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Applicability of the Dietetic Technique in the process of making green pea aquafaba (Pisum sativum, L.)

Aplicabilidade da Técnica Dietéticano processo de elaboração da aquafaba de ervilha verde (*Pisum sativum*, L.)

Luiza Guimarães Magalhães[1]
Gabriel Nathan da Costa Dias[2]
Vânia Mayumi Nakajima[3]
Elaine Cristina de Souza Lima[4]
Juliana dos Santos Vilar[5]

[1] Universidade Federal Fluminense, Faculdade de Nutrição Emília de Jesus Ferreiro. Niterói, RJ, Brasil.

[2] Universidade Federal do Rio de Janeiro, Instituto de Nutrição Josué de Castro. Rio de Janeiro, RJ, Brasil.

[3] Universidade Federal de Juiz de Fora, Instituto de Ciências Biológicas, Departamento de Nutrição. Juiz de Fora, MG, Brasil.

[4] Universidade Federal do Rio de Janeiro, Escola de Nutrição, Departamento de Nutrição Fundamental. Rio de Janeiro, RJ, Brasil.

[5] Universidade Federal do Rio de Janeiro,, Instituto de Nutrição Josué de Castro, Departamento de Nutrição Básica e Experimental. Rio de Janeiro, RJ, Brasil.

Correspondence

Juliana dos Santos Vilar
julianavilar@nutricao.ufrj.br

Assistant Editors

Lilia Zago
Aline Rissatto Teixeira
Isabelle Santana
Betzabeth Slater Villar

Abstract

Introduction: Vegetarian food is an alternative for healthy and sustainable eating practices. Peas are widely consumed in these diets and, during their preparation, the cooking water generates a by-product called aquafaba (AQ), which has been used as a substitute for eggs in culinary preparations. *Objective*: To apply the dietetic techniques in preparing green pea AQ and to determine its physicochemical characteristics and centesimal composition. *Methods*: On a laboratory scale, the peas were selected, sanitized and soaked, followed by cooking and subsequent separation of the AQ. The formation capacity and stability of the foam were assessed using a mixer. Relative density and kinematic viscosity were measured using a pycnometer and viscometer, respectively. Color was assessed with a colorimeter and the centesimal analyses followed the methods of the Adolfo Lutz Institute. *Results*: The yield obtained in the production of AQ was 250mL for every 100g of peas. The stability of the foam formed was 90%. The relative density of 1.013±0.00 and kinematic viscosity of 2.06 x 10^{-5} m^2/s were similar to water, while the dynamic viscosity was 20.8 mPa*s. The color revealed that the AQ foam is clear (L*=79.10±0.03). AQ has a high moisture content (96.82±0.06%); low ash (0.41±0.06%) and lipid content (0.10±0.18%) and a protein content of 2.07±0.10%. *Conclusion*: The study enabled the standardization of the process of obtaining pea DH and its characterization, contributing to the promotion of more sustainable food practices.

Keywords: Nutrition. Food. Vegetarian diet. Food Technology. Sustainable Food System.

Resumo

Introdução: A alimentação vegetariana é uma alternativa para práticas alimentares saudáveis e sustentáveis. A ervilha é amplamente consumida nessas dietas e, durante seu preparo, a água de cocção gera um subproduto, denominado aquafaba (AQ), que vem sendo utilizado em substituição ao ovo em preparações culinárias. *Objetivo*: Aplicar a técnica dietética na elaboração da AQ de ervilha verde e determinar suas características físico-químicas e composição centesimal. *Métodos*: Em escala laboratorial, realizaram-se a seleção, higienização e remolho dos grãos de ervilha, seguidos de cocção e posterior separação da AQ. Avaliaram-se a capacidade de formação e estabilidade da espuma com auxílio de batedeira. Determinaram-se a densidade relativa e a viscosidade cinemática com o picnômetro e viscosímetro, respectivamente. A cor foi avaliada com colorímetro e as análises centesimais seguiram os métodos do Instituto Adolfo Lutz (2008). ***Resultados***: O rendimento obtido na produção de AQ foi de 250mL para cada 100g de ervilha. A estabilidade da espuma formada foi de 90%. A densidade relativa de 1,013±0,00 e viscosidade cinemática a 2,06 x 10^{-5} m^2/s assemelharam-se à água, enquanto a viscosidade dinâmica foi de 20,8 mPa*s. A cor revelou que a espuma da AQ é clara (L*=79,10±0,03). A AQ possui alta umidade (96,82±0,06%); baixo teor de cinzas (0,41±0,06%) e lipídios (0,10±0,18%) e conteúdo de proteínas de 2,07±0,10%. ***Conclusão***: O estudo permitiu a padronização do processo de obtenção da AQ de ervilha e sua caracterização, de modo a colaborar com práticas alimentares mais sustentáveis.

Palavras-chave: Nutrição. Alimentação. Dieta Vegetariana. Tecnologia de Alimentos. Sistema Alimentar Sustentável.

INTRODUCTION

The reduction of animal product consumption is gaining momentum in Brazil, with more people adopting plant-based diets. There are several reasons for changing lifestyle to a plant-based diet, such as ethical ones, which include consideration of the right to life and the protection of animals, religious issues, concern for health, the environment and/or disliking the taste of meat.[1,2]

A survey conducted in 2018 in 142 Brazilian municipalities by IBOPE Inteligência showed that 14% of Brazilians declared themselves vegetarians. The same survey pointed out that more than half of the Brazilian population would consume more vegan products if they were better identified (55%) or if they were priced similarly to the products they usually consume (60%), and a large proportion of Brazilians expressed their desire to reduce their meat consumption.[3]

In this context, a diet based on plant-based foods is an interesting alternative for more suitable and healthier eating practices, with nutritional properties that are beneficial to health, given that it is based on a high consumption of vegetables, fruit, whole grains, legumes and oilseeds. It is in line with the 2014 *Food Guide for the Brazilian Population*, which recommends that the basis of human nutrition should be based on the consumption of *fresh* and/or minimally processed foods, restricting processed foods and avoiding ultra-processed foods.[4]

It is essential to consider the global impacts of farming on the climate and ecosystems, as well as on public health, since it requires large tracts of land for grazing and the production of feed to feed animals, occupying around 75% of the global arable land and degrading the environment.[5-7]

As a result, it is recommended to change the worldwide food system towards plant-based patterns, favoring the search for a more sustainable food system, which includes one that promotes, in addition to low environmental impact, food and nutritional security, guaranteeing health for current and future generations.[8,9]

There are, however, challenges in the *plant-based* market ranging from sensory attributes, health perceptions and marketing. One of the most significant obstacles in developing plant-based alternatives is replicating the sensory qualities of animal products, such as texture, taste and mouth feel. Another factor is the fact that many consumers associate *plant-based* products as healthier, but the reality is that some alternatives can be highly processed, raising questions about their nutritional value compared to whole foods or traditional animal products.[10-13]

Among the foods consumed in vegetarian and vegan diets are legumes such as peas *(Pisum sativum*, L.)[14] During their preparation, the water from their cooking generates a by-product called aquafaba (AQ) or "liluva", which has been used in vegetarian and vegan culinary preparations.[15] Aquafaba has gained popularity as a functional and versatile alternative in cooking, especially as an egg substitute. It is commonly used in meringues, mousses, mayonnaises and other products that traditionally use eggs.[1,2,15-19]

Aquafaba has foaming, emulsifying and gelling properties and is an option for reducing the consumption of animal-based foods, as well as encouraging the development of culinary skills, as recommended by the *Food Guide for the Brazilian Population* as one of the elements of an adequate and healthy diet.[4,20-22]

With this in mind, the aim of this study was to develop, on a laboratory scale, the process for obtaining Aquafaba from green peas *(Pisum sativum*, L.) and to determine its physicochemical characteristics and centesimal composition

MATERIAL AND METHOD

Process of obtaining aquafaba

The raw material used was dried, shelled and split type 2 green pea seeds *(Pisum sativum*, L.) from the Combrasil® brand, in 500g packets, lot 10L02ECN0086, purchased from a local market in the city of Rio de Janeiro, Brazil.

Pre-preparation

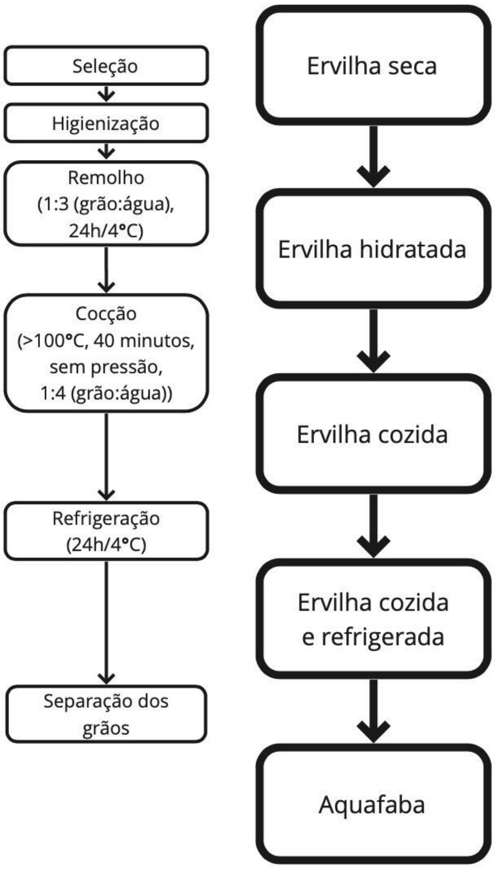
The pre-preparation was divided into three stages. The first was the selection of the grains, in which they were collected and sorted, separating the legumes for preparation. Possible inedible solid matter was also removed, according to the protocol proposed by Asla and Ertaş.[23]

Afterwards, the previously selected grains were washed with running drinking water and then the legume was soaked (ratio 1:3/grain:water) under refrigeration at 4°C for 24 hours. During this period, the water was changed twice during the process (after 8 and 16 hours from the start of soaking) and discarded after the established time (24 hours), as recommended by Domene.[24]

Production, preparation of aquafaba and preparation of the technical sheet

After preliminary tests, the best preparation technique was defined, which was conducted over moist heat, without pressure, using a domestic Dako®stove, in a 1:4 ratio (grain:water). Cooking was started at the maximum flame position for the first 10 minutes, then adjusted to the medium position until the cooking process was complete, which lasted a total of 40 minutes. The cooked legumes, along with the cooking water, were sequentially removed from the pan and transferred to a refractory dish, which was then fully sealed with PVC film and refrigerated at 4ºC for 24 hours. After this cooling period, a stainless steel sieve was used to separate the cooked peas from the now-formed aquafaba (Figure 1). The aquafaba was then weighedusing an SF-400 digital scale and a technical preparation sheet was drawn up (Figure 2).

Figure 1. Flowchart of the process for obtaining green pea aquafaba.



Note: Seleção: Selection,Higienização: Cleaning,Remolho: Soaking,Cocção: Cooking,Minutos: minutes,Sem pressão: without pressure,Grão:água: grain-to-water ratio,Refrigeração: Refrigeration,Separação dos grãos: Grain separation,Ervilha seca: Dry pea,Ervilha hidratada: Hydrated pea,Ervilha cozida: Cooked pea,Ervilha cozida e refrigerada: Cooked and refrigerated pea,Aquafaba: AquafabaE

Source: Prepared by the authors (2024).

Figure 2. Technical data sheet for the preparation of green pea aquafaba

<table>
<tr><th colspan="8">TECHNICAL PREPARATION SHEET</th></tr>
<tr><td colspan="2">Preparation</td><td colspan="6">Green pea aquafaba</td></tr>
<tr><td colspan="2" rowspan="2">Ingredients</td><td rowspan="2">Per capita</td><td rowspan="2">Correction factor</td><td rowspan="2">Gross weight</td><td colspan="3">Total Quantity</td></tr>
<tr><td colspan="2">Weight/Volume</td><td>Unit</td></tr>
<tr><td colspan="2">Green peas</td><td>500</td><td>1,00</td><td>500</td><td colspan="2">500</td><td>g</td></tr>
<tr><td colspan="2">Water for soaking</td><td>1500</td><td>1,00</td><td>1500</td><td colspan="2">1500</td><td>mL</td></tr>
<tr><td colspan="2">Water for cooking</td><td>2000</td><td>1,00</td><td>2000</td><td colspan="2">2000</td><td>mL</td></tr>
<tr><th colspan="8">Preparation Technique</th></tr>
<tr><td colspan="8">1- Select the peas and sanitize them under running water;
2- Weigh the peas;
3- Soak the peas in water for 24 hours under refrigeration;
4- Discard the soaking water and weigh the peas;
5- Cook the peas keeping the lid of the pan half open, initially over a high heat, reducing the flame to medium when it starts to boil;
6- After cooking, which should be stopped when the beans break, store the peas and aquafaba in a baking dish in the fridge for 24 hours;
7- Separate the peas from the aquafaba. Use the aquafaba or store it in the freezer.</td></tr>
<tr><td>Initial weight</td><td>500 g</td><td>Final weight</td><td>1250 g</td><td>Income</td><td>250 %</td><td>Cooking index</td><td>2,5</td></tr>
</table>

Source: Prepared by the authors (2024).

Foam capacity and stability

Foam capacity (FC) and foam stability (FS) were determined at the Food and Dietetics Laboratory of the Fluminense Federal University. FC and FS followed the method of Shim et al.[25] and Martinez et al,[26] respectively. For FC, the sample (40mL) was mixed in a stainless steel container using a GiromaxMallory® mixer, with 200W power, at 125 rpm, for 8 minutes. The contents were transferred to a transparent plastic container with a capacity of 350mL.

For FS, 50mL of the aquafaba sample was used to transform it into foam, using the same mixer and configuration as above. The contents were transferred to a 600mL graduated beaker and the volume analyzed immediately after the foam had formed and after 30 minutes.

FC and FS were determined using Equations 1 and 2, respectively:

$$FC\ (\%) = \frac{V_{f0}}{Vamostra}\ x\ 100 \quad (1)$$

$$FS\ (\%) = \frac{V_{f30}}{V_{f0}}\ x\ 100 \quad (2)$$

Where,

V_{f0}= volume (in mL) of foam formed immediately at time 0;

V_{sample}= initial volume (in mL) of liquid sample;

V_{f30}= volume (in mL) of foam formed after 30 minutes.

Emulsion index

The methodology according to Mustafa et al.[22] and Martinez et al.[26] was used and adapted to establish the emulsion index (IE). To analyze the emulsion, 20mL of the aquafaba sample and 20mL of Liza® brand soybean oil were added to a 150mL beaker in a 1:1 ratio (oil:aquafaba). The components were homogenized using a GiromaxMallory® mixer at speed 3 for 2 minutes. The mixture was then transferred to a 50mL beaker for observation. The volume of emulsion was recorded three times at 30 minutes, 1 hour, 1:30 hours, 24 hours and 4 days to establish the average result.

Relative density

The relative density of the samples was determined by the ratio between the absolute densities of the aquafaba sample and the water, using a pycnometer. Methodology 215/IV of the Adolfo Lutz Institute was followed,[27] and it was conducted in triplicate.

Kinematic and dynamic viscosity

The kinematic viscosity of the aquafaba was establishedusing a Ford cup viscometer with orifice no. 4, in accordance with the ABNT NBR 5849:2015 standard,[28] with the values expressed in m^2/s and the test conducted in triplicate.

The dynamic viscosity was calculated from the average values of the density of the pea aquafaba and the kinematic viscosity, according to ABNT NBR 5849:2015.[28] The result was given in milliPascal seconds (mPa*s).

Foam color

The color of the AQ foam was determined according to the CIELab system, indicating the coordinates L* (luminosity), a* (positive is red, while negative is green) and b* (positive is yellow and negative is blue).[29] The samples were measured in triplicate on a BYK Gardner Laboratory®Colorview 9000 colorimeter (Columbia, SC, USA), using the OnColor *software* .

Centesimal composition

Moisture, ash, lipid and protein content were establishedaccording to methodology 012/IV, 018/IV, 032/IV and 037/IV of the Adolfo Lutz Institute.[27] Carbohydrate content was determined by difference.

Statistical analysis

The data obtained was analyzed using descriptive statistics, using mean, variance and standard deviation, by tabulating the data in Microsoft® Excel *software.*

RESULTS AND DISCUSSION

Process of obtaining aquafaba

Based on the processes developed to obtain the AQ, it was possible to draw up the technical preparation sheet, which presented a cooking index of 2.5 and a preparation yield of 250% (Figure 2), which shows an important amount of product that is usually discarded and/or underutilized.

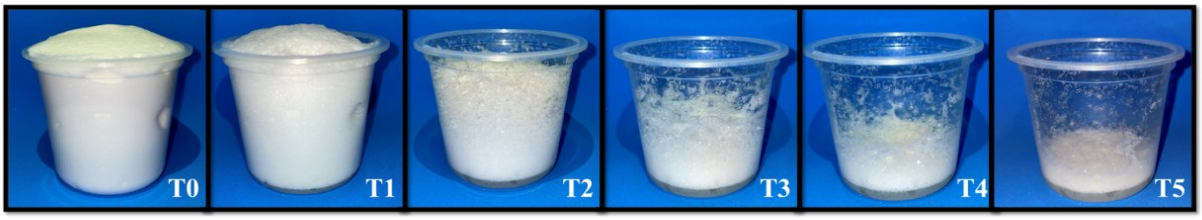
The change in the mass of the sample was due to the hydration of the peas, i.e. water was absorbed by the grains, which resulted in an increase in their initial (dry) mass, as well as a thermal gain due to cooking. The appropriate technique for preparing aquafaba was developed based on previous tests. The cooking process was adapted to be conducted without pressure, in order to preserve the pea grain when cooking and make it possible to obtain the AQ. In addition, the ratio for cooking was set at 1:4 (grain:water), since under cooking conditions, there is a loss due to the greater evaporation of water.

Physical and chemical characteristics

Foam formation and stability

The ability of aquafaba to form foam was observed (Figure 3), with an average of 910.71%±77.84.

Figure 3. Foaming capacity of green pea aquafaba.



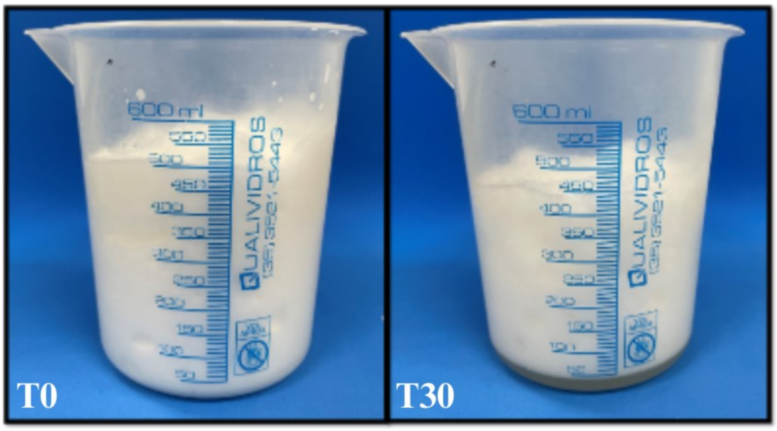
T0: immediately after training; T1: after 15 minutes; T2: after 30 minutes; T3: after 45 minutes; T4: after 1h; T5: after 1h30min.

Source: Prepared by the authors (2024).

Compared to the study by Kiliçli et al.[17] which found an average foaming capacity of 575%±12 for green pea aquafaba, the result found by the present study was much higher, which is most likely due to the individual features of the grains, soaking time, cooking time and temperature and the use of a different type of pot for the process of obtaining the aquafaba.[30]

Figure 4 shows the change in foam volume. Stability was checked by comparing the period immediately after its formation and after 30 minutes, with an average result of 90%.

Figure 4. Foam stability of green pea aquafaba



Source: Prepared by the authors (2024).

Regarding foam stability (ES), Kiliçli et al.[17] found an average percentage of 95.67%±2.20 for green pea aquafaba, a result which was higher but close to that found in the present study. Furthermore, in their analysis of different brands of canned chickpeas, Mustafa et al.[22] found foam stability ranging from 77 to 92%, while Aslan and Ertaş[23] established the FS for whole egg as 93.33%±2.00 and for chickpea aquafaba as 94.74%±1.03. Therefore, the result produced by this study is close to the data described in the literature.

In this context, it can be inferred that AQ has a good foaming capacity and stability, which corresponds to a positive result, since this technological property is very much required in cooking. Whipped DH has the potential to be used in several preparations as a substitute for whipped egg white, such as meringues, cakes and *soufflés*, in order to achieve greater sponginess and lightness.[31] One example was the study conducted by Nguyen et al.[32] who concluded that fava bean aquafaba can be used to replace egg white in *cupcakes*.

In order to better comprehend the possibilities for improving the properties of plant proteins, some studies have been conducted on legume protein isolates, but data on pea aquafaba is still scarce. Lafarga et al.[33] when assessing the functional properties of legume proteins obtained by solubilization observed that pre-treatments such as enzymatic hydrolysis, heating or high-pressure processing can also result in improved functional properties, such as foam formation capacity and stability.

High-pressure homogenization and the use of ultrasound enhanced the foaming capacity of isolated pea protein, as these treatments promote protein unfolding and expose more hydrophobic groups to its surface, increasing protein-water interactions and protein adsorption at the air-water interface.[34]

Emulsion index (IE)

The values found for IE from the aquafaba samples are shown in Table 1.

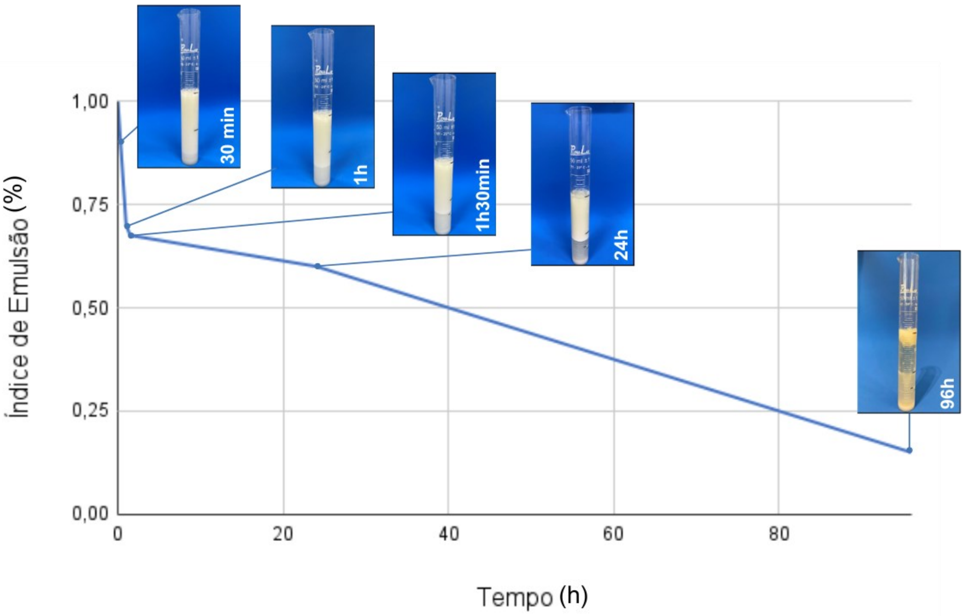
Table 1. Emulsion index of aquafaba samples at 30 minutes, 1 hour, 1:30 hours, 24 hours and 96 hours.

Sample	IE (%) after 30 minutes	IE (%) after 1 h	IE (%) after 1:30 h	IE (%) after 24 h	IE (%) after 96 h
AQ	85,00	70,00	67,50	60,00	15,00

Source: Prepared by the authors (2024).

The results of the emulsion index (Table 1) showed that the samples had separated phases after 30 minutes. The observation period was therefore an important factor in describing the results. As shown in the graph (Figure 5), at 1 hour and 30 minutes into the experiment, the volume drops rapidly compared to time 0. Conversely, in the same period for 24 hours, there is greater stability in the emulsion index. The interval from 24 to 96 hours presented the greatest drop, 75%, in the EI results, in contrast to the first moment of the analysis. From the first recording, it was possible to observe the separation of the phases. However, this separation is evidenced by the decrease in homogeneity after 24 hours, as shown in Figure 5.

Figure 5. Graph of Emulsion Index (%) x Time (h).



Source: Prepared by the authors (2024).

The findings found in this study for the emulsion index differ from that demonstrated by Kiliçli et al.[17] for green pea aquafaba, since the authors did not observe any phase separation (IE= 100%) after 1 hour, while in this study, it can already be observed after 30 minutes (IE= 85%), demonstrating a lower emulsifying property, which may be due to the different methods used to obtain the aquafaba.

The studies by He et al.[35] and Mustafa et al.[22] evaluated the emulsion stability of aquafaba from chickpeas, exhibiting values of 71.9% to 77.1% and 60% to 80%, respectively, over a 30-minute period, lower than the present study (IE= 85%) with green pea AQ.

Meurer et al.[36] also assessed the IE of *fresh* chickpea aquafaba, but at 1 hour, 12 hours, 24 hours and 4 days, observing no phase separation at the first moment observed (IE = 0%) and IE of 88% after 96 hours. Conversely, the AQ in the present study fell, resulting in an IE of 15%. It was observed that green pea AQ experienced a considerable significant volume within a short time frame, exhibiting a pattern similar to the initial half-hour findings in the studies conductedby He et al.[35] and Mustafa et al.[22]

Furthermore, it is worth noticing that the variation between the foam and emulsion properties studied is caused by the difference in the composition, additives, canning and cooking processes of the legumes.[25] In addition to the determinants mentioned, the contrast in the comparison results is also a product of the multiple periods of use of the mixer for foam formation and the amount of lipids transferred from the grain to the aquafaba during its cooking.[37]

Relative density

The relative density of DH was determined to be an average of 1.013±0.00, with a coefficient of variation of 0.05%. It can be seen that AQ has a density very close to that of water (1.00 g/cm³ = 1.00 g/mL), and this similar behavior is related to the high moisture content present in its composition.

The average relative density of the study on chickpea aquafaba by Shim et al.[25] is the closest to that found for green pea aquafaba, at 1.095. Conversely, data on samples made from split yellow peas

(1.021±0.005) and egg white (1.040±0.004) is higher than the result found, with egg white having a higher relative density.[37]

Kinematic and dynamic viscosity

The results obtained for kinematic viscosity, conducted at 25ºC, can be seen in Table 2, from which it was possible to calculate the coefficient of variation, which showed a value of 0.18%.

Table 2. Kinematic viscosity of water and pea aquafaba, in$^{m2/s}$, at 25ºC.

Fluid	Average time	Viscosity (m^2/s) at 25ºC
Water	9,70	2,00 x $^{10-5}$
Green pea aquafaba	9,85	2,06 x $^{10-5}$

Source: Prepared by the authors (2024).

The results revealed that, compared to water, AQ had a similar viscosity. Thus, the sample studied has a low viscosity, as well as a liquid and fluid pattern. Meurer et al.[36] observed a kinematic viscosity of 4.878 x $10^{-5}m^2/s$ for *fresh* chickpea aquafaba. Compared to the result of 2.06 x $10^{-5}m^2/s$ for AQ, it is understood that it is less viscous.

In relation to the dynamic viscosity of QA in the present study, a value of 20.8 mPa*s was obtained. Stantiall et al.[37] analyzed the dynamic viscosity of chickpea aquafaba (47 mPa*s), green lentil (25 mPa*s), white bean (4.5 mPa*s), yellow split pea (8.7 mPa*s) and white egg white (15 mPa*s). Although the viscosity of green pea aquafaba is lower than that of chickpeas and green lentils, it presents higher results than white egg white, as well as the other grains evaluated.

Viscosity influences foaming capacity and must be at levels that allow the product structure to absorb the maximum amount of air and the globules to undergo high levels of partial coalescence. An increase in viscosity can prevent air from entering the mixture; however, a low viscosity allows bubbles to merge more easily, forming larger, less stable bubbles that are more susceptible to internal pressure.[38] TheFoam capacity (FC) and Emulsion Stability(FS) values indicate that the viscosity of the aquafaba produced is possibly sufficientto support its foaming capacity.

Foam color

Table 3 shows the results of the color analysis of the foam, indicating the L*, a* and b* coordinates.

Table 3. Color parameters of aquafaba and foam. Results are three-way averages ± standard deviation.

Sample	L*	a*	b*
AQE	79,10±0,03	-0,92±0,72	7,25±0,58

AQE: pea aquafaba foam.
Source: Prepared by the authors (2024).

Based on the results, the sample exhibited a positive average L* value of 79.10±0.03, indicating high luminosity, which suggests that the foam is light in color. Regarding the a* value, which represents the red/green coordinates, the negative result shown in Table 3 reveals that the sample is green. Furthermore, with an average b* value of 7.25, representing the yellow/blue coordinates, the presence of a yellowish color is also noted.

When comparing the colors of the pea aquafaba foam from the present study with those of *fresh* chickpeas, as evaluated by Meurer et al,[36] it is noticeable that there was a positive variation of +2.76 in the brightness of the chickpea aquafaba samples. The a*b* coordinates were higher for AQ, indicating that its foam is less dark, more green and yellow than chickpea foam. In the same study, it was observed that the foam formed from white egg white is darker (L= 87.99), redder (a*= 0.01) and less yellow (b*= 4.67) than that of pea aquafaba.

Centesimal composition

The results of the centesimal composition of the green pea aquafaba are shown in Table 4.

Table 4. Centesimal composition of green pea aquafaba.

Features	Green pea aquafaba (%) [a]
Moisture	96,82±0,06
Protein	2,07±0,10
Carbohydrate	0,6 [b]
Ashe	0,41±0,06
Lipid	ND

[a] Mean ± Standard Deviation; ND= not detected.
[b] The percentage of carbohydrates was obtained by difference.
Source: Prepared by the authors (2024).

According to the outcomes obtained, it can be inferred that the AQ of green peas has a high moisture content, and it is higher when compared to the data published for chickpeas by Shim et al.[25] of 67.00%±1.87, in the study that compared the composition of aquafaba from different brands of canned chickpeas, being similar to split yellow peas (95.59%± 0.18), according to data from Stantiall et al.[37]

The protein content (2.07±0.10) found is higher compared to the data on chickpeas (0.95±0.01) and split yellow peas (1.27±0.02) found by Stantiall et al.,[37] which suggests that the AQ from the current study may confer greater nutritional value in relation to this component if it is used in culinary preparations.

The ash content obtained is close to that of yellow pea samples (0.40±0.00) and lower compared to chickpeas (0.57±0.01), according to Stantiall et al.[37]

Regarding lipids, it can be said that the AQ of green peas is similar to other legumes, since for yellow peas and chickpeas, determination was not possible, since the content found was below the detection limit of the method.[25,37]

In summary, the differences in centesimal composition are due to the fact that they are different legumes, as well as the different preparation methods, because during the soaking and cooking stages, nutrients are distributed from the grain into the water involved in the process, nutritionally modifying the QA. In addition, prolonged cooking can lead to a greater breakdown of the cell wall and, consequently, a greater transfer of nutrients to the water that will give rise to the AQ.[37] This indicates the importance of considering the possible genotypic variation of the legume in question, as well as the development of a technical preparation sheet for obtaining AQ, which is a product that can offer a promising alternative for vegetarian, vegan, egg-allergic and celiac consumers, due to its features as a multifunctional, plant-based, animal cruelty-free and additive-free ingredient.[19]

CONCLUSION

It conclusion, the process of obtaining green pea AQ can be optimized to achieve technological characteristics suitable for use in culinary preparations. Further research into its applicability is necessary to offer alternatives that promote a more sustainable diet and encourage the development of culinary skills. This will help ensure that vegetarians, vegans, and individuals following a meat-free diet are not overly reliant on industrialized foods.

REFERENCES

1. Hargreaves SM, Rosenfeld DL, Moreira AV, Zandonadi RP. Plant-based and vegetarian diets: an overview and definition of these dietary patterns. Eur J Nutr. 2023;62:1109-21. https://doi.org/10.1007/s00394-023-03086-z.
2. Slywitch E. Alimentação sem carne: um guia prático para montar a sua dieta vegetariana com saúde. 2nd ed ampliada e revisada. São Paulo: Editora Alaúde, 2023.
3. Sociedade Vegetariana Brasileira (SVB). Pesquisa do IBOPE aponta crescimento histórico no número de vegetarianos no Brasil. 2022 [acesso nov 2023]. Disponível em: https://svb.org.br/2469-pesquisa-do-ibope-aponta-crescimento-historico-no-numero-de-vegetarianos-no-brasil.
4. Brasil. Guia alimentar para a população brasileira. 2.ed. Brasília: Ministério da Saúde; 2014.
5. Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, Mueller ND, O'Connell C, Ray DK, West PC, Balzer C, Bennett EM, Carpenter SR, Hill J, Monfreda C, Polasky S, Rockström J, Sheehan J, Siebert S, Tilman D, Zaks DP. Solutions for a cultivated planet. Nature. 2011;478(7369):337-42. https://doi.org/10.1038/nature10452.
6. Schuck-Paim C. Sociedade Vegetariana Brasileira (SVB). Factsheet: Impactos da pecuária no Brasil e no mundo. 2017 [acesso Nov 2023]. Disponível em: https://svb.org.br/wp-content/uploads/2023/07/livros_impactos-da-pecuaria-no-brasil-e-no-mundo.pdf.
7. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. Lancet. 2019 [cited 2023 Nov];393:447-92. Available from: https://eatforum.org/content/uploads/2019/04/EAT-Lancet_Commission_Summary_Report_Portugese.pdf.
8. Food and Agriculture Organization of the United Nations; Bioversity International; Burlingame B, Dernini S. 2012 [cited 2023 Nov]. Sustainable diets and biodiversity. Available from: https://reterus.it/public/files/Eventi/unisustainathon/Med_Diet_-_sustainablec_-_FAO___Bioversity_1_.pdf
9. Johnston JL, Fanzo JC, Cogill B. Understanding sustainable diets: a descriptive analysis of the determinants and processes that influence diets and their impact on health, food security, and environmental sustainability. Adv Nutr. 2014;5(4):418-29. https://doi.org/10.3945/an.113.005553
10. Alcorta A, Porta A, Tárrega A, Alvarez MD, Vaquero MP. Foods for plant-based diets: challenges and innovations. Foods. 2021;10(2):293. https://doi.org/10.3390/foods10020293.

11. Andreani G, Sogari G, Marti A, Froldi F, Dagevos H, Martini D. Plant-Based meat alternatives: technological, nutritional, environmental, market, and social challenges and opportunities. Nutrients. 2023;15(2):452. https://doi.org/10.3390/nu15020452.
12. Euromonitor International. Plant-based foods face key challenges. 2023 [cited 2023 Nov]. Available from: https://www.euromonitor.com/article/plant-based-foods-face-key-challenges.
13. Glufke Reis G, Villar EG, Ryynänen T, Picanço Rodrigues V. David vs Goliath: the challenges for plant-based meat companies competing with animal-based meat producers. J Clean Prod. 2023. https://doi.org/10.1016/j.jclepro.2023.138705.
14. Foyer CH, Lam HM, Nguyen HT, Siddique KH, Varshney RK, Colmer TD, Cowling W, Bramley H, Mori TA, Hodgson JM, Cooper JW, Miller AJ, Kunert K, Vorster J, Cullis C, Ozga JA, Wahlqvist ML, Liang Y, Shou H, Shi K, Yu J, Fodor N, Kaiser BN, Wong FL, Valliyodan B, Considine MJ. Neglecting legumes has compromised human health and sustainable food production. Nat Plants. 2016;2(8). https://doi.org/10.1038/nplants.2016.112.
15. Serventi L, McNeill J. Upcycling aquafaba and liluva (food processing wastewater of legumes) into new value-added products. Curr Opin Food Sci. 2024. https://doi.org/10.1016/j.cofs.2024.101197.
16. Echeverria-Jaramillo E, Shin WS. Current processing methods of aquafaba. Trends Food Sci Amp Technol. 2023. https://doi.org/10.1016/j.tifs.2023.06.022.
17. Kiliçli M, Özmen D, Bayram M, Toker OS. Usage of green pea aquafaba modified with ultrasonication in production of whipped cream. Int J Gastron Food Sci. 2023. https://doi.org/10.1016/j.ijgfs.2023.100724.
18. Slywitch E. Guia alimentar de dietas vegetarianas para adultos. 1ª ed. Sociedade Vegetariana Brasileira: São Paulo, 2012.
19. Yazici GN, Taspinar T, Ozer MS. Aquafaba: a multifunctional ingredient in food production. Biol Life Sci Forum. 2022;18(24):1-6. https://doi.org/10.3390/Foods2022-13004.
20. Melina V, Craig W, Levin S. Position of the Academy of Nutrition and Dietetics: vegetarian diets. J Acad Nutr Diet. 2016;116(12):1970-80. https://doi.org/10.1016/j.jand.2016.09.025.
21. Schösler H, de Boer J. Towards more sustainable diets: insights from the food philosophies of "gourmets" and their relevance for policy strategies. Appetite. 2018;127:59-68. https://doi.org/10.1016/j.appet.2018.04.022.
22. Mustafa R, He Y, Shim YY, Reaney MJ. Aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake. Int J Food Sci Amp Technol. 2018;53(10):2247-55. https://doi.org/10.1111/ijfs.13813.
23. Aslan M, Ertaş N. Possibility of using 'chickpea aquafaba' as egg replacer in traditional cake formulation. Harran Tarım Ve Gıda Bilim Derg. 2020;24(1):1-8. https://doi.org/10.29050/harranziraat.569397.
24. Domene SMA. Técnica Dietética - Teoria e Aplicações. 2ª ed. Rio de Janeiro: Guanabara Koogan, 2018.
25. Shim YY, Mustafa R, Shen J, Ratanapariyanuch K, Reaney MJ. Composition and properties of aquafaba: water recovered from commercially canned chickpeas. J Vis Exp. 2018;(132). https://doi.org/10.3791/56305.
26. Martinez M, Stone AK, Yovchev AG, Peter R, Vandenberg A, Nickerson MT. Effect of genotype and environment on the surface characteristics and functionality of air-classified faba bean protein concentrates. Eur Food Res Technol. 2016;242(11):1903-11. https://doi.org/10.1007/s00217-016-2690-4.
27. Instituto Adolfo Lutz (IAL). Métodos químicos e físicos para análise de alimentos. São Paulo, 2008.
28. Associação Brasileira de Normas Técnicas (ABNT). NBR 5849: Tintas – Determinação de viscosidade pelo copo Ford. 2015 [acesso nov 2023]. Disponível em: https://www.normas.com.br/visualizar/abnt-nbr-nm/2570/abnt-nbr5849-tintas-determinacao-de-viscosidade-pelo-copo-ford.
29. Hunter RS. Photoelectric color difference meter. J Opt Soc Am. 1958;48(12):985. https://doi.org/10.1364/josa.48.000985.
30. Erem E, Icyer NC, Tatlisu NB, Kiliçli M, Kaderoglu GH, Toker ÖS. A new trend among plant-based food ingredients in food processing technology: aquafaba. Crit Rev Food Sci Nutr. 2021:1-18. https://doi.org/10.1080/10408398.2021.2002259.
31. Ornellas LH, Kajishima S, Verruma-Bernardi MR. Técnicas dietética: seleção e preparo de alimentos. 8ª ed. rev. ampl. São Paulo: Atheneu, 2007.
32. Nguyen TM, Nguyen TP, Tran GB, Le PT. Effect of processing methods on foam properties and application of lima bean (Phaseolus lunatus, L.) aquafaba in eggless cupcakes. J Food Process Preserv. 2020;44(11). https://doi.org/10.1111/jfpp.14886.

33. Lafarga T, Álvarez C, Villaró S, Bobo G, Aguiló-Aguayo I. Potential of pulse-derived proteins for developing novel vegan edible foams and emulsions. Int J Food Sci Amp Technol. 2019;55(2):475-81. https://doi.org/10.1111/ijfs.14286.
34. Yan J, Zhao S, Xu X, Liu F. Enhancing pea protein isolate functionality: a comparative study of high-pressure homogenization, ultrasonic treatment, and combined processing techniques. Curr Res Food Sci. 2023. https://doi.org/10.1016/j.crfs.2023.100653.
35. He Y, Shim YY, Mustafa R, Meda V, Reaney MJ. Chickpea cultivar selection to produce aquafaba with superior emulsion properties. Foods. 2019;8(12):685. https://doi.org/10.3390/foods8120685.
36. Meurer MC, de Souza D, Ferreira Marczak LD. Effects of ultrasound on technological properties of chickpea cooking water (aquafaba). J Food Eng. 2020;265:109688. https://doi.org/10.1016/j.jfoodeng.2019.109688.
37. Stantiall SE, Dale KJ, Calizo FS, Serventi L. Application of pulses cooking water as functional ingredients: the foaming and gelling abilities. Eur Food Res Technol. 2017;244(1):97-104. https://doi.org/10.1007/s00217-017-2943-x.
38. Rezvani F, Abbasi H, Nourani M. Effects of protein–polysaccharide interactions on the physical and textural characteristics of low-fat whipped cream. J Food Process Preserv. 2020;44(10). https://doi.org/10.1111/jfpp.14743

Contributors

Lima ECS and Vilar JS contributed to the conception and design of the study; Dias GNC and Magalhães LG conducted in the literature review; Dias GNC, Vilar JS and Magalhães LG were involved in data collection; Lima ECS, Vilar JS and Nakajima VM participated in data analysis and interpretation; Dias GNC and Magalhães LG prepared the manuscript; Lima ECS, Vilar JS and Nakajima VM contributed to the intellectual revision of the manuscript; Vilar JS gave the final approval of the version submitted to the journal.

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