

Cooking methods and organoleptic profile of vegetable cream: A comparative analysis

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ABSTRACT

Background

Soup is important in the Mediterranean diet, promoting the consumption of vegetables and legumes and providing essential nutrients. Some studies refer that soup becomes a source of comfort for 1 in 3 consumer's globally. However, its consumption has been declining in Portugal, considering this market is facing lower consumer demand, limited product innovation, and stiff competition.

Methods

This project aimed to encourage soup consumption by developing a sustainable, nutritionally balanced, allergen-free option, suitable from 8 months of age, enriched with olive oil and low in sodium. The formulations were based on: leek, zucchini, carrot, and orange lentils, processed fresh, dehydrated, or freeze-dried. Dehydration was carried out at 70°C for 10 hours (Proficook PC-DR 1116), while freeze-drying lasted 72 hours at -54°C (Mini Lablyo), leading to greater water loss. Colour parameters were measured with the Konica Minolta Chroma Meter CR-400 for all vegetables except lentils, which were analysed only in dry form. The soup was prepared using a Thermomix TM6 with 850ml of water, 100g of leeks, 100g of zucchini, 150g of carrots, and 50g of lentils. The ingredients were cooked for 25 minutes at 100°C, adding olive oil and progressive mixing (1 minute, speed 5-7).

Results

Consumer acceptance was evaluated with 36 participants through hedonic tests, showing that formulation II (dehydrated ingredients) was the most appreciated. Sodium chloride levels were determined using a 300 series Brix refractometer.

Conclusion

Overall, the results highlight the potential of dehydrated vegetable soups as a practical and nutritious solution to promote healthier eating habits.

Key-words: dehydration, freeze drying, mediterranean diet, soup

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INTRODUCTION

Soup is a fundamental part of the Mediterranean diet, but its consumption has been declining among the Portuguese population. The Portuguese favour eating vegetables and legumes, which are rich in vitamins, minerals, and fiber.¹ The use of legumes in the diet is below the recommended level, so the aim is to encourage their consumption, with soup being a good option for including them.² The freeze-drying process involves complex dehydration technology, combined with freezing the food and vacuum drying at low temperatures. The food is frozen, and its moisture is removed directly by sublimation in a vacuum environment, allowing for long-term preservation. Freeze-drying reduces water activity in cells, inhibiting enzyme activity and the growth and multiplication of microorganisms, as well as better preserving the nutrient content and flavour of the final product. This process also prevents microbial contamination and chemical changes such as enzymatic and non-enzymatic browning. This makes it one of the best processes to use to preserve a wide range of food products, where quality is paramount. However, this process is slower and more expensive compared to conventional dehydration. As a result, freeze-dried foods have high production costs.^{3,4,5} Dehydration is a food preservation method based on applying high temperatures and expelling water to prevent the deteriorating actions of microorganisms and enzymes. Foods with high moisture content, such as vegetables, are more susceptible to decomposition because the water inside them provides favourable conditions for enzymatic reactions and the subsequent growth of undesirable microorganisms, including bacteria, mould, and yeasts. However, this process negatively impacts on the nutritional and sensory properties of the products because of the use of hot air accompanied by lower drying rates and longer drying times. These changes cause alterations in the organoleptic characteristics of the food, including its colour, texture, flavour, and nutritional value.⁶ The main objective of the study is to create a sustainable, nutritionally balanced soup that is easy to prepare and

suitable for consumption from 8 months of age. It must also be free from allergens, yet contain traditional fat (olive oil) and reduced sodium content.

2. Methods

Three different soup recipes were prepared, all with the same ingredients and quantities (leeks, zucchini, carrots, and orange lentils), but using different preparation methods. The recipes consisted of I - preparation with fresh vegetables, II- preparation with dehydrated ingredients, and III- preparation with freeze-dried ingredients. The difference lies in how the ingredients were prepared. The vegetables were dehydrated in the Proficook PC-DR 1116 dehydrator for 10 hours at 70°C and freeze-dried in the Mini Labylo for 72 hours at -54°C.

Colour parameters were evaluated using the Konica Minolta Chroma Meter CR-400 for fresh, dehydrated, and freeze-dried vegetables, except for lentils, which were evaluated in dry form. Ready-made soups were also evaluated for organoleptic parameters.

The soups were prepared in a Thermomix TM6 model, using 850ml of water, 100g of leek, 100g of courgette, 150g of carrot and 50g of orange lentils. The ingredients were cooked for 25 minutes at 100°C on speed 1. After adding the olive oil, the mixture was blended for 1 minute on speed 5-7, gradually increasing the speed.

For each soup, the colour and sodium chloride content were also assessed using the 300 Brix series refractometer, the pH using the HANNA HI 3221 pH/ORP/ISE Meter, the Brix degree using the HI 96813 Wine Refractometer and subsequent calculation of the sucrose percentage.

3. Results

3.1. Weight

The weight of the different ingredients (leek, courgette, carrot and orange lentils) was determined when fresh, after dehydration and freeze-drying, except for the lentils, which were weighed only when dry, since they were purchased already dehydrated. The values obtained can be seen in **Table 1**, with the greatest water loss occurring during freeze-drying.

Table 1 - Weight of fresh, dehydrated, and freeze-dried ingredients

	Weight (g)		
	Fresh	Dehydrated	Freeze-dried
Leek	100	14,16	10,11
Zucchini	100	5,06	4,88
Carrot	150	16,87	15,95
Orange lentils	50		

3.2.Colour

The Konica Minolta Chroma Meter CR-400 was used for colour analysis. Five measurements were taken for each ingredient, evaluating the parameters that define colour: L*, a* and b*. For the final comparison, the

average values of each parameter were taken into account for each ingredient in fresh, dehydrated and freeze-dried form, as well as for the three ready-made soup formulations, as shown in Table 2.

Table 2 - Colour analysis of fresh, freeze-dried, and dehydrated vegetables and soups made with fresh, freeze-dried, and dehydrated vegetables

	Fresh colour			Dehydrated colour			Freeze-dried colour		
	L*	a*	b*	L*	a*	b*	L*	a*	b*
Leek	74,05	-7,96	42,64	82,36	-6,34	22,97	77,90	-10,18	36,92
Zucchini	86,00	-5,64	21,68	86,82	-3,10	25,12	89,11	-5,72	21,56
Carrot	57,00	29,83	48,15	58,17	23,30	38,68	77,62	19,09	35,94
Orange lentils	59,89	30,96	40,64	---	---	---	---	---	---
Soup	55,50	0,90	46,01	54,34	4,35	48,87	52,96	3,49	48,43

3.3.Sodium chloride percentage

The sodium chloride content of each soup was also assessed using a 300 Brix series refractometer.

Formulation III had the highest sodium chloride content, as can be seen in **Table 3**.

Table 3 - Percentage of sodium chloride in the three soup formulations

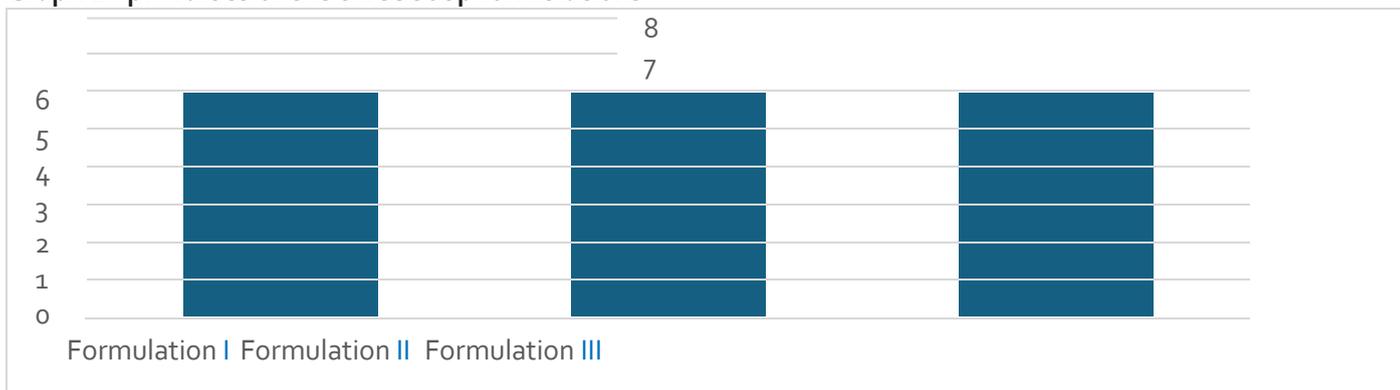
	% Sodium chloride
Formulation I	3,80
Formulation II	4
Formulation III	7

3.4. pH

The pH of the three soup formulations was assessed using the HANNA HI 3221 pH/ORP/ISE Meter. For each formulation, two measurements were taken,

recording the pH value obtained on the equipment and the respective temperature. After the measurement, it was possible to conclude that all formulations had a pH of 6 (Graph 1).

Graph 1 - pH values of the three soup formulations



3.5. Brix

The Brix value was assessed in the three soup formulations using the HI 96813 Wine Refractometer. The values obtained were 1, 1.8 and 1.7 for formulations I, II and III, respectively (Table 4). It was found that formulation II had a higher value, possibly justified by the fact that the vegetables used were previously dehydrated.

3.6. Sucrose percentage

After determining the Brix value, it was possible to calculate the percentage of sucrose. The values obtained were 10.85%, 19.42% and 17.73% for formulations I, II and III, respectively (Table 4). Thus, as in the determination of the Brix degree, it was in formulation II that the highest percentage of sucrose was found.

Table 4 - Brix degree and % sucrose of the different soups

Soup	Brix degree	% Sucrose
I	1	10,85
II	1,8	19,42
III	1,7	17,73



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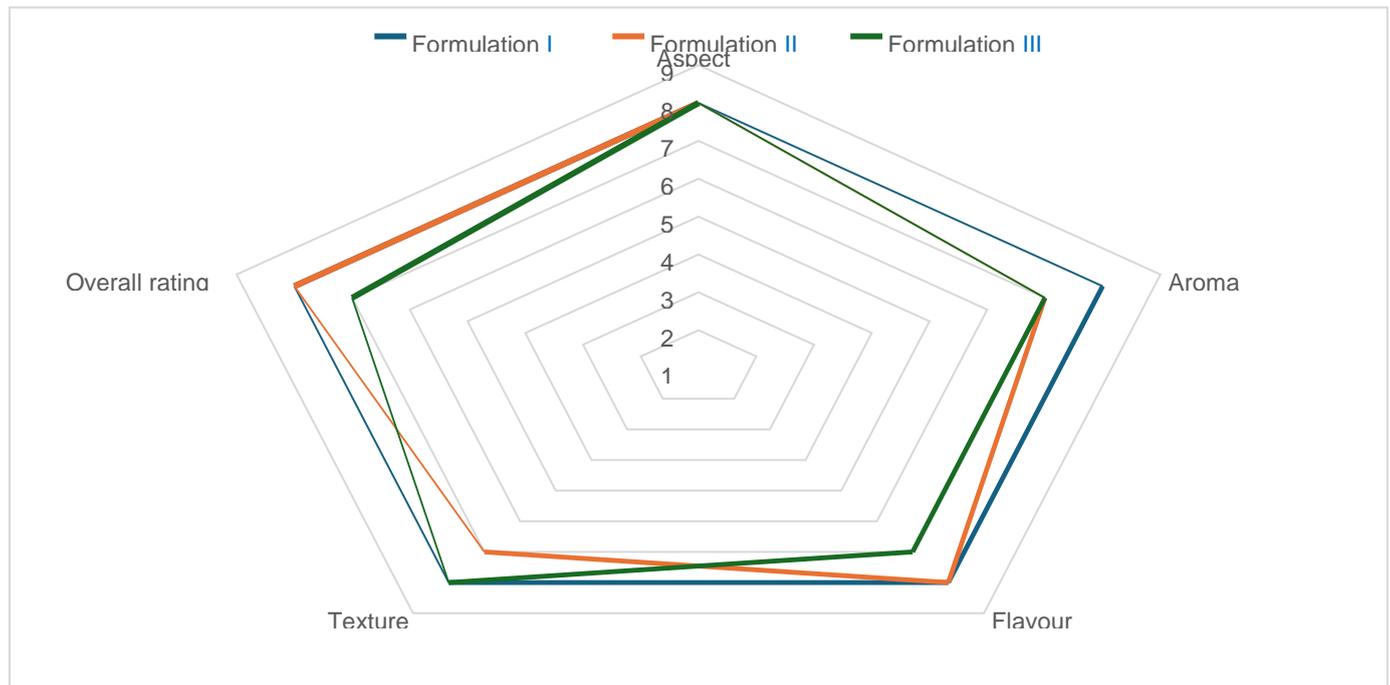
3.7. Sensory analysis

The three formulations were subjected to hedonic tests, in which 36 volunteers participated. As it did not involve the collection of personal data, the study did not require approval by an ethics committee. The evaluation was carried out using a questionnaire on Google Forms. The following parameters were

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evaluated for each of the soups: appearance, aroma, flavour, texture and overall evaluation. Each parameter was rated on a scale of 1 to 9, where 1 meant 'I disliked it extremely' and 9 meant 'I hugely enjoyed it'. Subsequently, the average of the results for each formulation was determined for each parameter (Graph 2).

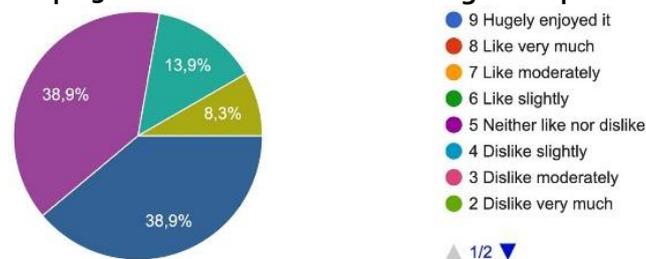
Graph 2 - Overall results of sensory analysis. Average values obtained from 36 responses are presented (scale 1-9, where 1 = dislike extremely and 9 = hugely enjoyed it).



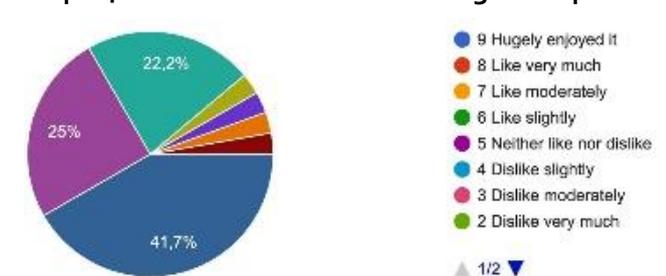
For formulation I, all parameters resulted in an average score of 8. In formulation II, appearance, flavour and overall assessment scored 8, while the remaining parameters scored 7. In formulation III, aroma, flavour and overall assessment resulted in an average score of 7, while the remaining parameters scored 8. Analysis of the data led to the conclusion that the most appreciated soup was I, i.e. the formulation with fresh

vegetables. On the other hand, when considering the same data in percentage terms obtained by Google Forms, soup II has the best rating in terms of overall assessment, i.e. a higher percentage in ratings 8 and 9 (Graphs 3 and 4). However, it should be noted that the assessments obtained for the three formulations were very positive and quite similar.

Graph 3 - Results of the overall rating of soup I



Graph 4 - Results of the overall rating of soup II



**DISCUSSION**

In the freeze-drying process, water in food is frozen and then sublimated by applying heat at very low pressure. Water vapor escapes from the food through channels formed by the sublimation of ice, maintaining the pressure in the freeze dryer. This explains why freeze-drying results in greater water loss in food.⁵ According to the results presented by Salehi, freeze-drying causes more efficient water loss due to its ability to create porous tissue, improving rehydration rates and product quality.⁷ Regarding the colour parameters analysed, formulation II presented the highest b^* parameter, i.e., more yellowish. This observation can be explained by the fact that positive heat is applied during dehydration, which in turn leads to the caramelization of the sugars present. It was also in this formulation that a higher value was found in the a^* parameter, i.e., it has a more reddish colour, resulting from the caramelization of sugars.⁵ Shen et al. observed that freeze-drying vegetables, such as carrots, generally results in lighter colours compared to fresh ones.⁸ Regarding the colour of the vegetables, it was found, prior to the preparation of the formulations, that freeze-drying resulted in a loss of colour, while dehydration preserved this characteristic, possibly due to caramelization reactions associated with the thermal process. The study by Petikirige et al. suggests that samples subjected to dehydration have a darker colour compared to freeze-dried samples.⁹ Formulation III had a higher sodium chloride content, which may be due to the fact that this formulation lost more water. The sodium content was not as diluted, since the vegetables absorbed most of the water when the soup was prepared. Thus, as the vegetables were freeze-dried, when in contact with water, rapid and complete rehydration occurred due to the porous structure of the food after freeze-drying. Thus, most of the water in the solution was used to rehydrate the vegetables, allowing for a higher sodium concentration.⁵ In the study by Jakubczyk & Jaskulska, a higher sodium concentration was also found in the freeze-dried soup, exceeding the recommended values in Poland, reinforcing that the final product should be served after rehydration.¹⁰ The highest Brix value was found in formulation II, since the vegetables used in its preparation were previously dehydrated, causing the sugars present to caramelize. The use of high temperatures, characteristic of this process, also

causes the loss of volatile components.⁶ Consequently, it was inevitable that the percentage of sucrose would be higher in this preparation. The study by Kumar & Suhag states that freeze-drying vegetables normally preserves higher Brix values when compared to dehydration, as the microstructure and bioactive components are preserved, leading to greater retention of flavours and sugars, while dehydration can lead to greater loss of these.¹¹ The sensory analysis carried out made it possible to assess which of the three formulations was most popular with participants. Although all formulations showed good results, formulation II obtained the best rating, as it achieved a higher percentage in the 8 and 9 ratings. This result was to be expected, given that the vegetables used were dehydrated, which implies caramelization of the sugars.⁵ This characteristic gives the soup a sweeter taste, which is usually more appreciated by consumers, so this would be selected for production, although there are some limitations regarding the method used for its production. Dehydration affects food in several ways, such as texture, flavour, aroma, colour and nutritional value. According to Jakubczyk, when comparing fresh soups with freeze-dried soups, reconstituted freeze-dried soups were rated positively in terms of flavour, consistency, aroma and overall quality, but the colour of the soup differs significantly from the colour of fresh soups.¹⁰ The application of heat required in this process results in the loss of heat-sensitive vitamins and oxidation. In addition, the evaporation of water resulting from this process causes the loss of water-soluble vitamins. Thus, in general, there is a significant loss of nutritional value in dehydrated foods, resulting in a less nutritious product. On the other hand, this process also has advantages, such as a production cost that is about four times lower than freeze-drying, and it is also faster.⁵ One of the limitations of this study is that it was not possible to analyse the energy value and macro- and micronutrient content of each of the formulations due to a lack of resources. It would be interesting to analyse this data to understand the exact nutritional impact of the different production methods, given that the same ingredients were used in the same quantities in the three vegetable cream formulations. This study enabled us to select the vegetable cream formulation most accepted by consumers, which is sustainable, nutritionally



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balanced, easy to prepare and suitable for consumption from 8 months of age, allergen-free, but containing traditional fat (olive oil) and reduced sodium content. In addition, it can be adapted for various conditions depending on the amount of olive oil, salt and water added during preparation.

5. Conclusion

With this study, we aimed to compare the acceptance of soup when prepared using various methods. We concluded that formulation II, i.e., with dehydrated ingredients, was better accepted in the hedonic tests.

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This may be because this recipe was made with traditionally dehydrated vegetables, using heat, which caused the sugars to caramelize, making the soup sweeter and probably more appealing to consumers. In the future, it would be interesting to complete this study, namely by analysing the energy value and macro and micronutrient content of each of the formulations, as well as conducting another study to assess the quantities and differences between these three formulations in terms of determining the product's shelf life and further investigating the sensory characteristics valued by consumers.

REFERENCES

1. Associação Portuguesa dos Nutricionistas. Sopas: Mais que um alimento, são um prato de saúde. E-books APN. 2013; nº 27: 1-49. ISBN: 978-989-8631-06-0.
2. Duarte M, Vasconcelos M, Pinto E. Pulse consumption among Portuguese adults: potential drivers and barriers towards a sustainable diet. *Nutrients*. 2020;12(11):1–13. doi:10.3390/nu12113336
3. Liu Y, Zhang Z, Hu L. High efficient freeze-drying technology in food industry. *Crit Rev Food Sci Nutr*. 2022; 62(12):3370–88. doi: 10.1080/10408398.2020.1865261.
4. Yao J, Chen W, Fan K. Novel efficient physical technologies for enhancing freeze drying of fruits and vegetables: a review. *Foods*. 2023;12(23):4321. doi: 10.3390/foods12234321.
5. Fellows P. Food processing technology. 2nd ed. Cambridge: Woodhead Publishing Limited; 2000. ISBN 1 85573 533 4.
6. Xu B, Tiliwa ES, Yan W, Azam SMR, Wei B, Zhou C, et al. Recent development in high quality drying of fruits and vegetables assisted by ultrasound: a review. *Food Res Int*. 2022;152:110744. doi:10.1016/j.foodres.2021.110744
7. Salehi, F. Recent Progress and Application of Freeze Dryers for Agricultural Product Drying. *ChemBioEng Reviews*. 2023; 10(5): 618-627. doi:10.1002/cben.202300003
8. Shen, J., Zhang, M., Mujumdar, A. S., Wang, Y., Chen, K., & Chen, J. Investigation on the discoloration of freeze-dried carrots and the color protection by microwave combined with coating pretreatment. *Drying Technology*. 2022; 40(16): 3568-3579. doi:10.1080/07373937.2022.2067865
9. Petikirige, J., Karim, A., & Millar, G. Effect of drying techniques on quality and sensory properties of tropical fruits. *International Journal of Food Science & Technology*. 2022; 57(11): 6963-6979. doi:10.1111/ijfs.16043
10. Jakubczyk, E., & Jaskulska, A. The Effect of Freeze-Drying on the Properties of Polish Vegetable Soups. *Applied Sciences*. 2021; 11(2): 654. doi:10.3390/APP11020654
11. Kumar, Y., & Suhag, R. (2024). Freeze Drying of Fruits and Vegetables. In R. B. Waghmare, M. Kumar, P. S. Panesar (Eds.), *Freeze Drying of Food Products: Fundamentals, Processes and Applications*. 2024; 73–104. doi:10.1002/9781119982098.ch3