	7.03	1.75	5.18	8.87	4.98	9.04	0.02
Control	3	35.35	0.42	34.29	36.40	34.90	35.74	
b*	3	35.29	1.04	32.70	37.88	34.57	36.49	
Aquafaba	6	35.32	0.71	34.57	36.07	34.57	36.49	0.93
Total								

Footnote: ANOVA analysis was applied.

The measurement results for color properties are shown in Table 4.5.

Table 4.5. Color Characteristics of Biscuits .

Identifiers	L*	a*	b*
Aquafaba	71.41	5.48	35.30
Control	68.96	8.59	35.35

4.5. pH Measurement

First, the pH of the aquafaba was measured and found to be 7.01. The pH value of the whipped aquafaba was also determined.

The pH was 7.01, yielding the same result. The pH of egg whites was also measured separately in their original state and after whipping.

In both measurements, the pH value was determined to be 9.29.

When pH meters were used on the biscuits, the pH of the aquafaba biscuit was found to be 7.38, while the control biscuit's pH was 7.38.

The pH of the biscuit was found to be 7.84. This difference is due to the pH values of chickpea water and egg white.

It originates from.

4.6. Proximate Analyses

4.6.1. Humidity Measurement

The moisture content of the aquafaba biscuit was found to be 3.23%. The moisture content of the control biscuit was...

It was found to be 5.65%. According to the TS EN ISO 712 analysis method, values ÿ6 are considered unsuitable for biscuits.

It is suitable for production (Topaloÿlu, 2019). The moisture content in 2 biscuits was found to be below 6%.

The control biscuit was found to be more moist than the aquafaba biscuit.

4.6.2. Protein Determination

The protein content of aquafaba biscuits was found to be 6.18%, while the protein content of control biscuits was 7.23%.

It was found that the control biscuit was made with egg white, which is an animal protein.

Its protein content is similar to that of aquafaba biscuits made with chickpea water.

4.6.3. Fat Determination

The fat content of aquafaba biscuits was found to be 15.97%, while the fat content of control biscuits was 15.72%.

The amounts of oil used in the recipe are in the same proportion.

4.6.4. Carbohydrate Determination

The carbohydrate value of aquafaba biscuits was determined after protein, fat, and ash content analysis.
This was determined through calculations. Aquafaba biscuits have a carbohydrate content of 77.84%.
The control biscuit contains 77.03% carbohydrates.

4.6.5. Nutritional Value

Nutritional value calculations for samples are based on carbohydrate, protein, and fat content.
This was carried out by taking the following measurements. According to the data obtained, 100 grams of biscuits with added Aquafaba...
The total energy value of the sample was calculated as 479.81 kcal, and this value...
311.36 kcal from carbohydrates, 24.72 kcal from protein, and 143.73 kcal from fat.
This is the source. In the control group biscuit sample, the total energy value was 478.52 kcal.
It was determined that the energy distribution according to components was 308.12 kcal from carbohydrates,
This consisted of 28.92 kcal from protein and 141.48 kcal from fat.

The calorie values of the biscuits are shown in Table 4.6.

Table 4.6. Calorie Calculations for Biscuits

Component	Aquafaba Biscuits	Control Biscuit
Carbohydrates (%/kcal)	77.84% ÿ 311.36 kcal	77.03% ÿ 308.12 kcal
Protein (%/kcal)	6.18% ÿ 24.72 kcal	7.23% ÿ 28.92 kcal
Fat (%/kcal)	15.97% ÿ 143.73 kcal	15.72% ÿ 141.48 kcal
Total Energy (100 g)	479.81 kcal	478.52 kcal

4.6.6. Determination of Ash Insoluble in Hydrochloric Acid (HCl)

The ash content of aquafaba biscuits was found to be 0.01%, while the ash content of the control biscuits was 0.02%.
According to the TS 2383 analysis method, an ash content below 0.2% is suitable for biscuit production.
2 biscuits were found to be within the appropriate range. Proximate analyses of the biscuits are shown in Table 4.7.
It has been shown.

Table 4.7. Proximate Analyses

Biscuit	Humidity measurement (%)	Protein determination (%)	Oil Tayini (%)	Carbohydrate Appointment (%)	Food Value (kcal/100 g)	Determination of ash insoluble in hydrochloric acid. (%)
Aquafaba	3.23	6.18	15.97	77.84	489	0.01
Control	5.65	7.23	15.72	77.03	487	0.02

The pH, moisture, protein, fat, and ash values of the biscuits were analyzed using SPSS and are presented in Table 4.8.

It has been shown.

Table 4.8. Chemical Analysis Results of Biscuits

Parameters	Biscuit Type	Arithmetic Average	Between Averages Difference
Ph	Aquafaba	7.84	0.46
	Control	7.38	
Moisture	Aquafaba	3.23	-2.42
	Control	5.65	
Protein	Aquafaba	6.18	-1.05
	Control	7.23	
Oil	Aquafaba	15.97	0.25
	Control	15.72	
Ash	Aquafaba	0.01	-0.01
	Control	0.02	

Footnote: Independent Samples T-Test was applied.

4.7. Texture Profile Analysis (TPA)

To determine the mechanical properties of the samples, the TA.XT Plus texture analyzer was used.
(Stable Micro Systems, Godalming, Surrey, UK) and HDP/3PB (3-Point Bending Rig)
A fracture test was performed using a probe. From the resulting texture profile curves...
by calculating hardness (fracture force), brittleness and area under the curve.
Fracture work has been determined. Test conditions: pre-test velocity 1 mm/s, test velocity 2 mm/s, distance 10
The test was performed using a trigger force of 20g and a diameter of mm. TPA analysis results.
This is shown in Table 4.9.

Table 4.9. TPA Analysis Results

Feature	Aquafaba Egg		Change
Breaking Force (N)	64.80	51.86	Higher aquafaba
Fragility (mm)	0.57	0.70	Higher aquafaba
Crushing Energy	7.87	6.69	Higher quality with eggs

For aquafaba biscuits, the average crushing force was 64.80, brittleness was 0.57, and crushing efficiency was...
Its energy was calculated as 7.87. In egg biscuits, the breaking force was 51.86, and the breakability was...
The electrical conductivity was calculated as 0.70, and the refractive index as 6.69.

4.8. Determination of Hydroxymethyl Furfural

HMF analysis of biscuit samples formulated with chickpea aquafaba and egg white.
The results are presented in Table 4.10.

Table 4.10. HMF Analysis Results

Example Name	HMF Peak Area	HMF Level (ppm)
Egg White-2	77.80	6.81
Chickpea Aquafaba	62.00	6.65

4.9. Sensory Analysis

ETÿ Cicibebe baby biscuit was used as the standard biscuit. All sensory analysis was performed.

In the tests, the aquafaba biscuit scored higher than the control biscuit.

Although the standard biscuit received the highest score of 7.33 for the appearance question, the control and aquafaba biscuits were also included.

When comparing biscuits, the aquafaba biscuit received 0.4 points higher approval rating.

The aquafaba biscuit received a score of 7.13, while the control biscuit scored 6.73.

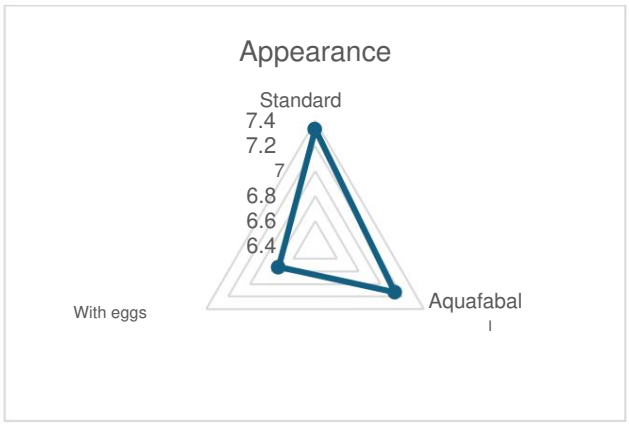

Figure 4.1. Graph of Responses to the Appearance Question According to the Sensory Analysis Questionnaire for Aquafaba and Control Samples.

The aquafaba biscuit received the highest score in color evaluation with 7.33.

The aquafaba biscuit received 0.53 points higher rating than the control biscuit.

The biscuit received a score of 7.20.

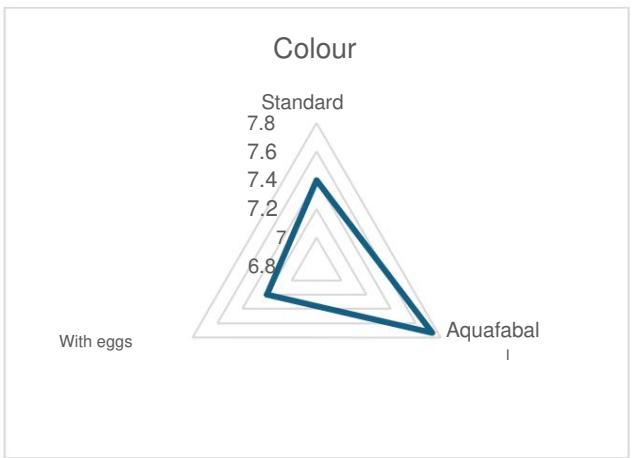

Figure 4.2. Graph of Responses to the Color Question According to the Sensory Analysis Questionnaire for Aquafaba and Control Samples.

Although the standard biscuit received the highest score of 7.53 in the hardness assessment, the control and
When comparing aquafaba biscuits, the aquafaba biscuit received 0.4 points higher approval rating.
The aquafaba biscuit received a score of 6.93, while the control biscuit received a score of 6.53.

Although the standard biscuit received the highest score in the taste evaluation, the aquafaba biscuit...
There is no significant difference between them. When comparing the control and aquafaba biscuits.
The aquafaba biscuit received 0.78 points higher rating than the control biscuit.
The biscuit received a score of 7.42, while the control biscuit received a score of 6.64.

In the crispness assessment, the standard biscuit received the highest score. Control and
When comparing aquafaba biscuits, the aquafaba biscuit scored 0.57 points higher than the control biscuit.
They received high praise. The aquafaba biscuit scored 7.14 points, while the control biscuit scored 6.57 points.

The standard biscuit received the highest score in the quality assessment. Control and
When comparing aquafaba biscuits, the aquafaba biscuit scored 0.43 points higher than the control biscuit.
They received high ratings. The aquafaba biscuit scored 7.28, while the control biscuit scored 6.85.

The highest score in the aroma evaluation was received by the aquafaba biscuit. Control
It received a higher rating of 0.64 points than the standard biscuit and 0.14 points higher than the regular biscuit.
The aquafaba biscuit received a score of 7.71, while the control biscuit received a score of 7.07.

The standard biscuit received the highest score in the chewability assessment. Control
When comparing the aquafaba biscuit and the control biscuit, the aquafaba biscuit scored 0.57 points higher than the control biscuit.
They received higher ratings. The aquafaba biscuit received 7.28 points, while the control biscuit received 6.71 points.
has received.

Although the aquafaba biscuit received the highest score in the presentation evaluation, it was standard and
There is no significant difference in score between this biscuit and the control biscuit. The aquafaba biscuit scored 7.50 points.
The control biscuit received a score of 7.42.

Aquafaba biscuits received the highest score in the acceptability assessment.
Compared to the control biscuit, the aquafaba biscuit scored 0.78 points higher than the control biscuit.
They received high praise. The aquafaba biscuit scored 7.71 points, while the control biscuit scored 6.93 points.
has received.

In terms of mouthfeel, the standard biscuit received the highest score.

When comparing the control and aquafaba biscuits, the aquafaba biscuit was 0.71 times lighter than the control biscuit.

The aquafaba biscuit received a higher rating, with 7.43 points, while the control biscuit received 6.71 points.

He/She scored points.

The answers to all sensory analysis questions are listed in Table 4.11 below.

Table 4.11. Average Values of Responses to Questions Asked in the Sensory Analysis Questionnaire for Aquafaba and Control Samples.

	Standard	Aquafaba	Control
Appearance	7.33	7.13	6.73
Colour	7.40	7.73	7.20
Hardness	7.53	6.93	6.53
Flavor	7.50	7.42	6.64
Brittleness	7.43	7.14	6.57
Quality	7.43	7.28	6.85
Smell	7.57	7.71	7.07
Chewability	7.43	7.28	6.71
Presentation	7.43	7.50	7.42
Acceptability	7.57	7.71	6.92
The feeling it leaves in the mouth	7.57	7.42	6.71

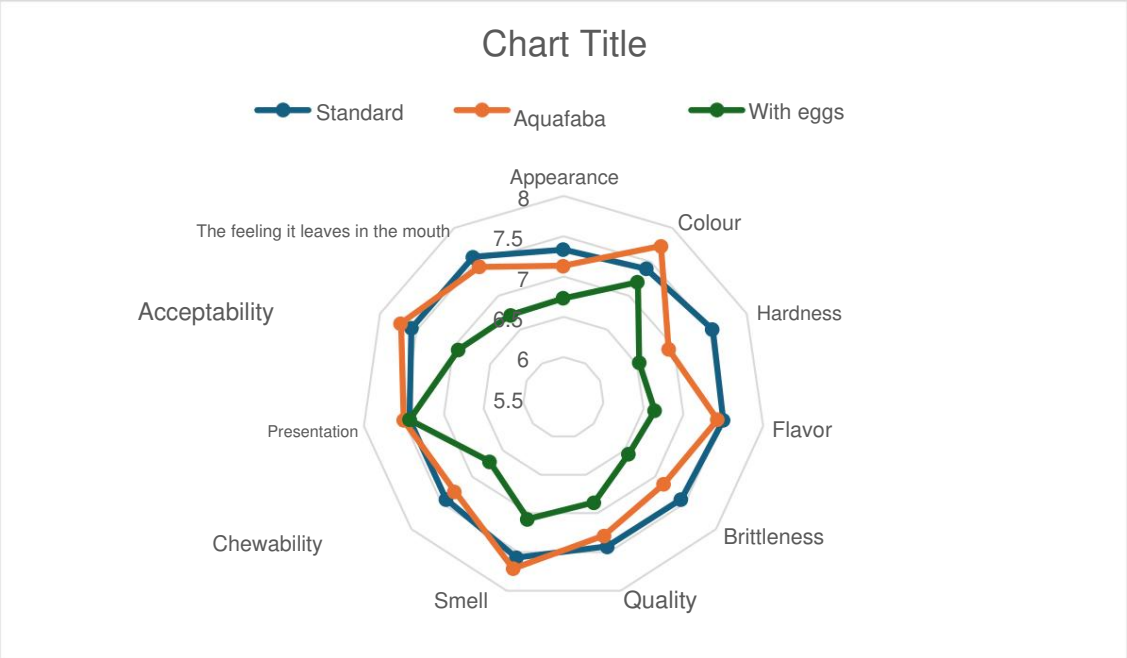

Figure 4.3. Graph of Responses to Questions Asked in the Sensory Analysis Questionnaire for Aquafaba and Control Samples.

4.10. Statistical Analysis

Statistical analysis of sensory data obtained from biscuit samples.

In the evaluation, appearance, color, firmness, and flavor were assessed using SPSS version 25.0 software.

crispness, quality, aroma, chewability, presentation, acceptability, and mouthfeel.

The criteria were calculated. The biscuits were coded with random three-digit codes and given to the panelists.

They have been distributed. The code for the aquafaba biscuit is 453, and the code for the control biscuit is 386. SPSS

The test results, conducted using a 9-point hedonic scale, were entered into the program. The panelists...

Scores were calculated based on the codes. Descriptive statistics were performed to determine the average.

Points have been earned.

By applying a pairwise comparison test (Independent Samples Test) to the data, the two groups were compared.

The significance of the differences between them was examined. If $P<0.05$, there was no statistically significant difference between the biscuits.

It is stated that there is a significant difference (Çanga and Efe, 2017).

The results of the sensory analysis are shown in Table 4.12.

Table 4.12. Sensory Analysis Results

Identifiers	T-statistic	P value	Average The difference	Standard Error The difference
Aquafaba-Control				
Colour	1.66	0.11	0.60	0.37
Hardness	1.17	0.25	0.46	0.28
Brittleness	0.16	0.11	0.51	0.35
Flavor	2.21	0.04	0.40	0.34
Quality	1.25	0.22	0.93	0.42
Smell	1.76	0.09	0.47	0.37
Chewability	2.24	0.03	0.53	0.30
Presentation	1.08	0.29	0.67	0.29
Acceptance	2.19	0.04	0.20	0.19
Appearance	1.64	0.27	0.80	0.36

Footnote: Independent Samples T-Test was applied.

Since the p-value for color was calculated as 0.11, there was a significant difference between aquafaba and control biscuits.

There is no difference. Hardness p-value 0.25, brittleness p-value 0.11, quality p-value 0.22 and

The odor p-value was calculated as 0.09, indicating no significant difference. Chewability p-value...

The value was found to be 0.03. Since P<0.05, the chewability result was lower than the control and...

There is a significant difference between aquafaba biscuits. Presentation p-value 0.29, appearance p-value...

The value was calculated as 0.27, indicating no significant difference. If accepted...

Since the p-value was 0.04, it is said that there is a statistically significant difference.

ARGUMENT

5.1. Measurement of Diameter, Thickness and Spread Rate

The diameter, thickness, and spread ratio values of the biscuit samples indicate the technological aspects of the final product.
critically important in objectively determining its quality and cooking characteristics.
These are quality parameters. In the literature, biscuit quality is generally assessed using a wide diameter and high...
The aim is to achieve a low spread rate and a low thickness value (Demir, 2015).
Diameter measurement indicates the degree to which the biscuit will rise during baking and how the dough will spread.
It is a direct indicator. In this study, biscuit samples with added aquafaba and a control group were analyzed.
In comparison, the increase in diameter of the control biscuits was 0.18 mm compared to the aquafaba samples.
It has been determined that there is more. This limited variation in diameter indicates that aquafaba is more effective in biscuits.
in terms of preserving structural integrity and ensuring controlled spread in its formulation
This demonstrates its suitability for production. Similarly, commercial production was demonstrated by Mamat et al. (2010).
In the study on the physicochemical properties of semi-sweet biscuits, the following were examined:
It has been reported that the diameter values of the biscuits vary between 63.50 mm and 70.64 mm.
The diameter data obtained from the study show parallelism with both the aquafaba and control samples.
The use of enzyme-resistant starch in biscuit production was reported by ÿeker (2006) et al.
In the study, diameter values were found to be between 7.01 and 7.60 cm. Thickness was 1.00-1.14 cm.
The spreading ratio was calculated to be between 5.71-7.41 cm (ÿeker et al., 2006).
The values are higher than our study for diameter (aquafaba 64.01 mm, control 64.19 mm).
The thickness was found to be 11.50 mm in the aquafaba biscuit and 11.30 mm in the control biscuit.
It has been calculated, according to ÿeker's study, that the control biscuit had enzyme-resistant starch added.
While the result is closer to biscuits, aquafaba biscuits are 0.1 cm thicker than this thickness range.
The spreading ratio was found to be excessive. The spreading ratio was calculated as 5.56 in the aquafaba biscuit and 5.68 in the control group.
The spread rates in our study were found to be lower than those in ÿeker's study, which indicates a decrease in diameter and
This is due to the thickness values. In the study conducted by Hayÿt and Yazÿcÿ, the diameter was 5 mm.
The thickness was set at 60 mm. At the end of the study, the diameter was 66.11-90.40 mm, and the thickness was 10.03 mm.
The thickness was found to be 16.47 mm, and the spreading ratio was between 4.04 and 9.02 (Hayÿt and Yazÿcÿ, 2023).
The diameter value was again found to be higher than our study's findings. Thickness and spread rate.
The values show parallelism for both the aquafaba-based and control biscuits. This was done by Yalçÿn.
In the study on the effect of poppy seed paste variety on biscuit quality characteristics, diameter 5.28-
The thickness was calculated to be 5.50 cm, 0.91-0.94 cm, and the spread ratio between 5.83-5.99.

The values vary according to the poppy seed paste inclusion rate. Aquafaba and control.

The biscuit samples fell within this range, yielding values suitable for the study.

The thickness of the biscuits is determined by the thermal denaturation of the gluten network and the resulting change in the biscuit structure.

between the stabilization and expansion of the dough due to the effect of leavening agents and water vapor.

This is due to a delicate balance (Mamat et al., 2010). When thickness measurements are examined,

The thickness of biscuits containing aquafaba was 0.2 mm greater compared to the control sample.

It has been determined that in biscuit technology, the final product does not rise excessively and its thickness increases.

(due to unwanted textural and packaging issues) often an unintended

This is the case (Demir, 2015). However, in our study, biscuits produced with a fixed weight (20 g)

This slight increase in thickness observed due to aquafaba is attributed to aquafaba's high water retention and

It is thought to be due to emulsion capacity and protein-starch interactions.

These values, which are quite close to the control group, indicate that aquafaba is an alternative to traditional building blocks.

This shows that it can be successfully used in biscuit production.

In biscuit technology, the spreading ratio is a key factor in ensuring the geometric and textural standards of the final product.

a critical quality in objectively determining the quality and cooking characteristics

It is a parameter. In the literature, the spread ratio of the biscuit is used in the formulation.

It is reported that this is directly affected by the softness and quality of the flour (HadiNezhad and Butler,

In this study (2009), all biscuit samples produced were made using the same quality and type of flour.

When the samples were compared, the spreading ratio was 0.12 higher in the control biscuit.

It was found that the levels were high, while the use of aquafaba led to a limited decrease in the spread rate.

The production of gluten-free biscuits with added chickpea flour was carried out by Cingöz and Güldane.

In the study, the diameter was 50.00-51.92 mm, the thickness was 9.86-14.58 mm, and the spread ratio was 3.44-5.27.

It was found that the diameter and spreading ratio increased as the addition of roasted chickpea flour increased.

height decreases (Cingöz and Güldane, 2023). Aquafaba and control biscuit spreading

The ratios remained in a lower range than those of chickpea flour biscuits. In our study, only white flour was used.

Since it is used, the spread rate is within a normal value. Demir (2015) and HadiNezhad and Butler

According to (2009), uncontrolled and excessive spreading in biscuits leads to textural defects in the final product.

This is an undesirable situation because of the cause. Accordingly, the quality of the flour is kept constant.

In the present study, achieving a lower spreading rate in aquafaba biscuits,

This was considered a positive finding in terms of preserving textural integrity.

This controlled spreading behavior of aquafaba can be attributed to the component's high water retention and emulsifying

capacity, as well as its ability to stabilize the dough matrix. On the other hand, baking

The temperature regime during baking also plays a decisive role in the spreading of the biscuit.

Sudden temperature increases during this period negatively affect the diffusion mechanism.
(HadiNezhad and Butler, 2009; Demir, 2015). Gluten-free biscuit made by Hayÿt and Gül (2019).
In the study of the optimization of flour formulation using the response surface method, spreading
The ratio varies between 5.02-6.87 (Hayÿt and Gül, 2019). Aquafaba and control biscuits also
It remains within this range. Doÿan's study examined some wheat varieties grown in Van and its surroundings.
In a study on biscuit quality, the spreading ratio was found to be between 6.4 and 8.8.
The variability in spreading ratio is linked to the hardness of the flour; spreading ratio decreases in hard flours.
This is observed (Doÿan and Uÿur, 2005). In our study, the values were lower than these ranges.
The spreading ratio has been calculated, taking into account that the flour used is biscuit-grade coarse flour.
It originates from.

5.2. Weight measurement

Weight loss of biscuit samples during baking and final weight values of the finished product,
in evaluating the baking characteristics and the water-holding capacity of the formulation
These are important quality indicators. In our study, biscuits with added aquafaba were compared with a control group.
There was a statistically significant difference between the biscuits in terms of the post-baking weight loss parameter.
No significant difference was observed. In both groups, the dough changed as a result of the cooking process.
Compared to its original weight, an average weight reduction of approximately 10 g has been recorded. This situation indicates that...
Aquafaba substitute removes moisture and evaporates free water during cooking.
This shows that it does not negatively affect its kinetics. In the literature, Mamat et al. (2010)
The study conducted by [author's name] found that the weights of commercial semi-sweet biscuits ranged from 7.73 g to 9.80 g.
It has been reported that the final weights of the biscuits obtained in our current study have changed.
The fact that it was higher than these values in the literature (20 g) indicates that the biscuit molds
This is due to differences in geometric dimensions and portioning volume. Engi's
the effect of different plant-based protein sources on the quality characteristics of gluten-free biscuits
In the study, the weight of the biscuits before baking was 5.99-6.52 g, while after baking it was 4.84-5.38 g.
It was measured as follows. Weight loss was 17.47–19.28% (Engi, 2024). Aquafaba and
The biscuits used in the study had a lower gram weight compared to the control biscuit.
Perundurai used statistical process control measures to determine the weight of the biscuit.
In the study on regulation, biscuits were examined. The most important aspects for biscuits were...
It has been stated that the two quality requirements are thickness and weight. Biscuit dough weight is 28.5-30.0
It has been shown that the dough weight varies between g (Perundurai, 2021). In our study, the dough weight was 30 g.
It has been adjusted accordingly. This shows a suitable result for the biscuits here. Cingöz and
In Güldane's study on producing gluten-free biscuits by adding roasted chickpea flour, the biscuits were baked.

The biscuit weight varies between 14.84-15.77 g (Cingöz and Güldane, 2023). This
The study did not specify the uncooked weight. In our study, however, the cooked weight was 20 g.
It has been calculated as follows.

5.3. Measurement of Foam Capacity and Stability

Methods of foam generation in food matrices provide the final product with lightness, a fluffy volume, and fineness.
It is frequently used to create a textured structure (Yÿldÿz and Kÿlÿnç ÿahin, 2023).
In this study, an alternative to the traditional egg white whipping technique is developed using aquafaba.
Biscuit production was carried out using this method; the resulting aquafaba foam was then processed industrially.
It has been determined that the foam has suitable functional capacity and stability for use.
In capacity measurements, the amount obtained with aquafaba immediately after the whipping process (0 min)
It was found that the foam volume was 10 mL greater compared to traditional egg whites.
In foam stability analyses, which reveal the system's stability over time, the result was 30
The amount of liquid phase that separates at the bottom of the beaker after a 1-minute incubation period is aquafaba-containing.
It was observed that the amount of aquafaba in the system was 1 mL less than that of egg white. These findings suggest that aquafaba...
Mechanical whipping not only creates a higher volume of foam, but also...
that it creates a foam matrix that is more resistant to liquid separation and more stable over time
This is demonstrated by the high foaming ability and structural stability exhibited by aquafaba.
Its soluble proteins, polysaccharides, and saponins create a flexible environment at the air-water interface.
with the ability to trap air bubbles more effectively by forming a film layer
This can be explained. In the study conducted by Hülaÿa (2025); peas, dry beans, chickpeas,
The foam volumes of kidney bean and Mexican bean aquafaba were investigated.
In the measurements, the highest foam volume at 1 minute was obtained with pea aquafaba, while at 5 minutes...
It was determined that chickpea aquafaba remained in the highest foam volume at the end of the minute.
(Hulagha, 2025).

In the study conducted by Çalÿkuÿu (2026); chickpeas, mung beans, green lentils, peas
Meringue production was carried out using bean aquafabas, and its foaming properties were investigated.
This was investigated. As a result of the evaluations, chickpeas were found to have the highest foam stability.
While the lowest foam stability was detected in pea aquafaba, the lowest foam stability was observed in pea aquafaba.
It has been observed (Çalÿkuÿu, 2026). In a study conducted by Akpÿnar (2025), vegan
A comparison of traditional and aquafaba-based methods in mousse production.
The findings were examined. The foam stability of aquafaba-substituted samples was found to be superior to that of conventional samples.
It has been shown that it is higher compared to that produced by the method (Akpÿnar, 2025). Büker's

Analysis of aquafaba using response-surface algorithm and distribution of plant-based mayonnaise.
In the usage study, the foam-generating capacity of aquafaba was found to be between 58.5% and 74.5%.
While varying, foam stability values ranged from 4.5% to 83.8% (Büker, 2023). In our study...
According to the data, the foam stability ratio was found to be lower. Foam stability in aquafaba biscuits.
It stands out with a rate of 93.33%. Foam stability lasts for 30 minutes following whipping.
Measuring the amount of liquid phase that separates and collects at the bottom of the beaker at the end of the incubation period.
It is calculated based on this principle. According to the analysis results, the amount of aquafaba used is...
the foam has a more successful structure over time compared to traditional egg white foam.
It has been determined that it protects and remains more stable in this way. Indeed, biscuits prepared with aquafaba
The foam stability of the dough was calculated as 93.33%, while in the control group biscuit...
The stability of the egg white foam used was determined to be 91.25%. This numerical value...
According to the values, aquafaba has a 2.08% higher concentration compared to egg white.
It has been observed that it exhibits foam stability. This resistance of aquafaba to liquid separation...
Structural resistance is due to the continuous presence of viscous hydrocolloids and soluble carbohydrates within it.
This can be explained by the fact that it slows down the flow of liquid due to gravity by increasing the viscosity of the phase.
This high stability data indicates the stability of the biscuit dough before baking, and
Therefore, it is a functional product that directly supports the targeted porous structure of the final product.
This has been considered an advantage.

5.4. Color Measurement

Color parameters in bakery products, control of the baking process, consumer acceptance and final
In addition to playing a decisive role in the technological quality of the product, heat treatment
It is also considered an indirect indicator of acrylamide formation that may occur during this process.
(Lu and Zheng, 2012). The development of the external color in biscuits is based on baking.
non-enzymatic reaction that occurs between reducing sugars and amino acids during this process
Browning (Maillard) reactions and caramelization mechanisms are involved.
(Majzoobi et al., 2016). In the literature, the product is associated with the over-progression of Maillard reactions.
The uncontrolled darkening of its color has implications for both its visual and chemical quality.
It has been reported to have negative consequences (Lu and Zheng, 2012). Colorimetric analysis
In this system, the L* value represents the degree of lightness/darkness on a scale from 0 (black) to 100 (white).
(Doÿan, 2002), and in the present study, three biscuit samples were measured.
The average L* value obtained was 71.41 in aquafaba biscuits and in the control group biscuits.
It was determined to be 68.96. The lower L* value in the control biscuits,
These samples, which traditionally contain egg whites, have a darker color profile.

This shows that excessive darkening of the color in biscuits is always considered a quality criterion.
Because it is not processed, aquafaba biscuits remain lighter in color and more balanced, resulting in higher final product quality.
This has been considered a more positive finding in this regard. This situation concerns aquafaba-containing products.
Maillard reactions and surface burns caused by baking are controlled in the formulation.
Çubuk and Özgören (2023), who examined the effects of black chickpea flour in gluten-free biscuit formulation, revealed
that it occurred at a more limited level compared to the rice flour group.
The biscuit base samples had a lower L* value, and the color values a * and b * were black, indicating the presence of chickpea flour.
It has been reported that the color changes were at higher levels than in the samples used. The addition of rice flour
resulted in a lighter color appearance compared to the addition of chickpeas (Çubuk and Özgören, 2023).
In the study conducted by Çalÿkuÿu (2026); peas, beans, mung beans and green
Vegetable meringues prepared using lentil boiling water and containing egg whites
The physicochemical properties of the meringues in the control group were compared. As a result of the research,
The highest L* value was obtained in samples produced with bean aquafaba, while the highest
The value of 'a ' was determined in the control group samples. For other color parameters, the groups differed.
No statistically significant difference was found between them (Çalÿkuÿu, 2026). Color
When the parameter a*, which determines the redness-greenness tones, is examined, the control biscuits' a*
While the a* value was found to be higher at 8.59, the a* value of aquafaba biscuits was 5.48.
It has been calculated. A higher positive a* value indicates the intensity of red tones,
The control group showed a more pronounced tendency to brown; while the aquafaba biscuits...
Despite being subjected to exactly the same baking time as the control group, excessive browning occurred.
This confirms that it does not show any signs of corrosion, and therefore better preserves color stability. Salur's
(2021), use of biscuit industry by-products in extruded snack food production
In the study examined, the L*, a*, and b* color values of the produced extruders were analyzed.
The study results showed that the L* values of the samples were 61.10–68.30; a* values were 4.60–10.30; and b* values were...
It was found to be in the range of 22.50–37.30 (Salur, 2021). In our study, the color was found to be yellowish-
In the evaluation based on the b* value, which represents the blueness component, it was found to be aquafaba.
The biscuits in the control group had an average value of 35.30, while the control group biscuits had an average value of 35.35.
The groups were statistically very close and similar in terms of jaundice tone.
Results have been obtained. As a result, aquafaba substitution has been shown to restore the characteristic yellow hue of the biscuit.
while preserving, it is technologically more advantageous by limiting excessive browning and redness.
It can be said that it offers a color profile.

5.5. pH Measurement

In bakery products, pH value determines the rheological properties of the dough and the chemical effects during baking.
reactions affect the textural parameters of the final product, such as fragility, and especially infants.
It is a critical quality criterion that directly affects the digestibility level in the diet. Aksoy
In the study conducted by (2021), the ideal pH range for a quality biscuit is 7.0 to 8.0
The pH should be between these ranges; lower pH values below this range are undesirable for the product.
It has been reported that this leads to a vulnerability. As a result of the analyses carried out in this study,
The pH value of the control group biscuits was measured as 7.84, while the pH of the biscuits with added aquafaba was...
The value was determined to be 7.38. When the numerical data is examined, it is seen that aquafaba biscuits
It was observed that it exhibited a more acidic character, 0.46 units higher than the control sample. Buhl and
In the study conducted by his colleagues, aquafaba samples with different pH levels
The functional properties of aquafaba were compared; the effect of increasing pH level on the aquafaba's performance was examined.
A significant increase in emulsion stability was observed (Buhl et al., 2019).
Akpÿnar's (2025) study on the foaming effect of aquafaba in pH 3, 5, 6 and 7 environments.
In the study comparing their capacities, it was found that the maximum foam volume occurred at pH 5.
It has been determined (Akpÿnar, 2025). In the literature, studies specifically on baby biscuits have been conducted.
Assessments indicate that low pH and high acidity levels can cause stomach upset in infants.
to avoid problems, therefore production should be carried out within suitable non-acidic pH ranges.
It is emphasized that this is necessary (Aktaÿ, 2025). Both the control and the current study produced
The biscuit samples containing aquafaba were found to be acidic; on the contrary, both formulations...
and is within the ideal pH limits (7.0-8.0) prescribed for standard bakery products.
These results were determined. These results are based on the literature findings of Aksoy (2021) and Aktaÿ (2025) and
It fully complies with the quality criteria, and the aquafaba substitute's chemical composition in the final product is consistent.
that it does not cause any problems in terms of stability and consumer health, biscuit
It has been shown to possess suitable chemical properties for its production.

5.6. Humidity Measurement

Moisture content in bakery products affects the textural properties, chemical stability, and
It is one of the most critical quality parameters that directly determines microbiological safety.
The generally low moisture content of biscuits encourages microbial growth and reduces water content.
By limiting its activity, it contributes to minimizing the risk of microbiological spoilage.
It provides (Misra and Tiwari, 2014). According to the TS EN ISO 712 analysis method, the moisture content in biscuits...
While a ratio below 6% (ÿ6) is considered acceptable; in the present study, aquafaba addition
The moisture content of the biscuits in the control group was determined to be 3.23%, while the moisture content of the control group biscuits was 5.65%.
The data were compared, and it was found that the moisture content of aquafaba biscuits was controlled.

It is observed that it was 2.42% lower compared to the group. Karaoÿlu et al.
In their study (1998), they found that the moisture content of biscuits varied between 1.8-5.7%.
It has been reported that the moisture content in biscuits should be 1-5%, and both moisture values obtained in our study were in
accordance with this wide reference range. On the other hand, Tetik (2018) stated that the moisture content in biscuits should be 1-5%.
limiting the percentage and protecting the product from moisture and oxygen with suitable packaging.
It has been stated that it will have a long shelf life in this condition. In this context, it has a moisture content of 3.23%.
The aquafaba biscuits fully meet the aforementioned narrowed reference range and quality
While it was determined that it conformed to the standards; the control biscuit with 5.65% moisture content was within this range.
It is quite close to the upper limit and outside the ideal limits suggested by Tetik (2018).
It has been observed. Demir (2015) reported that the moisture content of biscuits varied between 4.25-4.86% and
Researchers calculated that adding ingredients like whole wheat flour to the formulation increased moisture content.
Literature indicates that increasing the moisture content of biscuits accelerates microbial growth, and this...
It is emphasized that this will create an undesirable situation in terms of product quality and shelf life (Olcay).
(Demir, 2019). Accordingly, flour quality and baking conditions are kept constant.
In our study, aquafaba-substituted biscuits had a much lower moisture content compared to the control group.
Its ability to display content has been considered a significant technological advantage. Aquafaba
The reason the moisture content in the biscuits remains so low is due to the free water in the biscuit structure being lost during baking.
this allows aquafaba proteins to leave the matrix more easily during cooking or during the process of cooking.
This can be explained by structural changes. Consequently, the low moisture content of aquafaba biscuits,
Extending shelf life by delaying microbiological spoilage, allowing for longer safe storage.
in terms of storability and maintaining quality characteristics, the final product quality
It has made a very positive contribution.

5.7. Proximate Analyses

In the biscuit industry, the rheological properties of the dough and the textural quality of the final product are important.
To optimize the supply chain, soft drinks, which generally have a low protein content, are used.
Wheat flours are preferred. However, the nutritional quality and protein requirements of the final product must be considered.
To meet this requirement, the other raw materials included in the formulation are rich in amino acids.
It is important that it has a protein profile. In this study, the protein content of control group biscuits was examined.
The protein content of biscuits with added aquafaba was calculated as 7.23%, while the protein content of biscuits with added aquafaba was 6.18%.
It has been determined. When the numerical data are examined, it is seen that aquafaba substitute, which is a plant source,
It performed very similarly to egg white, which is a source of animal protein, and
It has only 1.05% lower protein content than the control biscuit.
It is seen in the literature that in the study conducted by Karaoÿlu et al. (1998), protein in biscuits was found.

It has been reported that the amount varies between 4.6% and 7.6%; both obtained in the present study
Both the control group (7.23%) and the aquafaba biscuit (6.18%) had protein values within this reference range.
It was found that there was a complete agreement. However, Baltacÿoÿlu and Ülker (2017) found that in biscuits
While Uysal (2005) reported the average protein content as 6.9%, with plant proteins
Enriched gluten-free biscuits have a crude protein content between 3.33% and 5.96%.
He reported that it had changed. In our study, the protein content detected for aquafaba biscuits was 6.18%.
Although its value is slightly above the upper limit stated by Uysal (2005) for gluten-free biscuits and therefore outside this
specific range, it generally falls within the standard biscuit literature and the findings of Baltacÿoÿlu and Ülker.
This largely coincides with the 6.9% protein content findings of Cingöz and Güldane (2017).
In a study conducted by (2021), chickpea powder was added to gluten-free biscuit formulation.
The effects of (flour) addition on the nutritional value of the product were investigated. The findings obtained are as follows:
Accordingly, the raw material, initially determined as 3.97% in the control group biscuit sample...
The protein content increased significantly to 8.07% with the addition of roasted chickpea flour as a substitute.
It has been reported that the price has risen to that level. This situation indicates that chickpea flour is used in gluten-free bakery products, both...
An effective way to both enrich protein and improve nutritional profile.
This shows that it can be used as a functional component (Cingöz and Güldane, 2021).
In conclusion, the use of aquafaba as a substitute for animal-derived egg whites
The biscuits were able to significantly maintain their nutritional protein profile and achieve the targeted results.
It can be said that it successfully meets legal/technological quality criteria.

The carbohydrate content in biscuits determines the product's primary energy source. Nutritional value for biscuits...
It is affected by the carbohydrate content; carbohydrates form the basis of calorie density.
It constitutes 77.84% of the aquafaba biscuits used in our study, while the control biscuit constituted 77.03%.
It has a carbohydrate content. In the study conducted by Aydos and Ertaÿ (2023), different
The carbohydrate content of biscuit samples to which medlar powder was added in certain proportions was 67.47%.
It was determined that the values varied between 68.53% (Aydos and Ertaÿ, 2023). These values were used instead of flour.
Increasing the proportion of medlar powder leads to a decrease in carbohydrate content.
is decreasing. In another study, it was found that sprouted rye and oat substitutes were used in biscuits.
The effect of the samples on the total carbohydrate content was examined; according to the analysis results
It was determined that the carbohydrate values of the products ranged between 67.99% and 70.06%.
(ÿirin, 2021). In Engi's study titled "The Effect of Different Plant-Based Protein Sources on the Quality Characteristics of
Gluten-Free Biscuits," different flour and protein sources (100% wheat flour,
100% gluten-free flour, pea protein-gluten-free flour blend, fava bean protein-gluten-free flour blend
Total carbohydrates of biscuit samples produced using gluten-free flour (and protein blend)

It was determined that their content varied between 68.72% and 76.15%. With the addition of legume protein.
It has been observed that carbohydrate levels decrease (Engi, 2024). Orange and pomegranate peel
In the research that evaluated the possibilities of using waste in biscuit and cake production,
With an increase in the proportion of shell replacements in the formulation, the carbohydrate content of the products also increases.
A decrease has been observed (Erdoÿdu, 2023).

In biscuit technology, fat content affects the rheological properties of the dough, its processability, and the final product.
the fundamental element that directly affects the balance of brittleness and sensory acceptability
It is one of the components. As a result of the analyses carried out in this study, the control group
The fat content of the biscuits was calculated as 15.72%, while the fat content of the biscuits with added aquafaba was...
It was determined to be 15.97%. Both biscuit formulations contain the same amount of margarine.
Despite being used, aquafaba substitute biscuits showed a 0.25% difference compared to the control sample.
It has been determined that it has a higher fat content at this level. In the literature, Karaoÿlu and
In the study conducted by et al. (1998), the fat content of standard biscuits was found to be between 10.1% and 10.1%.
It has been reported that it can vary within a wide reference range of 24.6%. In our current study, we obtained...
It is observed that both the control and aquafaba-containing biscuit fat values are within these legal and technological limits.
On the other hand, Esendemir et al. (2025) found that aquafaba in chickpeas
Because it is obtained as boiling water, it naturally has a very low fat content.
They reported that it is a byproduct component (Esendemir et al., 2025). Margarine in the recipe
In the current study, where the amounts were kept constant, this 0.25% observed in aquafaba samples...
The slight increase in fat is due to the egg whites and aquafaba that replace the flour in the formulation.
from the differences in micro-level fat composition they contain in their unique matrices and
This is thought to be due to aquafaba's ability to emulsify during cooking. Result
As a result, the aquafaba substitute negatively affected the overall fat profile and industrial standards of the biscuit.
It has been shown that it can be successfully integrated into traditional recipes without affecting them in any way.

The nutritional value of biscuits is determined by the combination of carbohydrates, proteins, and fats.
is calculated (Baysal, 2004). The average calorie amount in 100 g of biscuits is a nutritional value.
This constitutes its nutritional value. The nutritional value for aquafaba biscuit is 479.81 kcal, and for control biscuit...
It has been calculated as 478.52 kcal. Its high nutritional value is due to its high protein, vitamin, and vitamin content relative to calories.
It is the condition of having a higher mineral content. For biscuits, this high content is achieved by increasing the protein ratio.
It is formed. While the protein values in the biscuits we obtained are similar, egg white
Because it provides animal-derived protein, its absorption and bioavailability in the body is better than aquafaba.
It is higher. The milk and multigrain approach by Aggarwal et al. (2016)
low-calorie biscuit formulation using artificial sweeteners and fat substitutes.

In the study, the average calorie values of the control and optimized biscuits were 525 and 525, respectively.
It was found to be 485 kcal. When the calorific values of the final products are evaluated, this
The aquafaba-based and control biscuit samples developed in this study are similar to the milk and multi-grain biscuits found in the literature.
Low-calorie, optimized biscuits obtained using matrices and fat/sugar substitutes.
their formulations showed a close correlation with the calorie range, but fell slightly below it.
It is observed that when the calorific contributions of the macronutrient components in the formulation are examined;
Increasing the protein content while simultaneously decreasing the carbohydrate ratio improves the product's quality.
It appears to be a key factor in reducing overall energy density.
Although carbohydrates and proteins have equal theoretical physiological energies (4 kcal/g), in the food matrix...
high caloric components and digestible carbohydrates protein
Replacing it with enrichment reduces the total amount of metabolizable energy.
This ensures that the use of aquafaba preserves the basic nutritional structure of the biscuit.
while improving, a product profile was obtained that also aligns with low-calorie functional food standards.
It shows that it makes it possible to do so.

Ash content in bakery products refers to the total mineral matter contained in the final product.
It is an important quality indicator reflecting its content and nutritional richness (Haider et al., 2022).
Ash content in foods is the ratio of inorganic mineral substances to the total weight of the product.
It expresses the rate (Aktaÿ, 2025). As a result of the analyses carried out in this study,
The ash content of the control group biscuits was calculated as 0.02%, while the biscuits with added aquafaba...
The ash content was determined to be 0.01%. In the literature, Yÿldÿz (2012) reported that the ash values of biscuits...
It has been reported that the distribution ranges between 1.35% and 1.71%; the results we obtained in the current study.
Both the control and aquafaba biscuit ash content is well below this reference range.
It has remained within the aforementioned limits. This significant decrease in ash content is due to the biscuit.
The flour used in its production is highly refined (low ash content, high whiteness level).
(due to the high level of inorganic matter) and the inorganic substance load of other ingredients in the prescription
It is thought that Karaaÿaoÿlu and his friends (1993) “Biscuits, Crackers, Cakes, Bars and
Nutritional Values of Wafers: Protein, Fat, Moisture, Ash, Carbohydrate, and Energy Content
In his study titled; plain, petit beurre, picnic, cocoa, hazelnut, sesame, cream, fruit and
The ash content of different types of biscuits, including those coated in chocolate, was analyzed.
The study found that the ash content of the biscuit samples examined ranged from 0.1% to 1.1%.
This has been reported (Karaaÿaoÿlu et al., 1993). In the said study, many with different characteristics
The fact that numerous types of biscuits were examined revealed a wide range of variation in ash content.
This has led to the emergence of ash in the biscuit samples analyzed in this study.

their values are within the range of 0.1–1.1% reported by Karaaÿaoÿlu et al. (1993).

It has been determined that this difference is due to the composition of the raw materials used, the formulation, and the production process.

It is thought that this may be due to differences in conditions and the additives used. The addition of whole pumpkin seed

powder to biscuits, as studied by Baltacÿoÿlu and Ülker...

In the study examining the effects on quality parameters, the ash values of the samples were analyzed.

The results were analyzed and varied between 0.46% and 1.55%. The highest ash content was...

The highest substitution rate was observed in the biscuit sample containing 45% whole pumpkin seed powder.

The high ash content in biscuits is due to the high concentration of minerals in the formulation and the materials used.

It is directly related to the yield (whiteness) of the flour (Aktaÿ, 2025). In all biscuit samples

In our current study, where the same type of flour was used, there was a difference between the control group and the aquafaba samples.

The minimal difference of 0.01% detected is due to the unique mineral content of egg white, an animal source.

the substance content and inorganic component load, compared to aquafaba, a plant byproduct.

It can be said that this stems from the fact that it is higher. As a result, aquafaba substitution

This leads to a statistically radical change in the total ash and mineral profile of the biscuit.

It was determined that it did not open and maintained the overall inorganic matter balance of the final product.

5.8. Texture Profile Analysis (TPA)

Textural characteristics of biscuit samples have an impact on consumer preference and mouthfeel.

It is one of the most important quality parameters that directly determines the quality of biscuits. In this study, biscuits

TPA analysis was applied to determine the mechanical behavior; the crushing force of the samples was determined.

(N), fracture distance (mm) and fracture energy (N.s) values were calculated.

According to the analysis results, the crushing force of the control group biscuits was 51.85 N, and their brittleness was...

The value was determined as 0.70 mm and the crushing energy as 6.69 N.s; while biscuits with added aquafaba...

The breaking force was 64.79 N, the fracture resistance value was 0.57 mm, and the breaking energy was 7.87 N.s.

It has been determined. When the numerical data are compared, the breaking strength of aquafaba biscuits has been found to be higher.

It is observed that the refractive energy is 12.94 N and the fracture energy is 1.18 N.s higher than the control sample.

In the study conducted by Aslam et al. (2014), it was found that the crushing force and crushing energy were low.

It has been reported that this indicates a decrease in the tensile strength of biscuits; this

Accordingly, in our current study, we found that aquafaba biscuits have higher crushing strength and

Its energy content indicates that the product exhibits a more resistant structure to mechanical stress.

In contrast, Demirel (2017) states that deformation resistance in biscuits is represented by...

Excessive increase in hardness and textural durability parameters affects product quality (rigid structure)

He stated that this could pose a negative situation in terms of aquafaba. However, in our study, aquafaba
The breakage (breaking distance) value of the biscuits was 0.11 mm higher than that of the control biscuit.
The low reading indicates that this increase in hardness does not cause negative petrification, but rather the product
It stretches less and breaks suddenly and prematurely, therefore it is more brittle compared to the control group.
It shows that it has acquired a textural structure. This durable structure obtained by substituting aquafaba.
and a crispy texture; the stable gel matrix formed by chickpea proteins during baking and
This can be explained by the internal pore structure, which takes shape through more controlled diffusion. Celia and
In a study conducted by his colleagues, different sorghum flour concentrations were found to affect the Tissue-TPA profile.
Analysis showed that it caused interference. Control - 0%; F1 - 25%; F2 - 50%; F3 - 75% and
F4 - TPA analysis was performed on biscuits with 100% sorghum flour added. Formulation F3, 25594.44
It exhibited higher values with N hardness, 251 N brittleness, and 0.27 adhesion.
Flexibility was unaffected. Peak gumminess (53.08 N) and chewability (1471.15 mJ) were observed.
The values were found in the F4 – 100% FS formulation (Celia, 2022). These values
It is in a higher price range compared to aquafaba biscuits.

5.9. Determination of Hydroxymethyl Furfural

5-hydroxymethylfurfural (HMF) is found in foods subjected to heat treatment in acidic environments.
via dehydration of reducing sugars or decomposition via Maillard reaction
It is an important synthesized organic compound (Shapla et al., 2018; Choudhary et al., 2021).
In toxicological studies conducted over the years, HMF is closely monitored in terms of food safety.
It has become a parameter; mutagenic, genotoxic, organotoxic and enzyme inhibitory in the body.
It has been reported that it can create effects (Shapla et al., 2018). This study was conducted
Chromatographic analysis revealed that the control group biscuits contained 6.81 mg of HMF.
During the calculation, the HMF content of biscuits with added aquafaba was determined to be 6.65 mg.
When the numerical data were examined, it was found that the HMF content of aquafaba-substituted biscuits was higher than that of the control sample.
It is observed that it remains at a lower level compared to that. In the literature, HMF in bakery products...
formation kinetics; low pH, low water activity, high firing temperature and prolonged baking
It is emphasized that it increases in direct proportion to their duration (Petisca et al., 2014; Roldan et al.,
2026). Indeed, in a study conducted by Roldan et al. (2026) with different cereal flours, 10
Even in biscuits baked for as little as a minute, the amount of HMF does not exceed food safety limits.
It has been reported that it may pose a risk in this regard; in our current study, biscuits were consumed for 30 minutes.
Despite being baked throughout, HMF formation, especially in aquafaba specimens, is quite limited.
The fact that it was suppressed is a remarkable and positive finding. Hamzalÿoÿlu and Gökmen (2017)
Formation and elimination of 5-hydroxymethylfurfural during in vitro digestion of the biscuits he produced.

In the reactions study, cookies obtained from bakery products were subjected to heat.
It has been reported that it contains 0.5–74.5 mg/kg HMF depending on the load (Hamzalioglu and Gokmen,
Petisca et al. (2014), who examined commercial bakery products, found HMF in biscuits (2017).
Its content exhibited a wide distribution between 1.65 mg and 82.78 mg, with the highest HMF content.
While reporting that their values are generally clustered in chocolate biscuits; Haider et al. (2022)
Depending on the chemical composition of the biscuits, the amount of HMF ranges from 1.8 mg to 34.9 mg.
It was stated that there was a change in both the control (6.81%) and aquafaba obtained from our study.
The biscuit values with added 6.65% are consistent with both literature (Petisca et al., 2014; Haider et al., 2022).
It is close to and within the lower limits of the predicted safe reference ranges.
The 5-hydroxymethyl-2-furfural content found in biscuits produced for children was examined.
The samples examined in the study were divided into three groups. The first group of biscuits is suitable for children
older than six months, the second group for children older than one year, and specific samples for the third group.
No age range was specified. In the first sample group, the amount of 5-HMF was 0.34-1.73 mg/kg.
The levels of HMF ranged from 0.57-1.78 mg/kg in the second group and from 1.80-34.99 mg/kg in the third group.
The amount of HMF was found to be higher in the third group than the others.
Since the acceptable daily intake is 2 mg/kg body weight, it was detected in all samples.
The amount of 5-HMF obtained is not considered dangerous in a normal biscuit dose (Švecova and Mach, 2017).
Acrylamide and 5-HMF are produced during the baking of biscuits.
In the study on hydroxymethylfurfural formation, the cooking temperature should be higher than 250°C.
It leads to HMF formation, and biscuits should be baked at a maximum temperature of 200°C.
It has been determined. In our study, aquafaba and control biscuits were baked at 160°C. Flour
In our study, where external factors such as quality, baking temperature, and baking time were kept constant,
The fact that aquafaba biscuits have a lower HMF content is due to the aquafaba being added to egg whites.
compared to Maillard reaction precursors (especially in terms of free amino acid profile)
balanced concentration or, as seen in our pH analysis findings, compared to the control group
This can be explained by its lower acidity (pH 7.38). Consequently, the use of aquafaba...
By limiting the formation of chemical toxins (HMF) in biscuits, food safety criteria are met.
It can be said that it has been successfully received and offers a sound product formulation.

5.10. Sensory Analysis

The success and market share potential of new product development efforts in the food industry ultimately depend on
It is directly related to the sensory characteristics that ensure the product is accepted by its target audience.
In this study, the biscuit samples produced were evaluated by panelists.
When the results of the sensory analysis performed were examined; appearance, firmness, taste, crispness,

In terms of chewability, mouthfeel, and overall quality parameters, it is the best of the standard biscuits.

It has been found to receive high approval ratings. However, color, scent, presentation, and overall acceptance were also considered.

In terms of usability criteria, biscuits with added aquafaba stood out, achieving the highest scores.

When the control group and the aquafaba biscuits were compared with each other, the aquafaba biscuits showed the following results:

The substitute samples' textural and flavor profiles match the traditional biscuit offered by the standard.

It performed quite close to its characteristics, superficial/aromatic aspects such as color and scent.

In terms of parameters, it surpassed the control group, resulting in higher panelist satisfaction.

It has been determined that it provides. When a holistic evaluation of sensory analysis is made, aquafaba

Its use preserves the characteristic sensory balance of the biscuit, enhancing edibility and preference.

In terms of feasibility indices, it is more advantageous and successful compared to control group samples.

It is observed that the corn biscuits exhibit structural and physical profiles during the cooking process.

In a study examining the changes, sensory firmness was tested and corn ratio was analyzed.

The hardness of high-yielding biscuits was not well-received (Lara et al., 2011). Brittleness in biscuits.

Or, as long as flexibility isn't excessive, it's considered a pleasant sensory trait.

Although the hardness of the aquafaba biscuit was not as good as the standard, our study yielded positive results.

Kunt's gluten-free biscuits, made with rice and corn starch, have received nutritional value.

In the study, buckwheat flour, carob flour and chickpea flour were added to increase its value.

Samples with 20% and 30% buckwheat flour added were positive in terms of sensory evaluation, while samples with 40% buckwheat flour...

The addition of chickpea flour negatively affects sensory characteristics and reduces the liking rate.

The addition of this product resulted in the biscuit type receiving the highest praise in terms of color and appearance (Kunt, 2018). Our

In our study, the aquafaba-based biscuit also showed more positive results in terms of color compared to the control.

Production of Gluten-Free Biscuits with Added Roasted Chickpea Powder: 20% in the TOPSIS Application Study

Biscuits to which chickpea powder was added received the closest approval rating to the control biscuit.

The study determined that 15 panelists aged 20-60 years were given a sensory evaluation using a 5-point hedonic scale.

The following assessments were conducted: color, odor, crispness, melt-in-your-mouth texture, and overall acceptability.

It has been evaluated. It has been observed that the aroma increased with the addition of roasted chickpea powder. Crispness and

The melting sensation in the mouth increased with the addition of more roasted chickpea powder, yielding positive results.

As the addition of roasted chickpea powder increased, overall acceptability decreased. However, in terms of color value, the most...

Adding a higher amount of roasted chickpea powder improves the color of the biscuit and yields more positive results.

(Cingöz and Güldane, 2023). In our study, the addition of aquafaba improved color properties compared to the control.

This makes it more positive. Similarly, aquafaba biscuits are generally more acceptable.

The control biscuit stood out more than the standard one and received a near-standard approval rating. Uÿkun

In the study, which examined the use of the plant as a functional ingredient in biscuit production,

The effects of rhubarb addition on the sensory properties of the product were evaluated.

Sensory analysis results included: surface appearance, shape, crispness, chewing, and swallowing.
Biscuits with rhubarb in terms of characteristics, taste-aroma and overall acceptability parameters.
No statistically significant difference was found between the samples and the control group, and
It was determined that the samples exhibited similar sensory profiles. 30 panelists aged 18-65.
They were informed before the evaluation. These findings suggest that the rhubarb plant affects consumer acceptance of biscuits.
without negatively affecting its availability and organoleptic qualities, a functional
Sensory analysis shows that it can be included in formulations as an additive.
The results range between 3.53 and 4.17. No significant difference was observed.

In conclusion, this high acceptance rate of biscuits produced with aquafaba from sensory panels is noteworthy.
Availability scores for this plant-based byproduct for individuals following a vegan diet and those with egg allergies.
In biscuit formulations aimed at specific consumer groups, such as those mentioned, animal protein
as an alternative, high-potential and functional substitute component to its sources
This strongly suggests that it can be used.

CONCLUSION AND RECOMMENDATIONS

This research explores an alternative functional ingredient to egg white in biscuit formulations.
This reveals the potential of using aquafaba. Aquafaba possesses

In addition to its foaming, emulsification, foam generation and stabilization capabilities, the product...
The textural and sensory properties it provides support this substitution. Physical quality
When the parameters were examined, the control was based on diameter, thickness, and spread rate values.
It has been determined that this group is closer to standard norms, and optimization is being considered in this regard.
Studies are needed. Indeed, high thickness is required in biscuit production.
Since this was not a desired quality criterion, a more limited degree of swelling in the control sample ensured
compliance with the standards. In line with the relevant literature and industrial expectations,
In biscuit formulations, other geometric and textural aspects are more important than volumetric thickness.
It appears that the parameters are evaluated first. In terms of the weight parameter...
Both samples showed proximity to standard biscuit values, and there were differences between the groups.
No statistically significant difference was found ($p<0.05$). Foam capacity and
As a result of stability analyses, it was found that aquafaba had both higher levels after the whipping process.
It is superior in both creating foam volume and maintaining this foam structure.
It was determined that the control biscuit exhibited a lower L* value.
The study revealed that using egg whites resulted in a darker color in the product.
The fact that biscuits containing aquafaba remain lighter in color is due to Maillard reactions, which cause browning.
This is an indication that the reaction occurs less frequently in these samples. The average a* value.
In this respect, the aquafaba samples had lower values compared to the control biscuits.
It has been determined that the control group is structurally more reddish in tone.
This confirms. On the other hand, there are statistically significant differences between the b* color components of the samples.
No significant difference was detected. Acidity is a quality criterion in baby biscuits.
not required, and both experimental groups have a pH range consistent with standard biscuit norms.
This has been demonstrated. According to moisture measurement, the moisture content of the aquafaba biscuit was 2.42% higher than the control biscuit.
The lower moisture content provides a significant advantage. Low moisture content is microbiologically and chemically beneficial.
By limiting spoilage reactions, it increases the shelf life of the final product. This situation,
Longer-term storage and logistics processes in industrial biscuit production lines and
This allows for safe execution. Based on the findings,
Biscuits containing aquafaba have a low moisture content, which provides a commercially viable shelf life.
This points to its potential and supports the marketability of the product. Aquafaba is plant-based.
Despite being derived from animal sources, its protein content is close to that of animal sources, making it vegan.
Aquafaba is an alternative and sustainable source that will reduce the protein deficiency in their diets.
The carbohydrate content of the biscuits was found to be 0.81% higher than the control sample.
This is explained by the fact that the carbohydrate content in the dry matter of the substituted chickpea aquafaba is
higher than the carbohydrate content of the egg white. Energy values of the samples.

Upon examination, it was determined that aquafaba biscuits had a calorie content of 479.81 kcal/100g, while the control group biscuits had a calorie content of 478.52 kcal/100g. The difference found between the two groups... The difference of 1 kcal was not statistically significant, and the use of aquafaba... It was assessed that the oil did not lead to a significant change in the total energy value of the product. In terms of ash parameters, aquafaba biscuits showed statistically significant differences compared to the control sample. There is no significant difference at the level. TPA analysis data shows that chickpea water use does not affect eggs. Compared to other methods, it increases the crispness of the biscuit while also improving its structural integrity. Textural analyses reveal that the use of aquafaba supports the biscuit's quality. Studies have shown that it increases mechanical resistance. High hardness in biscuit structure is reported in the literature. Since the degree was considered an undesirable characteristic, the control group hardness parameter In terms of its properties, it is more compliant with the standard. In contrast, aquafaba is less suitable in terms of its brittleness characteristics. The formulation containing this ingredient is more compliant with standard biscuit specifications and the product It has been observed to confer a positive vulnerability. Sensory assessment results. Upon examination, biscuits with added aquafaba showed superior performance in all sensory qualities compared to the control group. It was found that it received higher approval scores. This was done by the panelists. In the evaluation, the following parameters were tested: appearance, color, firmness, flavor, crispness, smell, chewability, presentation, mouthfeel, overall quality, and general acceptability. Examples The most pronounced variation between them was observed in flavor scores. In contrast, the lowest It was determined that the difference lies in the presentation parameter. This situation applies to both biscuits. Its formulation also shares similar qualities in terms of presentation characteristics and visual presentation aesthetics. This can be explained by the fact that the HMF content of both biscuit samples was within acceptable limits. It was determined that it remained within the limits. The aquafaba biscuit had a lower value compared to the control sample. The presence of HMF, chemical misinformation in the formulation, and undesirable compounds. This confirms that the risk of occurrence is lower. These research findings, The study reveals that aquafaba-substituted biscuits, developed based on a standard baby biscuit formulation, have commercial potential on an industrial scale. The product... When physicochemical, textural and sensory quality parameters are evaluated as a whole, Its compliance with general consumer standards has been verified. This developed formulation, in particular... sensitive consumers who adopt a vegan diet or have egg allergy/intolerance It offers a healthy, reliable and functional alternative for these groups. However, the statement to measure the market success and consumer perception of the product in a more objective way In the name of future studies, focus group-focused specific sensory studies that directly include the target audience will be conducted. And clinical trials need to be conducted.

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APPENDICES

Appendix 1. Sensory Analysis Evaluation Form:

BISCUIT SENSORY ANALYSIS FORM

History:

Panelist's Full Name:

Age:

Educational Background:

Features	Aquafaba biscuits	Control biscuits
Appearance		
Colour		
Hardness		
Brittleness		
Flavor (Smell + Taste + Aroma)		
General Acceptability		
Chewability		
Smell		
The feeling it leaves in the mouth		
Presentation		
Quality		

Note: General Acceptability includes all sensory characteristics, both those stated and not stated in this form.

It is an assessment that encompasses all aspects.

Appendix 1. (Continued)

Overall Scoring Table

Point	Explanation
1	Not for consumption
2	Too bad
3	Bad (defective)
4	Borderline (Somewhat weak)
5	Middle
6	Quite good
7	Good
8	Very good
9	Perfect

The appearance should be smooth, unbroken, uncracked, and not dried out on the outside.

The color should be light brown, not burnt or reddened.

The interior should look cooked, with evenly distributed fat.

The hardness should be not too hard, it should be brittle.

The flavor should be a pleasant biscuit taste, smell, and aroma.

The texture should be crisp and easily crumbled.

The scent should be pleasant, not smelling like chickpeas.

The preference should be such that it can be purchased as an alternative to regular biscuits.

It will be tested by cooking it in two ways: with egg white and with aquafaba.

RESUME

Personal Information:

Name and Surname: Elif POLAT

Educational Background:

Bachelor's Degree: Erzincan Binali Yÿldÿrÿm University, Department of Nutrition and Dietetics (2016-2020)

Master's Degree: Erzincan Binali Yÿldÿrÿm University, Institute of Health Sciences, Nutrition and Studying in the Department of Dietetics