FOOD and HEALTH

FOOD and HEALTH
E-ISSN 2602-2834

Food and Health 12(1), 72-82 (2026) • https://doi.org/10.3153/FH26007

Research Article

Functional and sensory properties of legume-derived aquafaba in angel cakes

Burcu SARI GENÇAĞ, Gülşah TURHAN

Cite this article as:
Sarı Gençağ, B., Turhan, G. (2026). Functional and sensory properties of legume-derived aquafaba in angel cakes. *Food and Health*, 12(1), 72-82. https://doi.org/10.3153/FH26007

Cappadocia University, Department of Gastronomy and Culinary Arts, Nevşehir 50240, Türkiye

ORCID IDs of the authors:
B.S.G. 0000-0002-2847-297X
G.T. 0009-0009-0534-9205

Submitted: 03.10.2025
Revision requested: 22.10.2025
Last revision received: 26.10.2025
Accepted: 01.11.2025
Published online: 05.01.2026

Correspondence:
Burcu SARI GENÇAĞ
E-mail: burcu.sari@kapadokya.edu.tr

Available online at
http://jfhs.scientificwebjournals.com

ABSTRACT

This study evaluated aquafaba obtained from four legumes: chickpea (CP), mung bean (MB), green lentil (GL), and dermason/white bean (WB) as a complete egg-white substitute in angel cake. Functional properties (foaming capacity and stability; emulsion stability) and cake quality (pH, protein, ash, moisture, colour, baking loss, volume index, and sensory evaluation, n=25) were assessed. The egg-white control (C) showed the highest foaming capacity (608.52%) and stability (92.04%). Among aquafaba samples, CP, MB, and GL exhibited comparable foaming performance (≈145–148% capacity; ≈76–78% stability), whereas WB was significantly lower (116.59%; 56.37%) ($p < 0.05$). Cakes with aquafaba had lower pH and generally lower protein than the control, with GL the lowest; moisture was highest in MB and WB, while ash showed no difference. Colour analysis revealed darker crumbs with reduced lightness and yellowness. Baking loss increased with aquafaba (MB and WB highest), while volume index decreased; CP retained the most significant volume among the aquafaba groups. Sensory results showed no significant differences among C, CP, and GL, while MB and WB scored lower. Overall, CP and to some extent GL provided the most favourable technological and sensory performance, emphasising legume type as a key factor for successful egg replacement in cakes.

Keywords: Aquafaba, Legume, Angel cake, Sustainable food ingredients

Introduction

Eggs are a fundamental ingredient in the food industry, prized for their nutritional value and unique functional properties, including coagulation, binding, foaming, and emulsification, which are essential for the structure and texture of many baked goods (Baldwin, 1986; Yazıcı & Ozer, 2021). Egg whites, in particular, are critical for creating the light, airy texture of products like angel food cake due to their exceptional foaming capabilities (Li et al., 2022; Razi et al., 2023). However, several factors, including dietary preferences (veganism, vegetarianism), health concerns (e.g., egg allergies, cholesterol), and rising costs, have created a growing demand for adequate egg substitutes (Mustafa et al., 2018; Godefroidt et al., 2019).

This has led researchers to explore various plant-based alternatives. Among the most promising is "aquafaba," the viscous liquid left over from cooking legumes such as chickpeas (Grossi Bovi Karatay et al., 2022). The term, derived from the Latin words for water (aqua) and bean (faba), was coined in 2014 (Buhl et al., 2019; Erkoç, 2022). Aquafaba's ability to mimic the functional properties of egg whites is attributed to its composition of proteins, starches, and saponins that leach from the legumes during cooking (El-Adawy, 2002). These components enable aquafaba to be whipped into a stable foam and to act as an emulsifier, making it a popular ingredient in vegan baking for products like meringues, mousses, and cakes (Li et al., 2022; Razi et al., 2023).

Earlier studies have focused primarily on chickpea aquafaba as an egg replacer. For instance, Mustafa et al. (2018) reported that sponge cakes prepared with chickpea aquafaba exhibited comparable texture and colour to those made with egg whites. Similarly, Aslan and Ertaş (2020) found that replacing up to 50% of eggs with chickpea aquafaba resulted in favourable physical and sensory outcomes, including acceptable colour and texture.

In recent years, however, the scope of aquafaba research has expanded beyond chickpeas to include other legumes and to better understand compositional and functional variations. For example, a comparative study on French meringues made with aquafaba from chickpea, pea, lentil, pinto bean, and soybean revealed that pea and chickpea aquafaba achieved superior air incorporation and foam stability, emphasising the key influence of legume type on aeration and moisture retention properties (Oliveira et al., 2025). Likewise, Konal et al. (2025) demonstrated that aquafaba derived from white and black chickpeas, red kidney beans, and white beans could successfully replace eggs in cake formulations, with white chickpea aquafaba showing the highest foam stability and emulsion capacity, leading to cakes with desirable crust lightness and sensory acceptability. Beyond functional properties, Huang et al. (2024) revealed that aquafaba from chickpeas and common beans contains bioactive oligosaccharides and γ-glutamyl peptides with potential prebiotic and taste-enhancing (kokumi) effects, highlighting its emerging role as a biofunctional ingredient. Together, these studies indicate that both the legume source and its compositional characteristics profoundly affect aquafaba's technological, nutritional, and sensory performance.

Building upon this foundation, the present study conducts a comparative evaluation of aquafaba derived from four different legumes (chickpeas, green lentils, mung beans, and dermason beans) as complete egg-white substitutes in angel cake formulation. Functional properties, including foaming capacity and stability, as well as emulsion stability, were determined. Cake samples were analysed for physicochemical parameters (pH, protein, ash, and moisture content), colour, baking loss, and volume index. Sensory evaluation was also performed to assess taste, texture, colour, and overall acceptability.

This investigation aims to identify the most suitable legume source for aquafaba-based egg substitution, thereby contributing to the development of sustainable, allergen-free, and clean-label bakery products while promoting the valorisation of legume byproducts as valuable functional ingredients.

Materials and Methods

Materials

Chickpeas (*Cicer arietinum* L.), green lentils (*Lens culinaris*), mung beans (*Vigna radiata*), and dermason beans (*Phaseolus vulgaris*) were procured from a local market in Nevşehir, Turkey. Other ingredients, including all-purpose flour, powdered sugar, canola oil, vanilla and salt, were also locally sourced.

Preparation of Aquafaba

The four types of legumes were individually washed and soaked in water. Following pre-trials to determine optimal cooking times and temperatures for each legume, they were boiled until tender. After cooking, the legumes were allowed to cool to room temperature and then refrigerated for 24 hours. The cooking liquid (aquafaba) was then carefully strained from the legumes and stored for use in the cake formulations.

Cake Formulation and Preparation

Five different angel food cake formulations were prepared, as detailed in Table 1. One formulation served as the control (C), using 150 mL of egg white. The other four formulations (CP, MB, GL, WB) each used 150 mL of aquafaba from chickpeas, mung beans, green lentils and white beans, respectively, as a complete egg white substitute.

Table 1. Angel cake formulations

Group	Egg White (mL)	Aquafaba (mL)	Flour (g)	Vanilla (g)	Powdered Sugar (g)	Salt (g)
C	150	0	100	10	75	2
CP	0	150	100	10	75	2
MB	0	150	100	10	75	2
GL	0	150	100	10	75	2
WB	0	150	100	10	75	2

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB).

The cake batter was prepared following a modified method from Mustafa et al. (2018). The egg white or aquafaba was whipped in a stand mixer (Öztiryakiler Gurmeaid Mikser), starting at a low speed and gradually increasing to maximum. Salt was added as the foam began to form. Powdered sugar was gradually incorporated while whipping at high speed for 3 minutes until a stiff, glossy foam was achieved. Flour and vanilla were sifted together and gently folded into the foam in three additions. The batter was poured into ungreased angel food cake pans and baked in a preheated oven (Electrolux Air-O-Steam) at 170°C for approximately 40 minutes. The cakes were then inverted and cooled completely before analysis.

Analysis of Aquafaba

Foaming capacity (FC) and foam stability (FS)

FC and FS were measured according to the method described by Mustafa et al. (2018). A 5 mL sample of aquafaba was diluted with 10 mL of water and whipped at high speed for 2 minutes. The foam volume was recorded immediately (V_{F0}) and after 30 minutes (V_{F30}). FC and FS were calculated using the following equations.

$$\%FC = \frac{V_{F0}}{V_{initial}} \times 100$$

$$\%FS = \frac{V_{F30}}{V_{F0}} \times 100$$

Emulsion stability (ES)

The emulsion stability of the cooking waters was determined according to the method described by Martinez et al. (2016). For this purpose, 5 mL of aquafaba and 5 mL of canola oil were mixed using a mixer (Öztiryakiler Gurmeaid Mixer) at speed 10 for 2 minutes to achieve homogenization. The resulting emulsion was immediately transferred quantitatively into a 10 mL graduated cylinder. After 30 minutes, the volume of the separated aqueous phase was measured, and emulsion stability was calculated according to the equation below.

$$\%ES = \frac{V_B - V_A}{V_B} \times 100$$

V_B: Volume of aquafaba before homogenization (5 mL)

V_A: Volume of aqueous phase separated after 30 minutes

Analysis of Cakes

Physicochemical analysis

The pH values of all cake samples were measured using a portable pH meter equipped with a penetration probe (Milwaukee, MW102-F, Romania). Moisture, protein, fat, and ash contents were determined according to the Official Methods of Analysis of AOAC International (AOAC, 2005).

Physical analysis

Baking loss was determined as the percentage difference in weight before and after baking, calculated using the following equation. Following baking and cooling of the cake samples, colour measurements were performed on both the crust and crumb using a colourimeter (PCE-CSM 3, PCE Instruments, Germany). The measurements were carried out at room temperature, and the colour parameters L^* (lightness), a^* (red-green axis), and b^* (yellow-blue axis) were recorded. For each sample, values were taken from at least three different points to ensure representativeness.

The volume index of the cake samples was determined according to the template method described by Rahmati and Tehrani (2014) and AACC Method 10-91 (AACC, 1983). After baking, the cakes were allowed to cool at room temperature and then sliced vertically into two equal halves. Each half was further cut into several slices with a thickness of 2.5 cm. The height of each slice face was measured at different positions. The volume index was determined according to the following equation.

$$Baking\ Loss\ (\%) = \frac{W_1 - W_2}{W_2} \times 100$$

W_1: Weight of baked sample (g)

W_2: Weight of unbaked (dough)sample (g)

$$Volume\ Index = B + C + D$$

B: Height 2.5 cm to the left of the center

C: Height at the center of the cake

D: Height 2.5 cm to the right of the center

Sensory Analysis

Sensory evaluation of the cake samples was conducted using a five-point hedonic scale. Panellists were asked to score the samples in terms of flavour, internal colour, external colour, texture, and overall acceptability (1: dislike extremely – 5: like extremely). A total of 25 panellists participated in the evaluation. The sensory assessment was performed immediately after the cakes were produced and allowed to cool at room temperature for 30 minutes.

Statistical Analysis

The planned experiments were conducted in two replications with three parallels. Statistical analyses of the data were performed using the SPSS for Windows software package (Version 21.0) at a 95% confidence level. Within each experiment, the data were evaluated using one-way and two-way ANOVA, and mean comparisons were carried out with Duncan's multiple range test.

Results and Discussion

Foam Capacity and Stability

Foaming properties are among the most critical functional characteristics of eggs and their substitutes, as they directly influence the texture, volume, and porosity of baked products (Laursen et al., 2025). Egg whites typically exhibit superior foaming capacity and stability due to their high protein content, particularly ovalbumin, which unfolds and forms viscoelastic films around air bubbles during whipping (Abeyrathne et al., 2025). Aquafaba, on the other hand, owes its foaming properties to proteins, polysaccharides, and saponins that leach into the cooking water of legumes. These compounds reduce surface tension and enhance the stability of air–water interfaces. However, variations in legume type and composition significantly affect aquafaba performance (Stasiak et al., 2023; de Barros Miranda et al., 2024).

The results of this study (Table 2) revealed significant differences ($p < 0.05$) among the experimental groups. The control cake prepared with egg whites (YBK) exhibited the highest foam capacity (608.52%) and foam stability (92.04%), confirming the well-established superiority of eggs in foaming functionality. No statistically significant differences ($p > 0.05$) were observed among the chickpea (CP), mung bean (MB), and green lentil (GL) aquafaba groups in terms of foam capacity and stability, indicating comparable foaming performance. In contrast, the dermason bean (WB) group exhibited significantly lower values for both foam capacity and stability ($p < 0.05$), suggesting its limited potential as an egg white substitute in cake formulations.

Mustafa et al. (2018) reported that aquafaba from canned chickpeas exhibited foaming capacities ranging from 182% to 476% and stabilities between 77% and 92%, with some samples performing comparably to egg white. Similarly, Alsalman et al. (2020) showed that chickpea-to-water ratio and cooking time significantly influence foam properties, with maximum foam capacity reaching 120% and stability extending up to 57 min under optimised conditions. Wei et al. (2024) further demonstrated that aquafaba could enhance the foaming performance of mung bean proteins, achieving foam capacity values of ~85% and stability exceeding 90%. This improvement was attributed to the interaction of aquafaba's proteins, saponins, and carbohydrates with legume proteins, which increased interfacial film thickness and bulk viscosity, thereby stabilising air bubbles.

Table 2. Foam capacity and stability results of the experimental groups

Groups	Foam Capacity (%)	Foam Stability (%)
C	608.52±1.81^{a}	92.04±1.70^{a}
CP	148.14±2.24^{b}	75.98±2.48^{b}
MB	145.87±1.64^{b}	76.33±0.51^{b}
GL	145.04±1.25^{b}	78.01±2.45^{b}
WB	116.59±3.10^{c}	56.37±1.75^{c}

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB)

Emulsion Stability

Emulsion stability (ES) plays a key role in the quality of bakery products, as it ensures uniform distribution of fat and water phases, directly influencing crumb structure, moisture retention, and mouthfeel (Kohajdová et al., 2009; Xiao et al., 2025). Egg whites are known for their excellent emulsifying properties, mainly attributed to surface-active proteins such as ovalbumin and globulins that rapidly adsorb to the oil–water interface and form viscoelastic films (Razi et al., 2023). In contrast, aquafaba derives its emulsifying functionality from a combination of soluble proteins, polysaccharides, and saponins that leach into the cooking liquid of legumes during processing (Sahin et al., 2024; Koriyama et al., 2025). These compounds reduce interfacial tension and promote the stabilisation of dispersed oil droplets, although the extent of stabilisation varies depending on the legume type and extraction method (Fuentes Choya et al., 2023; Koriyama et al., 2025).

The results of this study revealed significant differences ($p < 0.05$) among the experimental groups (Table 3). The egg white control (C) showed the highest emulsion stability (95.33%), confirming its superior ability to stabilise oil-in-water emulsions. Among the aquafaba samples, mung bean (MB, 85.96%) exhibited the best performance, followed by chickpea (CP, 82.40%) and green lentil (GL, 73.66%). Dermason bean aquafaba (WB, 61.44%) recorded the lowest emulsion stability, indicating limited emulsifying potential.

Overall, while egg whites remain the gold standard for emulsification, mung bean and chickpea aquafaba demonstrated promising functionality, approaching the performance of the control. These results highlight the potential of aquafaba as an egg white substitute in baked products, although legume type strongly influences its emulsifying efficiency.

Similar findings have been reported in previous studies, where chickpea aquafaba demonstrated moderate-to-high emulsion stability values (60–80%) depending on processing and brand variability (Mustafa et al., 2018). Alsalman et al. (2020) also showed that cooking conditions, particularly chickpea-to-water ratios and cooking times, significantly influenced aquafaba's foaming and emulsifying properties, while Wei et al. (2024) highlighted that the inclusion of aquafaba enhanced the stability of mung bean protein-based emulsions. Collectively, these studies support the present findings that aquafaba, especially from chickpea and mung bean, can function as an effective plant-based emulsifier, though legume source and processing conditions remain decisive factors.

Table 3. Emulsion stability (%) of experimental groups

Groups	Emulsion stability (%)
C	95.33 ± 2.52^{a}
CP	82.40 ± 2.50^{c}
MB	85.96 ± 1.89^{b}
GL	73.66 ± 3.38^{d}
WB	61.44 ± 1.90^{e}

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB)

Physicochemical Analysis of Cakes

The physicochemical properties of the cake samples are presented in Table 4. Significant differences ($p < 0.05$) were observed among the groups in terms of pH, protein, and moisture content, while ash values showed no significant variation.

The pH of the control cake prepared with egg white (8.87) was markedly higher than that of the aquafaba-based cakes (6.42–6.63). This reduction in pH is consistent with previous studies reporting that aquafaba generally exhibits a more acidic character compared to egg whites, primarily due to the presence of organic acids, proteins, and saponins leached from legumes during cooking (Aslan & Ertaş, 2020; Grossi Bovi Karatay et al., 2022). The lower pH of aquafaba cakes may influence Maillard and caramelisation reactions, thereby affecting colour development and flavour.

Protein content also varied significantly across the samples. The control (8.42%) exhibited the highest protein value, reflecting the rich protein composition of egg whites. Among the aquafaba groups, mung bean (6.66%) and white bean (6.59%) cakes had relatively higher protein contents, whereas green lentil aquafaba (4.28%) resulted in the lowest value. The reduced protein levels in aquafaba cakes compared to the control are in agreement with earlier findings indicating that aquafaba contains substantially lower protein concentrations than egg white (Mustafa et al., 2018; Nguyen & Tran, 2021). These differences in protein content directly affect foaming and emulsifying abilities, with implications for cake volume and texture.

Moisture content was significantly affected by the type of aquafaba used. Cakes prepared with mung bean and white bean aquafaba exhibited the highest values (32.38% and 31.05%, respectively), followed by the control (26.71%). In contrast, green lentil aquafaba resulted in the lowest moisture content (21.27%). The higher moisture retention observed in mung bean and white bean aquafaba cakes can be attributed to the water-binding capacity of soluble polysaccharides and proteins, which help reduce water loss during baking.

Ash values remained relatively constant across all groups (1.81–1.91%), with no significant differences observed ($p > 0.05$). This indicates that the mineral contribution of aquafaba was comparable among different legume types under the present experimental conditions. In contrast, Aslan & Ertaş (2020) reported that the ash content of cakes decreased as the proportion of chickpea aquafaba increased, compared to egg-based formulations. Similarly, Konal et al. (2025) found that cakes prepared with aquafaba from different legumes (white and black chickpea, white and red beans) exhibited ash values ranging between 1.01% and 1.18%, which were generally lower than those of the egg-based control.

Overall, these results demonstrate that the substitution of egg white with aquafaba significantly influences the pH, protein, and moisture content of cakes, while ash values remain stable. The observed differences highlight the importance of legume type in determining the functional and nutritional quality of aquafaba-based baked products.

Table 4. Physicochemical properties of cake samples

Groups	pH	Protein (%)	Ash (%)	Moisture (%)
C	8.87±0.02^a	8.42±0.06^a	1.91±0.02^a	26.71±0.25^c
CP	6.63±0.03^b	6.51±0.03^d	1.89±0.03^a	25.44±0.50^d
MB	6.42±0.02^c	6.66±0.01^b	1.81±0.13^a	32.38±0.50^a
GL	6.44±0.10^c	4.28±0.04^e	1.89±0.03^a	21.27±0.33^e
WB	6.49±0.05^c	6.59±0.03^c	1.91±0.02^a	31.05±0.49^b

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB)

Physical Analysis of Cakes

The colour parameters (L^*, a^*, b^*) of the cake samples are presented in Table 5. Significant differences ($p < 0.05$) were observed among the groups for both crumb and crust colour.

The control cake prepared with egg white exhibited the highest L^* value in the crumb (75.59), indicating a lighter internal structure compared to the aquafaba-based cakes. In contrast, the mung bean aquafaba (MB) group had the lowest crumb lightness (43.87), reflecting a darker interior. This reduction in L^* values in aquafaba samples can be attributed to the presence of pigments and proteins in legumes, which intensify Maillard and caramelisation reactions during baking (Mohammed et al., 2012; Aslan & Ertaş, 2020).

Regarding the a^* values, green lentil aquafaba (GL) resulted in the highest redness (4.30) in the crumb, whereas mung bean aquafaba (MB) produced the lowest (1.20). The crust colour followed a similar trend, with the control and white bean (WB) groups showing higher a^* values (17.26 and 17.10, respectively), while the MB group had the lowest (9.20). These variations can be linked to differences in the composition of legume aquafaba, including phenolic compounds and reducing sugars, which influence browning reactions (He et al., 2021).

In the crust, the b^* values of white bean (WB) and green lentil (GL) aquafaba samples (31.08 and 29.74, respectively) were statistically similar to the control (29.99), whereas chickpea (CP) and mung bean (MB) groups exhibited significantly lower yellowness values ($p < 0.05$). These results indicate that the type of aquafaba can influence crust colour development, with some legumes supporting a level of browning comparable to egg white, likely due to their content of reducing sugars and surface-active compounds that enhance Maillard and caramelisation reactions during baking.

Overall, the substitution of egg white with aquafaba significantly altered the colour characteristics of cakes, particularly reducing crumb lightness and yellowness while increasing redness in some legume-based formulations. These findings are consistent with previous studies reporting that legume-derived ingredients contribute to darker and more intense colour profiles in baked products compared to egg-based formulations (Ozkahraman et al., 2016; Konal et al., 2025).

The baking loss values of the cake samples ranged between 7.65% and 13.42% (Table 6). The control group with egg white (C) exhibited the lowest baking loss (7.65%), while the mung bean (MB) and white bean (WB) aquafaba groups showed the highest values (13.42% and 12.92%, respectively). The elevated baking loss in aquafaba-based cakes can be attributed to the relatively lower protein content and weaker binding capacity of aquafaba compared to egg whites, which results in reduced water retention during baking. The control group, with the highest protein content (8.42%), exhibited the lowest baking loss (7.65%), highlighting the superior water-binding and gel-forming capacity of egg white proteins, particularly ovalbumin (Katekhong & Charoenrein, 2017; Wang et al., 2025). In contrast, aquafaba-based samples, despite containing moderate protein levels (e.g., MB: 6.66%, WB: 6.59%), demonstrated significantly higher baking losses (13.42% and 12.92%). This suggests that not only protein content but also the functional quality of legume-derived proteins plays a crucial role in determining baking performance.

The volume index of cakes ranged from 7.23 to 9.58. The control group (C) achieved the highest volume index (9.58), significantly outperforming the aquafaba-based formulations ($p < 0.05$). Among the aquafaba groups, chickpea aquafaba (CP) maintained a relatively higher volume index (7.97). In contrast, mung bean (MB), green lentil (GL), and white bean (WB) aquafaba samples all showed similarly lower values (7.73, 7.33, and 7.23, respectively), with no significant differences among them. These reductions in cake volume are likely associated with the lower foaming capacity and stability of aquafaba compared to egg whites, which directly influences the incorporation and retention of air during baking (Lomakina & Mikova, 2006; Crawford et al., 2023).

Overall, the substitution of egg white with aquafaba led to higher baking losses and reduced cake volume, though variations among legume types were evident. Chickpea aquafaba showed relatively better performance compared to other legumes, consistent with previous studies highlighting its superior functional properties (Mustafa et al., 2018; Grossi Bovi Karatay et al., 2022; Konal et al., 2025).

Sensory Analysis

The sensory evaluation results are presented in Table 7. Representative images of the cakes prepared with egg white and different legume aquafaba samples are shown in Figure 1.

No significant differences ($p > 0.05$) were observed among the control, chickpea aquafaba and green lentil aquafaba samples in terms of flavour, colour, texture, and overall acceptability. These findings indicate that both chickpea and green lentil aquafaba can achieve sensory performance comparable to egg white in cake formulations. For aroma, however, the control and chickpea aquafaba groups received significantly higher scores (4.08 and 3.96, respectively) compared to the other aquafaba samples. In contrast, mung bean and dermason bean aquafaba cakes scored significantly lower across most attributes, particularly for texture and overall acceptability, suggesting limited consumer appeal ($p < 0.05$).

Similar to previous reports, both chickpea and green lentil aquafaba can deliver acceptable sensory quality in baked products under appropriate processing and formulation conditions, supporting their use as legume-based alternatives to egg white (Mustafa et al., 2018; Stantiall et al., 2018; Konal et al., 2025).

Table 5. *Color parameters (L*, a*, b*)* of cake samples

Groups	Crumb of cakes			Crust of cakes		
	L^*	a^*	b^*	L^*	a^*	b^*
C	75.59±2.99^a	2.81±0.13^b	18.79±0.30^a	59.98±0.64^a	17.26±0.76^a	29.99±0.93^a
CP	57.79±4.62^c	2.80±0.50^b	13.89±1.03^c	47.40±1.43^c	13.53±0.56^b	27.08±0.86^b
MB	43.87±1.50^e	1.20±0.16^c	8.89±0.19^d	57.54±2.84^a	9.20±0.98^c	27.54±1.46^b
GL	52.48±2.58^d	4.30±0.19^a	15.42±0.09^b	49.08±2.35^c	14.72±1.46^b	29.74±0.79^a
WB	65.27±1.27^b	2.71±0.22^b	14.70±0.17^{bc}	53.17±1.18^b	17.10±0.51^a	31.08±0.55^a

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB)

Table 6. Baking loss and volume index of cake samples

Groups	Baking Loss (%)	Volume Index (%)
C	7.65±0.96^c	9.58±0.60^a
CP	10.24±0.30^b	7.97±0.45^{ab}
MB	13.42±1.05^a	7.73±1.70^b
GL	10.74±0.03^b	7.33±0.64^b
WB	12.92±0.93^a	7.23±0.25^b

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB)

Table 7. Sensory evaluation results of cake samples

Groups	Flavor	Color	Texture	Aroma	Overall acceptability
C	3.64±0.91^a	4.12±0.88^a	3.44±1.00^a	4.08±0.86^a	3.92±0.76^a
CP	3.48±0.92^a	4.08±0.76^a	2.92±1.00^a	3.96±0.74^a	3.64±0.64^a
MB	2.04±0.98^b	2.84±0.94^b	1.64±0.81^b	2.92±1.08^{bc}	2.20±0.91^b
GL	3.44±0.71^a	3.72±0.79^a	3.00±1.04^a	3.40±0.71^b	3.56±0.77^a
WB	2.20±1.26^b	2.36±1.25^b	1.76±0.83^b	2.44±1.04^c	1.80±0.87^b

Control with egg white (C), Chickpea aquafaba (CP), Mung bean aquafaba (MB), Green lentil aquafaba (GL), White bean aquafaba (WB)

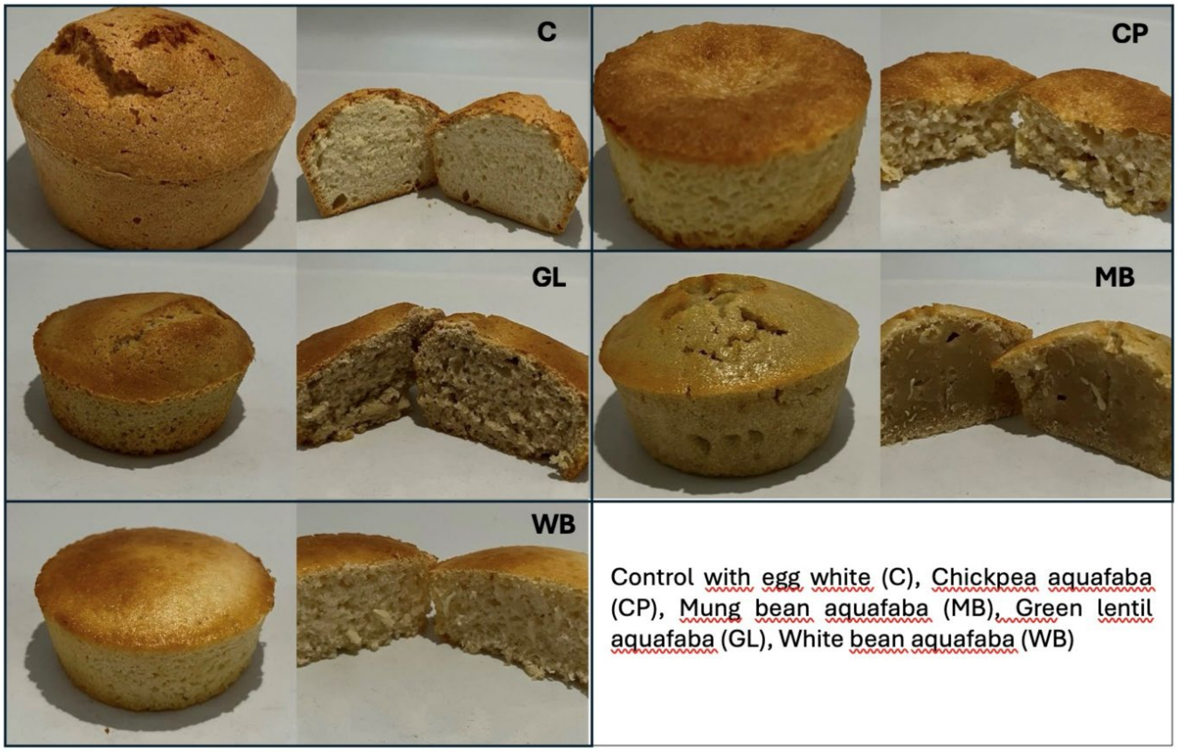

Figure 1. Appearance of angel cakes prepared with egg white (control) and different legume-derived aquafaba samples

Conclusion

This study demonstrated that aquafaba derived from different legumes can serve as a complete egg white substitute in angel cake, though the legume source strongly influences its functionality and sensory performance. Chickpea and green lentil aquafaba showed the most promising results, achieving foaming, emulsifying, and sensory properties comparable to egg whites, while mung bean performed moderately, and dermason bean proved the least suitable. The use of aquafaba not only supports the development of allergen-free and vegan bakery products but also contributes to the valorisation of legume by-products, aligning with sustainable food system goals. Future research should focus on optimising extraction and processing conditions to enhance the protein and functional quality of aquafaba and broaden its application in diverse bakery and food formulations.

Compliance with Ethical Standards

Conflict of interest: The author(s) declare that they have no actual, potential, or perceived conflicts of interest related to this article.

Ethics committee approval: The authors declare that this study does not involve experiments with human or animal subjects, and therefore, ethics committee approval is not required.

Data availability: The data will be made available upon request by the author(s).

Funding: This study was supported by TÜBİTAK 2209-A University Students Research Projects Support Program.

Acknowledgements: We thank the Scientific and Technological Research Council of Türkiye (TÜBİTAK).

Disclosure: -

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