Use of Hemp, Alternative Proteins, and Spices in the Development of a Functional Food Product

J. Hinton, R. Kaur, M. Verghese

*

Nutritional Biochemistry and Carcinogenesis Laboratory, Department of Food and Animal Sciences, Alabama A&M University, Normal, AL 35762

DOI: 10.29322/IJSRP.13.08.2023.p14009
http://dx.doi.org/10.29322/IJSRP.13.08.2023.p14009

Paper Received Date: 11th June 2023
Paper Acceptance Date: 26th July 2023
Paper Publication Date: 6th August 2023

Abstract: Obesity and type 2 diabetes have become prevalent in adolescents in the United States due to a diet that is high in saturated fats and simple sugars. Functional foods have become popular due to their potential to prevent chronic diseases. Hemp, alternative proteins, and spices were incorporated into a food product as functional ingredients for a targeted physiological function in preventing obesity and type 2 diabetes in adolescents. The objectives of this research were to determine the antioxidant potential of selected flours (Hemp, Almond, Coconut, and All-purpose), develop a functional food product (Camunas) using alternative proteins and spices, determine the antioxidant potential of Camunas (pre-baked and post-baked), and determine effects of Camunas on metabolizing (α – amylase and α – glucosidase and lipase) enzymes. Antioxidant potential was determined through 2,2-diphenyl-1-picrylhydrazyl scavenging ability (DPPH), ferric reducing antioxidant power (FRAP), Trolox equivalent antioxidant capacity (TEAC), and nitric oxide radical scavenging (NORS) assays. The product development steps were used to prepare Camunas using selected alternative flours with various spices including ginger, garlic, and turmeric. Hemp flour exhibited the highest antioxidant activity in all assays except NORS where almond flour exhibited the highest. A successful functional food product (Camunas) was developed. Sensory analysis suggests Camunas will be considered accepted by consumers and shelf-life analysis determined that Camunas maintained quality when frozen at least 1 month. Savory and sweet Camunas exhibited significant antioxidant power post-processing. This allows Camunas to be marketed to reduce the risk of chronic diseases in adolescents. Camunas were also able to successfully inhibit carbohydrate and fat metabolizing enzymes, possibly reducing the risk of type II diabetes and obesity.

Keywords: Hemp, Antioxidant, Functional, Obesity, Diabetes

1. INTRODUCTION

The connection between a healthier life and a nutritious diet is becoming increasingly apparent to the average consumer. This has pushed functional foods to the forefront of the industry. Functional foods are foods that provide consumers with health benefits beyond basic nutrition (Hasler, 2002). This is possible when specific essential nutrients or other food ingredients such as protein and spices are incorporated into a food product for a targeted physiological function. A study even found that some spices may "…display prebiotic-like activity by promoting the growth of beneficial bacteria and suppressing the growth of pathogenic bacteria…" (Lu et al., 2017). Evidence also exists that suggests that bioactive peptides hold health beneficial potential to regulate physiological functions of the body (Chakrabarti et al., 2018). The demand for these added health benefits has increased as obesity and other health concerns become more prevalent. As a result, according to SPINS market research, products featuring protein as the prominent functional ingredient have seen a steady increase in sales (nutraingredients-usa.com, 2019). The Institute of Food Technologists' (IFT) Annual Food Expo (IFT 18, 19, and 20) has showcased meat alternatives and clean meat over the last few years. This may be a result of research suggesting that a vegetarian diet yields several health benefits including diversifying beneficial microbes in the gut (Tomova et al., 2019), lower risk of gout (Chiu et al., 2020), decreased risk of colon cancer (Orlich et al., 2015), and decreased risk of cardiovascular diseases (Fraser et al., 2014). Subsequently, there has been a steady increase in the demand for plant-based protein. The Plant Based Foods Association (PBFA) reports that in 2019 plant-based foods saw a retail sales growth of 11.4% with a market value of $5 billion (Redman, 2020). Though the market has seen several plant-based options grow in popularity, there is still a gap where more vegan and vegetarian options can be introduced while providing more information about the potential health benefits for consumers. A study found

This publication is licensed under Creative Commons Attribution CC BY.

that adolescents', though they possessed a general understanding that eating healthier is beneficial, perception of plant-based food was one that favored convenience and familiarity with an "…incomplete and superficial knowledge of the merits of a diet with limited refined and animal products but high in plant-based foods" (Ensaff et al., 2015). Furthermore, additional research is needed on the potential benefits of using protein/plant powders as functional ingredients. Almond, coconut, and hemp protein powders have been selected to be used to develop a functional food product for their various nutritive benefits. Almond flour is high in monounsaturated fat which, when consumed, and lead to an increase in high-density lipoproteins or "good cholesterol" (Morton et al., 2019). Its high prebiotic dietary fiber content can promote a healthier digestive system while its antioxidant content can help decrease the risk of heart disease and cancer. Coconut flour is gluten-free and has a lower glycemic index than wheat flour because of its dietary fiber content (Trinidad et al., 2006). Coconut can also act as a much sweeter and more flavorful alternative to wheat flour as coconut itself has a mild, sweet taste. The use of hemp as a functional ingredient in food products is becoming increasingly popular and has provided an opportunity to take advantage of a rapidly expanding market (Rupasinghe et al., 2020). The market size of global industrial hemp was estimated be 4.71 billion dollars in 2019 and is expected to have a compound annual growth rate of 15.8% over the next 7 years (Industrial Hemp Market Size | Industry Report, 2020–2027, 2020). Spices and herbs have been used for years as preservatives and flavor enhancers. As preservatives they can increase the shelf life of food products by eliminating foodborne pathogens that may be present (El-Sayed & Youssef, 2019). Furthermore, the medicinal benefits of spices have been studied by the food industry in hopes of taking advantage of their potential for improving health. In vitro and in vivo studies have provided evidence of spices' use as digestive stimulants and antioxidants (Viuda-Martos et al., 2010).

2. JUSTIFICATION

The use of hemp, coconut, and almond powders/flours may provide food products that would normally be 100% all-purpose flour with health benefits not previously provided. Almond flour and coconut flour are both gluten free and an excellent source of dietary fiber that may promote a healthier digestive system in consumers (Kamil & Chen, 2012; Trinidad et al., 2006b). Hemp protein's high essential amino acid content and outstanding digestibility give it great nutritional value and functionality in food products (Wang & Xiong, 2019). Spices that are used as functional ingredients have a role in the enhancement of gastrointestinal health and the regulation of gut microbes (Lu et al., 2017). The use of these ingredients will help to fill a market gap where there is a lack of functional foods containing multiple alternative protein flours and decrease the risk of chronic diseases in adolescents.

3. OBJECTIVE

To determine the antioxidant potential and effect on carbohydrate and lipid metabolizing enzymes of a developed functional food product (Camunas) utilizing alternative protein powders to reduce the likelihood of chronic diseases among adolescents using following assays: 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) free radical scavenging, ferric reducing antioxidant capacity (FRAP), trolox equivalent antioxidant capacity (TEAC), nitric oxide radical scavenging (NORS).

4. MATERIALS & METHODS

4.1. Instrumentation

Centrifuge (Survall Legend XTR centrifuge, Thermofischer Scientific), rotary evaporator (Buchi Rotavapor R-215, USA), Synergy HT microplate reader (BioTek Instruments, Inc.; Synergy MTX multimode reader, S1LFA; Highland Park, Winooski; VT).

4.2. Sample Preparation

Alternative proteins and Camunas were extracted using deionized distilled water, and 80% ethanol. The protein isolate solvents were stirred for 2 hours at 23oC. Samples were centrifuged using Thermo Scientific ST8 Bench top centrifuge (Waltham, MA) at 3000Xg at 4□C for 20 minutes. Samples were then evaporated using a BuchiRotavapor R-100 rotary evaporator (New Castle, DE) and filtered with Whatman no. 4 filter paper. Extracts were stored at -20□C until analysis.

4.3 Product Development

Camunas were developed using the stages of product development (ideation, concept development, protocept development, marketing, and commercialization). This included gathering preliminary antioxidant data on the alternative protein powders to combine them in the Camunas' formulation. Sensory analysis was performed with 30 untrained panelists (majority being African American sophomores attending Alabama A&M University) using a 5-point hedonic scale rating the overall acceptability of several attributes of

This publication is licensed under Creative Commons Attribution CC BY.

Camunas to determine consumer acceptability. Shelf-life analysis was conducted over 33 days to determine the physiochemical stability (pH, water activity, color, and specific texture) of Camunas over time.

4.4 Antioxidant Content

4.4.1 DPPH (2,2 diphenyl-1-dicrahydrazyl radical scavenging)

Percent inhibition of DPPH was determined using the method by Gajula et al. (2009).

4.4.2 FRAP (Ferric Reducing Antioxidant Power)

FRAP was conducted using the method developed by Benzie & Strain (1996) with slight modifications using FeSO4.7H2O standard.

4.4.3 TEAC (Trolox Equivalent Antioxidant Capacity)

TEAC of extracts was determined using the protocol suggested by Miller et al (2003) with slight modifications.

4.4.4 NORS (Nitric Oxide Radical Scavenging)

The nitric oxide radical scavenging activity was determined using Griess reagent and method by Sakat, Juvekar, and Gambhire (2010).

4.5 Inhibition of Metabolizing Enzymes

Percent inhibition of α-amylase, α-glucosidase, and lipase was determined using methods described by Mutai et al (2015).

5. RESULTS & DISCUSSION

5.1 Antioxidant Activity

Preliminary data showed that there was antioxidant activity in the alternative protein powders which can be seen in Table 1-4.

5.1.1 DPPH (2,2 diphenyl-1-dicrahydrazyl radical scavenging)

Table 1 shows the results for Diphenyl-1-Picrylhydrazyl Radical Scavenging Ability of All-purpose, Almond, Coconut, and Hemp protein powders in Aqueous and Ethanol solvents. All-purpose protein powder extracts (aqueous) in yielded higher DPPH inhibition (49.16%) compared to all other protein extracts. Coconut protein powder extracts (ethanol) had the lowest DPPH inhibition (6.52%) compared to all other protein powder extracts. Table 5 shows the results of the DPPH assay for Camunas pre and post bake. Post-bake ethanol extracts showed significantly higher DPPH radical scavenging activity than aqueous extracts in both sweet and savory Camunas. This may have been due to the phytochemicals present becoming more concentrated as moisture was lost during the baking process. We can conclude that Camunas were able to successfully scavenge DPPH.

5.1.2 FRAP (Ferric Reducing Antioxidant Power)

Table 6 shows the FRAP results for Camunas pre and post-bake. Post-bake aqueous extracts were able to reduce ferric iron to ferrous iron significantly more than ethanol extracts in both sweet and savory Camunas, with post-baked extracts reducing ferric to ferrous 9.77 folds less than aqueous. From this data we can conclude that Camunas do have the ability to reduce ferric iron to the ferrous form.

5.1.3 TEAC (Trolox Equivalent Antioxidant Capacity)

Table 7 shows the TEAC of Camunas pre and post bake. There were no significant differences between solvents or processing methods for both savory and sweet Camunas. However, both savory and sweet Camunas were able to scavenge the ABTS radical as compared to the Vitamin E analogue Trolox.

5.1.4 NORS (Nitric Oxide Radical Scavenging)

This publication is licensed under Creative Commons Attribution CC BY.

Table 8 shows the ability of pre and post bake Camunas to scavenge nitric oxide radical. Savory post-bake aqueous extracts were significantly more successful at scavenging nitric oxide radical than ethanol extracts. The opposite was observed for sweet Camunas where ethanol extracts were more successful. Nitric oxide at high levels is toxic in the body. Therefore, we can conclude that Camunas can reduce the risk of the formation of that harmful peroxynitrite radical and the occurrence of chronic diseases.

5.2 Inhibition of Metabolizing Enzymes

Table 9-11 show the ability of Camunas to inhibit both carbohydrate and lipid metabolizing enzymes to decrease the risk of diabetes and obesity in adolescents. Savory post-bake aqueous extracts showed a significantly lower ability to inhibit alpha amylase than ethanol extracts. However, we can conclude that both savory and sweet Camunas successfully inhibited alpha amylase. Post-bake ethanol extracts exhibited significantly higher alpha glucosidase inhibition than aqueous extracts. Like amylase, we can conclude that Camunas successfully inhibit alpha glucosidase and can be marketed to reduce the risk of type 2 diabetes in adolescents. Post-bake ethanol extracts exhibited significantly higher lipase inhibition than aqueous extracts. Sweet and savory Camunas were able to successfully inhibit lipase and can therefore be marketed to reduce the risk of obesity in adolescents

5.3 Sensory Evaluation

57% of panelists were male and 90% were African American. The average age of panelists was between 17 and 25 years old with most of them being sophomore students at Alabama A&M University. Figure 1-2 show the overall acceptability of savory and sweet Camunas. Savory Camunas received generally positive feedback from panelists with most rating their color, aroma, mouthfeel, and flavor as like or like very much. 60% of panelists rated the overall acceptability of savory Camunas as like to like very much which was a great sign that we would have success once the product hits the market. The product was considered both flaky and buttery which was in line with the desired attributes. Sweet Camunas received positive feedback as well with most panelists rating their color, aroma, mouthfeel, and flavor as like to like very much. 63% of panelists rated the overall acceptability of sweet Camunas as like or like very much which is evidence that they will perform well on the market. Sweet Camunas were considered flaky, buttery, and, as expected, sweet.

5.4 Shelf-Life Analysis

Figure 3-10 show the results of the shelf-life analysis over 33 days for water activity, pH, color, and specific texture. There were no significant differences in water activity between days for neither savory nor sweet Camunas. This can be seen in Figures 4 and 5. The water activity was consistently above 0.8. Although this water activity is conducive for pathogenic bacteria growth, the product will be frozen and concerns for microbiological safety are minimal. There were no significant differences between days for the pH of savory and sweet Camunas. The pH remained relatively stable at a pH around 5.8 which may be conducive for pathogenic bacteria. However, the product will be frozen, so safety is not a major concern. There were some significant differences in specific texture seen between days for both sweet and savory Camunas. However, these differences were expected due to the heterogeneous nature of the Camunas' filling. This is a desired attribute in Camunas as it is key to consumer acceptability. that there were no significant differences in color for sweet and savory Camunas over the course of 33 days. Since the Camunas were frozen, this was expected.

6. CONCLUSION & RECOMMENDATIONS

Preliminary results showed that hemp flour significantly exhibited the highest antioxidant activity in all assays except NORS where almond flour exhibited the highest. A successful functional food product (Camunas) was developed. Sensory analysis suggests Camunas will be considered accepted by consumers and shelf-life analysis determined that Camunas maintained quality when frozen at least 1 month. Savory and sweet Camunas exhibited significant antioxidant power post processing. This allows Camunas to be marketed to reduce the risk of chronic diseases in adolescents. Camunas were also able to successfully inhibit carbohydrate and fat metabolizing enzymes giving them the potential to reduce the risk of type II diabetes and obesity.

It is recommended that microbiological analysis could be conducted on Camunas. However, since Camunas are meant to be a frozen product, biological contamination should not be an issue. It is also recommended that several line extensions be developed that may allow Camunas to be enjoyed during different eating occasions such as breakfast, lunch, and dinner. Lastly, for more precise sensory analysis, a trained sensory panel could be used in future work.

This publication is licensed under Creative Commons Attribution CC BY.

7. APPENDICES

Table 1. Diphenyl-1-Picrylhydrazyl Radical Scavenging Ability of All-purpose, Almond, Coconut, and Hemp protein powders in Aqueous and Ethanol solvents

Diphenyl-1-Picrylhydrazyl Radical Scavenging Ability (%)		
	Aqueous	Ethanol
All-Purpose	$8.28 \pm 0.61^{a,yz}$	$11.07 \pm 0.68^{a,z}$
Almond	$9.58 \pm 0.42^{b,y}$	$21.67 \pm 1.21^{a,y}$
Coconut	$5.99 \pm 1.02^{b,z}$	$19.43 \pm 0.79^{a,y}$
Hemp	$13.35 \pm 0.43^{b,x}$	$61.16 \pm 0.96^{a,x}$

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences ($p>0.05$) between solvents. Values with common superscript (xyz) show no significant differences between flours.

Table 2. Ferric Reducing Antioxidant Power of All-purpose, Almond, Coconut, and Hemp protein powders in Aqueous and Ethanol solvents

Ferric Reducing Antioxidant Power (µmol Fe (II)/100g)		
	Aqueous	**Ethanol**
AP	$\mathbf{0.42 \pm 0.05^{b,z}}$	$\mathbf{1.72 \pm 0.03^{a,z}}$
Almond	$\mathbf{4.14 \pm 0.11^{a,y}}$	$\mathbf{2.81 \pm 0.11^{b,y}}$
Coconut	$\mathbf{8.30 \pm 0.06^{a,x}}$	$\mathbf{7.19 \pm 0.06^{b,x}}$
Hemp	$\mathbf{10.24 \pm 0.22^{b,w}}$	$\mathbf{59.84 \pm 0.25^{a,w}}$

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences ($p>0.05$) between solvents. Values with common superscript (xyz) show no significant differences between flours.

This publication is licensed under Creative Commons Attribution CC BY.

Table 6. Nitric Oxide Radical Scavenging of All-purpose, Almond, Coconut, and Hemp protein powders in Aqueous and Ethanol solvents

Nitric Oxide Radical Scavenging NITRIC OXIDE RADICAL SCAVENGING (mg AA/100g of sample)		
	Aqueous	**Ethanol**
AP	**2914.00 ± 236.56^{b,y}**	**5365.60 ± 290.32^{a,y}**
Almond	**26199.00 ± 338.71^{a,x}**	**3107.50 ± 10.75^{b,yz}**
Coconut	**2962.00 ± 48.39^{a,y}**	**612.90 ± 10.75^{b,z}**
Hemp	**1188.00 ± 16.13^{b,z}**	**25408.60 ± 1494.62^{a,x}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between flours.

Table 4. Trolox Equivalent Antioxidant Capacity of All-purpose, Almond, Coconut, and Hemp protein powders in Aqueous and Ethanol solvents

Trolox Equivalent Antioxidant Capacity (mM T.E./ 100 g of sample)		
	Aqueous	**Ethanol**
AP	**109.38 ± 0.92^{a,x}**	**109.55 ± 2.68^{a,y}**
Almond	**116.43 ± 4.60^{a,x}**	**108.06 ± 0.33^{a,y}**
Coconut	**116.22 ± 2.35^{a,x}**	**111.27 ± 1.23^{a,y}**
Hemp	**120.93 ± 3.09^{b,x}**	**146.56 ± 2.96^{a,x}**

This publication is licensed under Creative Commons Attribution CC BY.

Table 5. 2,2-Diphenyl-1-Picrylhydrazyl Radical Scavenging Ability of Camunas Pre-bake and Post-bake in Aqueous and Ethanol solvents

2,2-DIPHENYL-1-PICRYLHYDRAZYL RADICAL SCAVENGING ABILITY (%)			
Savory	***Aqueous***	***Pre-bake***	**9.61 ± 1.01^{a,x}**
		Post-bake	**7.74 ± 0.53^{b,x}**
	80% Ethanol	***Pre-bake***	**15.81 ± 1.28^{a,x}**
		Post-bake	**19.27 ± 0.77^{a,x}**
Sweet	***Aqueous***	***Pre-baked***	**7.08 ± 0.84^{b,x}**
		Post-bake	**1.12 ± 0.63^{b,y}**
	80% Ethanol	***Pre-bake***	**25.94 ± 0.23^{a,x}**
		Post-bake	**28.89 ± 4.05^{a,y}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

Table 6. Ferric Reducing Antioxidant Power of Camunas Pre-bake and Post-bake in Aqueous and Ethanol extracts

FERRIC REDUCING ANTIOXIDANT POWER (µmol Fe (II)/100g)			
Savory	***Aqueous***	***Pre-baked***	**11.26 ± 0.08^{a,x}**
		Post-baked	**7.27 ± 0.53^{a,y}**
	80% Ethanol	***Pre-baked***	**3.69 ± 0.22^{b,x}**
		Post-baked	**3.00 ± 0.03^{b,x}**
Sweet	***Aqueous***	***Pre-baked***	**9.99 ± 0.36^{a,x}**
		Post-baked	**39.88 ± 1.97^{a,y}**
	80% Ethanol	***Pre-baked***	**1.11 ± 0.02^{b,y}**

This publication is licensed under Creative Commons Attribution CC BY.

		Post-baked	**4.08 ± 0.28^{b,x}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

Table 7. Trolox Equivalent Antioxidant Capacity of Camunas Pre-bake and Post-bake in Aqueous and Ethanol extracts

TROLOX EQUIVALENT ANTIOXIDANT CAPACITY (mM T.E./ 100 g of sample)			
Savory	***Aqueous***	***Pre-baked***	**128.00 ± 5.30^{a,x}**
		Post-baked	**120.65 ± 2.15^{a,x}**
	80% Ethanol	***Pre-baked***	**112.70 ± 2.35^{a,x}**
		Post-baked	**111.87 ± 2.99^{a,x}**
Sweet	***Aqueous***	***Pre-baked***	**108.48 ± 0.62^{a,x}**
		Post-baked	**109.38 ± 5.26^{a,x}**
	80% Ethanol	***Pre-baked***	**109.88 ± 0.72^{a,x}**
		Post-baked	**109.54 ± 1.22^{a,x}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

Table 8. Nitric Oxide Radical Scavenging Activity of Camunas Pre-bake and Post-bake in Aqueous and Ethanol extracts

NITRIC OXIDE RADICAL SCAVENGING ACTIVITY (mg AA/100g of sample)			
Savory	***Aqueous***	***Pre-baked***	**5155.90 ± 338.71^{a,x}**
		Post-baked	**5865.60 ± 134.41^{a,x}**
	80% Ethanol	***Pre-baked***	**5032.30 ± 43.01^{a,x}**
		Post-baked	**4973.10 ± 69.89^{b,x}**
Sweet	***Aqueous***	***Pre-baked***	**5473.10 ± 376.33^{a,x}**
		Post-baked	**3742.00 ± 215.05^{a,x}**
	80% Ethanol	***Pre-baked***	**5016.10 ± 5.38^{a,x}**

This publication is licensed under Creative Commons Attribution CC BY.

		Post-baked	**4516.10 ± 43.01^{a,y}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

Table 9. α- Amylase Inhibition of Camunas Pre-bake and Post-bake in Aqueous and Ethanol extracts

α- AMYLASE INHIBITION (%)			
Savory	***Aqueous***	***Pre-baked***	**13.12 ± 2.60^{b,x}**
		Post-baked	**13.89 ± 4.77^{a,x}**
	80% Ethanol	***Pre-baked***	**40.90 ± 5.58^{a,x}**
		Post-baked	**35.93± 4.36^{b,x}**
Sweet	***Aqueous***	***Pre-baked***	**30.07 ± 10.60^{a,x}**
		Post-baked	**31.68 ± 2.20^{a,x}**
	80% Ethanol	***Pre-baked***	**37.10 ± 0.93^{a,x}**
		Post-baked	**42.96 ± 2.81^{a,x}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

Table 10. α-Glucosidase Inhibition of Camunas Pre-bake and Post-bake in Aqueous and Ethanol extracts

α-GLUCOSIDASE INHIBITION (%)			
Savory	***Aqueous***	***Pre-baked***	**38.05 ± 6.19^{b,x}**
		Post-baked	**42.75 ± 7.19^{b,x}**
	80% Ethanol	***Pre-baked***	**74.31 ± 20.85^{a,x}**
		Post-baked	**75.36 ± 12.65^{a,x}**
Sweet	***Aqueous***	***Pre-baked***	**47.49 ± 8.41^{a,x}**
		Post-baked	**47.42 ± 7.66^{a,x}**

This publication is licensed under Creative Commons Attribution CC BY.

	80% Ethanol	***Pre-baked***	**80.58 ± 14.82^{b,x}**
		Post-baked	**83.08 ± 83.08^{b,x}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

Table 11. Lipase Inhibition of Camunas Pre-bake and Post-bake in Aqueous and Ethanol extracts

LIPASE INHIBITION (%)			
Savory	***Aqueous***	***Pre-baked***	**38.05 ± 0.55^{b,x}**
		Post-baked	**42.75 ± 0.40^{b,x}**
	80% Ethanol	***Pre-baked***	**74.31 ± 5.23^{a,x}**
		Post-baked	**75.36 ± 10.51^{a,x}**
Sweet	***Aqueous***	***Pre-baked***	**47.49 ± 1.28^{b,x}**
		Post-baked	**47.42 ± 1.85^{b,x}**
	80% Ethanol	***Pre-baked***	**80.58 ± 7.57^{a,x}**
		Post-baked	**83.08 ± 10.94^{a,x}**

Values are given at a 0.05g/ml concentration. Values with common superscript (abc) show no significant differences (p>0.05) between solvents. Values with common superscript (xyz) show no significant differences between processing methods.

This publication is licensed under Creative Commons Attribution CC BY.

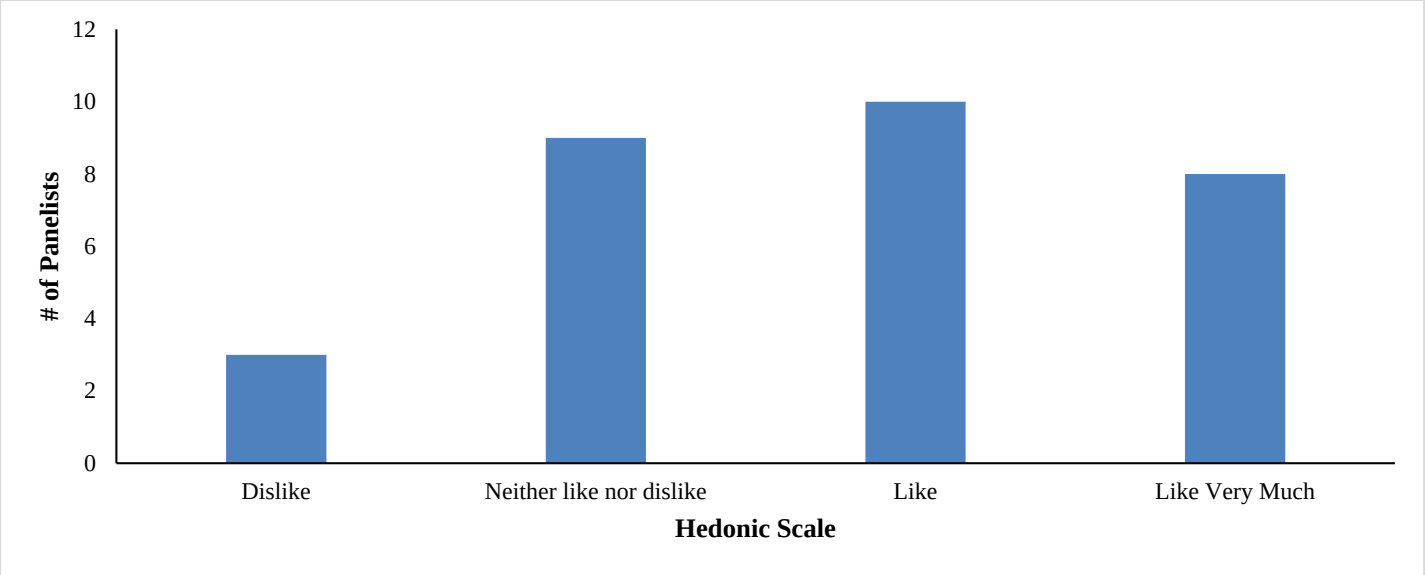


Figure 1. Rating of Savory Camuna's overall acceptability by panelists who participated in the sensory evaluation of Camunas. (n=30).

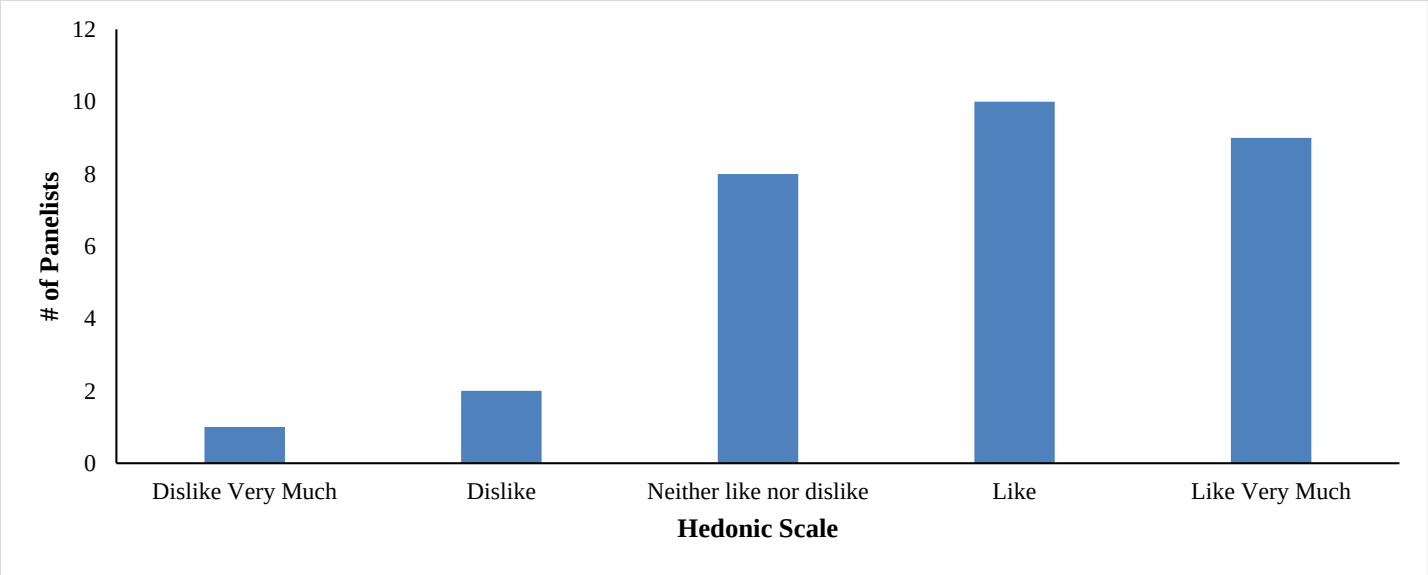
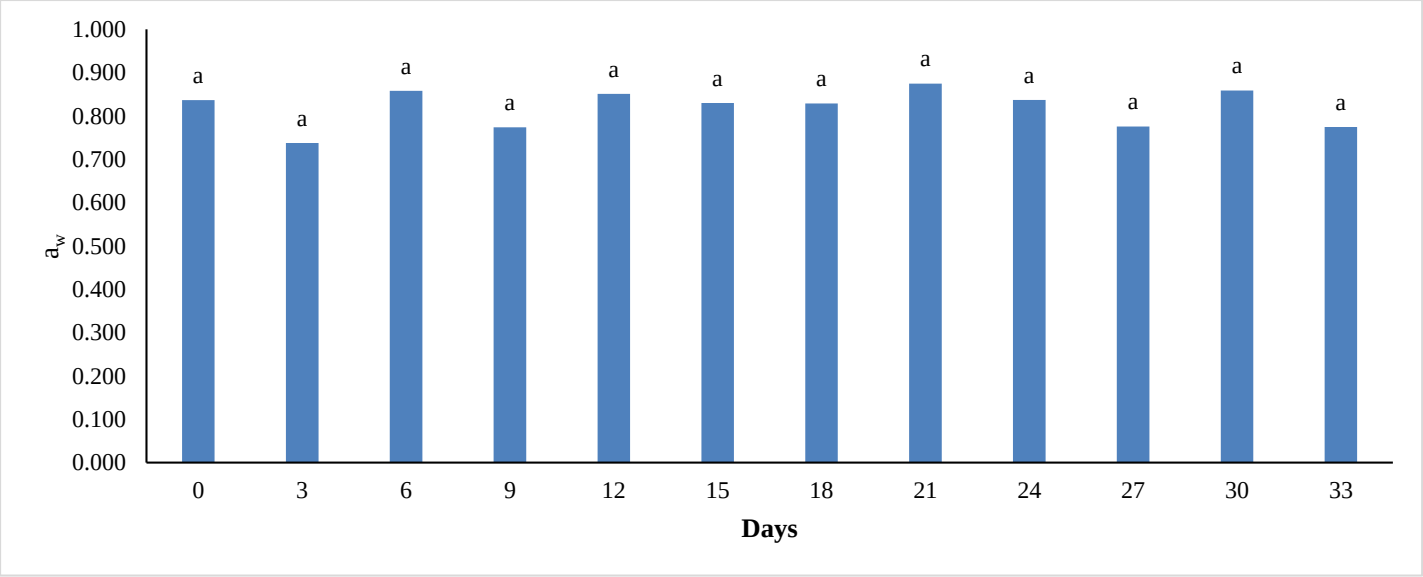


Figure 2. Rating of Sweet Camuna's overall acceptability by panelists who participated in the sensory evaluation of Camunas. (n=30).

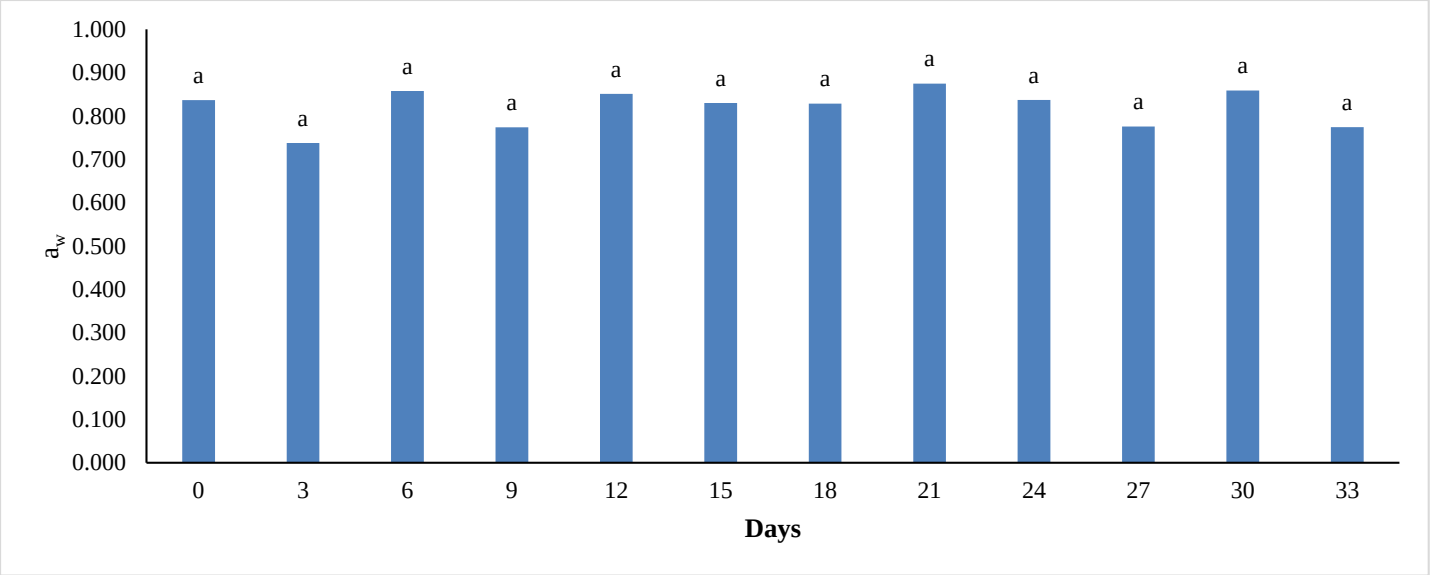
This publication is licensed under Creative Commons Attribution CC BY.



Days with common superscript (abc) indicate the lack of significant difference between them ($P > 0.05$). Days without a common superscript (abc) indicate significant difference between them ($P < 0.05$).

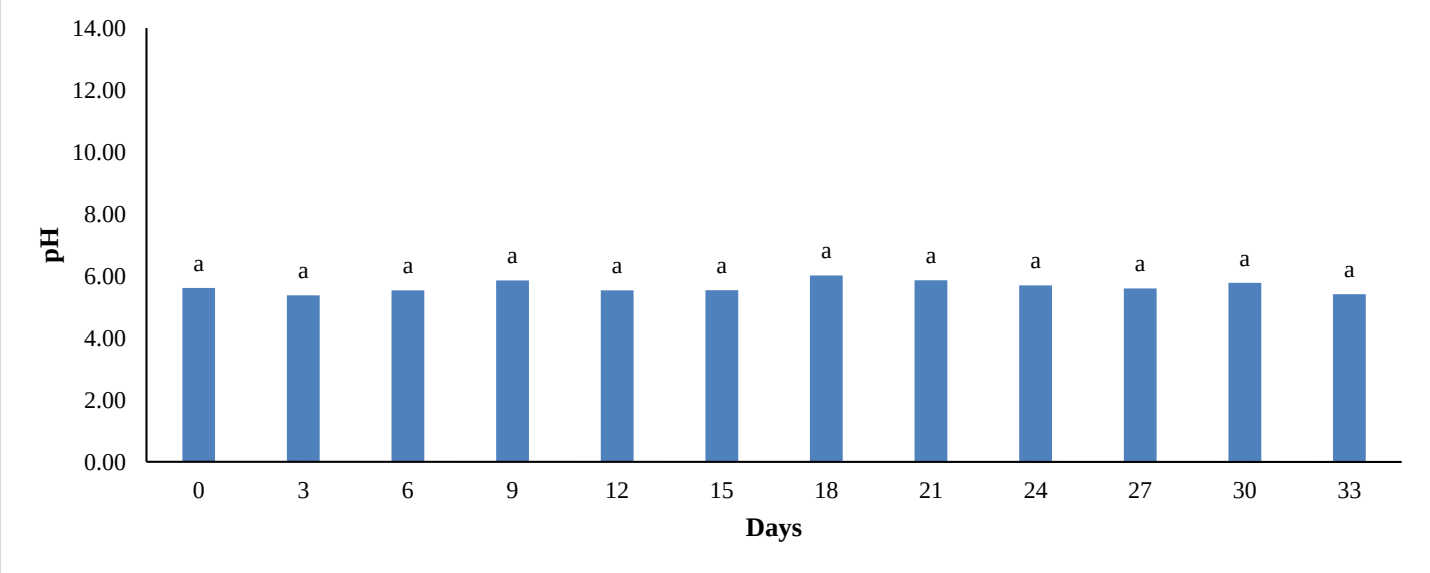
Figure 3. Water Activity of Savory Camunas over a period of 33 days

This publication is licensed under Creative Commons Attribution CC BY.



Days with common superscript (abc) indicate the lack of significant difference between them (P > 0.05). Days without a common superscript (abc) indicate significant difference between them (P < 0.05).

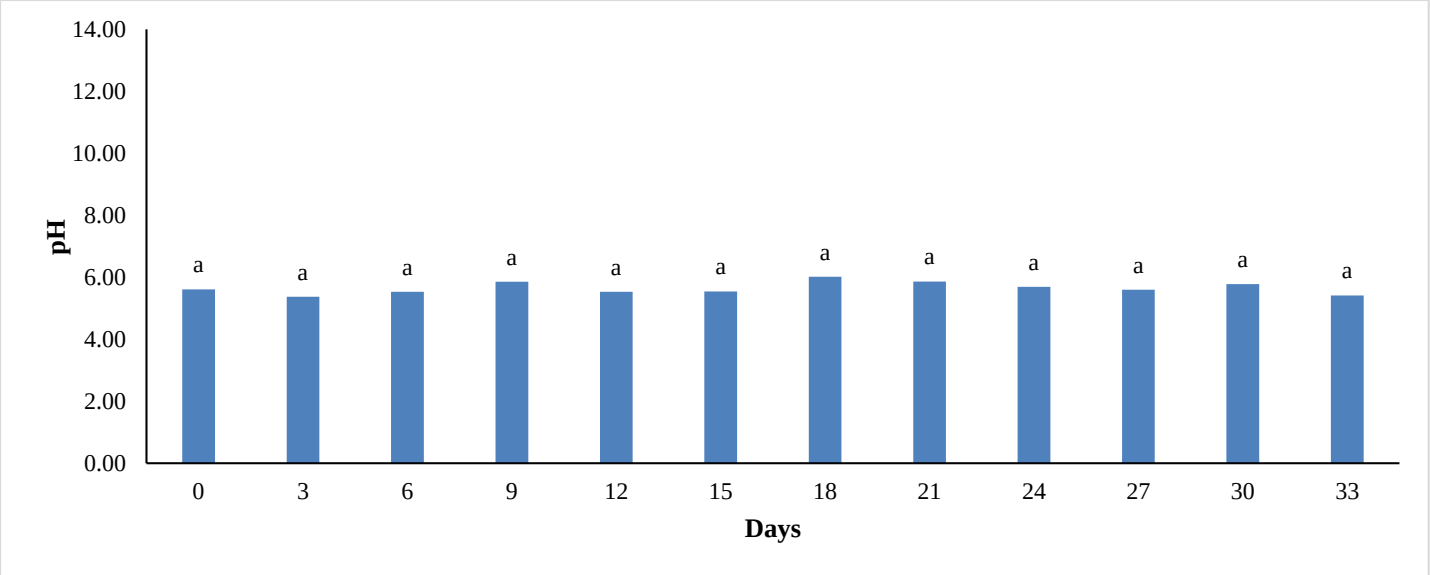
Figure 4. Water Activity of Sweet Camunas over a period of 33 days



Days with common superscript (abc) indicate the lack of significant difference between them (P > 0.05). Days without a common superscript (abc) indicate significant difference between them (P < 0.05).

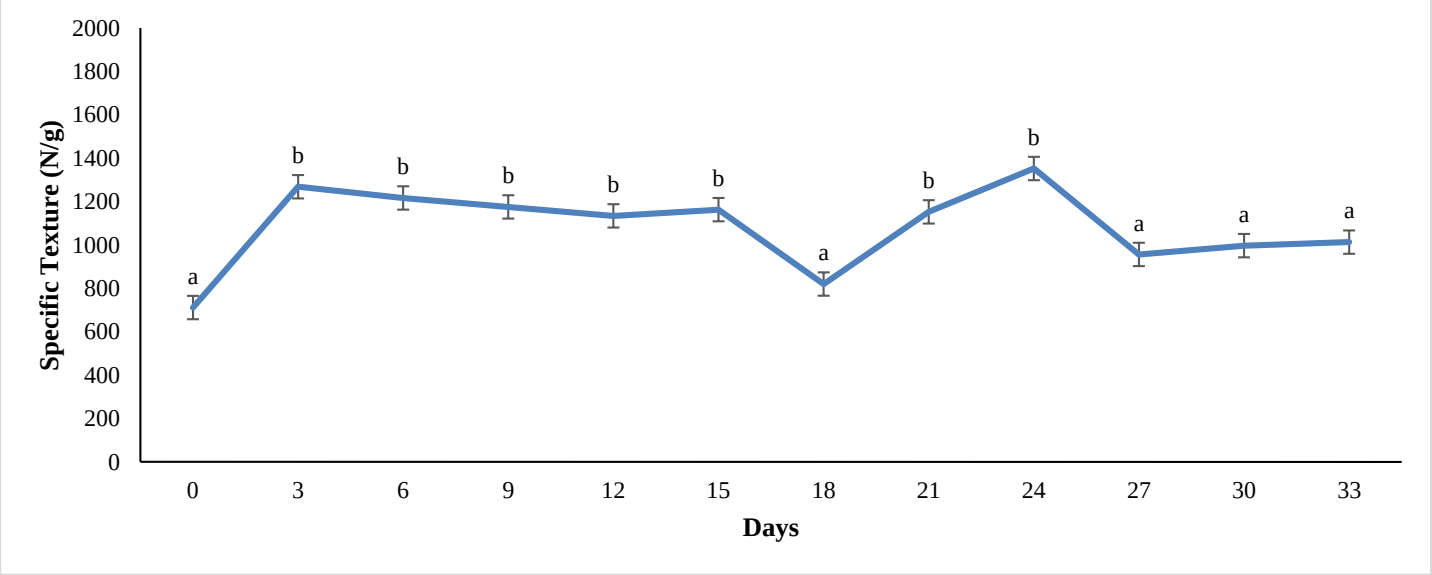
Figure 5. pH of Savory Camunas over a period of 33 days

This publication is licensed under Creative Commons Attribution CC BY.



Days with common superscript (abc) indicate the lack of significant difference between them (P > 0.05). Days without a common superscript (abc) indicate significant difference between them (P < 0.05).

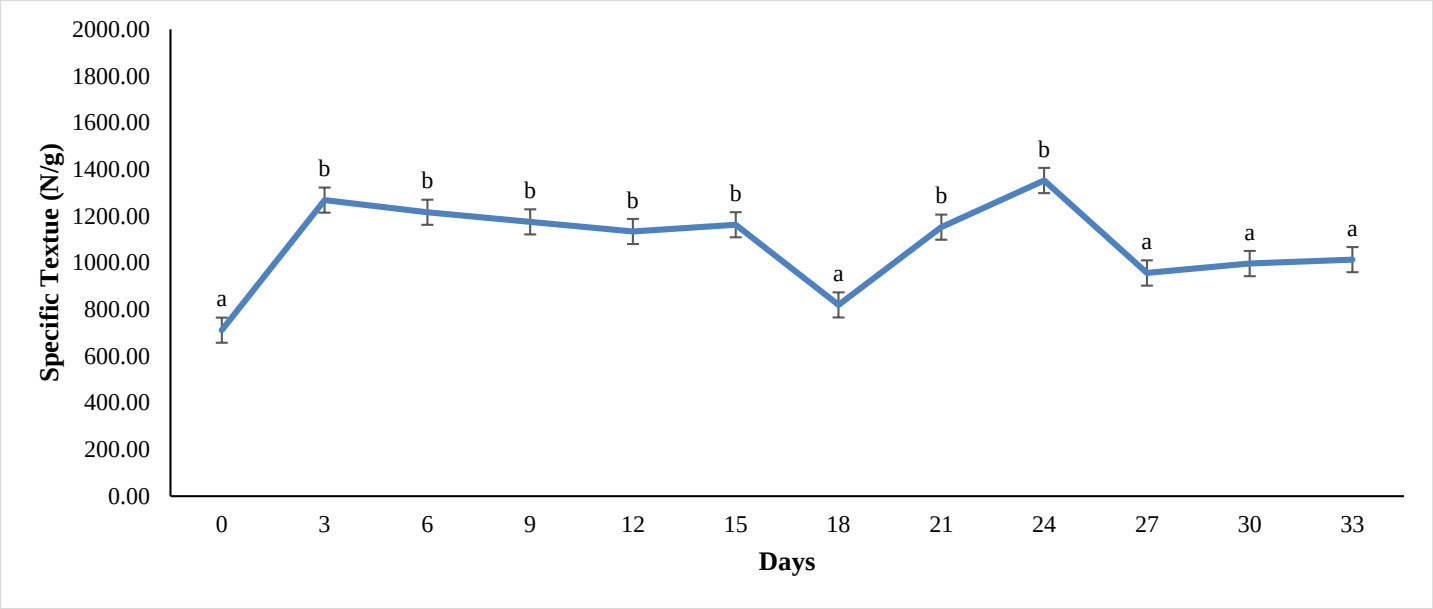
Figure 6. pH of Sweet Camunas over a period of 33 days



Days with common superscript (abc) indicate the lack of significant difference between them (P > 0.05). Days without a common superscript (abc) indicate significant difference between them (P < 0.05).

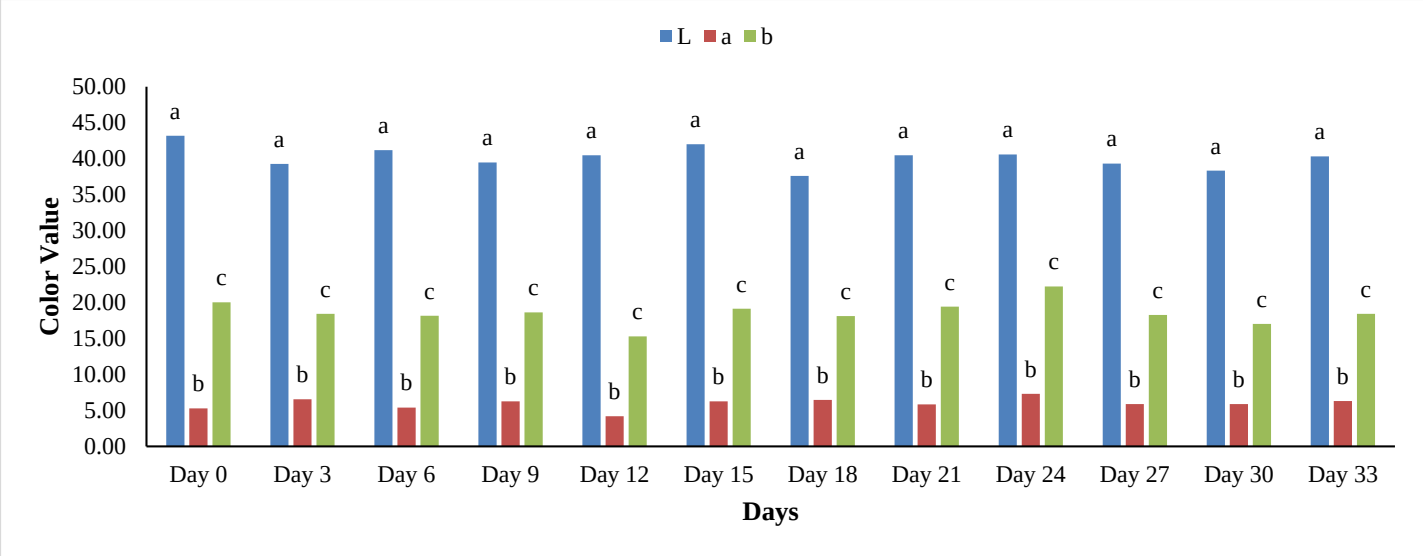
Figure 7. Specific Texture (N/g) of Savory Camunas over a period of 33 days

This publication is licensed under Creative Commons Attribution CC BY.



Days with common superscript (abc) indicate the lack of significant difference between them (P > 0.05). Days without a common superscript (abc) indicate significant difference between them (P < 0.05).

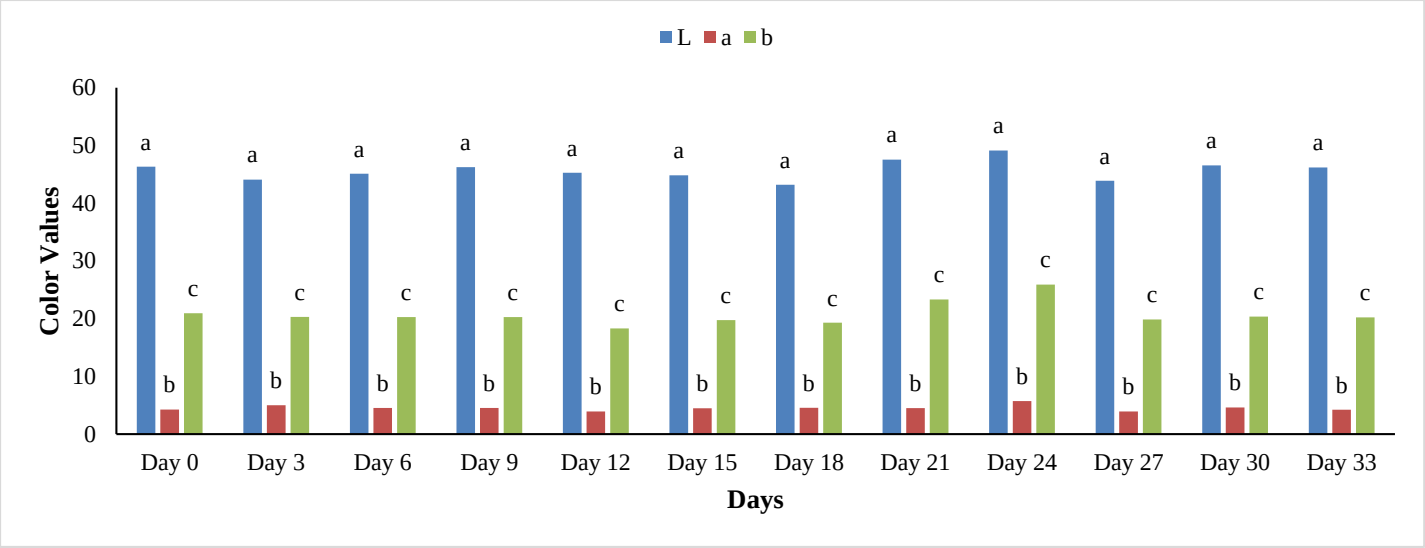
Figure 8. Texture (N/g) of Sweet Camunas over a period of 33 days



Days with common superscript (abc) indicate the lack of significant difference between them (P > 0.05). Days without a common superscript (abc) indicate significant difference between them (P < 0.05).

Figure 9. Determination of L*a*b* (color) values of Savory Camunas over a period of 33 days

This publication is licensed under Creative Commons Attribution CC BY.



Days with common superscript (abc) indicate the lack of significant difference between them ($P > 0.05$). Days without a common superscript (abc) indicate significant difference between them ($P < 0.05$).

Figure 10. Determination of L*a*b* (color) values of Sweet Camunas over a period of 33 days

References

1. Hasler, C. M. (2002). Functional Foods: Benefits, Concerns and Challenges—A Position Paper from the American Council on Science and Health. The Journal of Nutrition, 132(12), 3772–3781. https://doi.org/10.1093/jn/132.12.3772

2. Lu, Q., Summanen, P., Lee, R., Huang, J., Henning, S., Heber, D., Finegold, S., & Li, Z. (2017). Prebiotic Potential and Chemical Composition of Seven Culinary Spice Extracts. Journal of Food Science, 82(8), 1807–1813. https://doi.org/10.1111/1750-3841.13792

3. Chakrabarti, S., Guha, S., & Majumder, K. (2018). Food-Derived Bioactive Peptides in Human Health: Challenges and Opportunities. Nutrients, 10(11), 1738. https://doi.org/10.3390/nu10111738

4. nutraingredients-usa.com. (2019, March 27). At Expo West 2019, enduring appeal of protein shows. Retrieved June 23, 2021, from https://www.nutraingredients-usa.com/Article/2019/03/27/Expo-West-2019-Trend-for-protein-in-everything-continues-to-grow

5. Tomova, A., Bukovsky, I., Rembert, E., Yonas, W., Alwarith, J., Barnard, N., & Kahleova, H. (2019). The Effects of Vegetarian and Vegan Diets on Gut Microbiota. Frontiers in Nutrition, 6. https://doi.org/10.3389/fnut.2019.00047

6. Chiu, T., Liu, C., Chang, C., Lin, M., & Lin, C. (2020). Vegetarian diet and risk of gout in two separate prospective cohort studies. Clinical Nutrition, 39(3), 837–844. https://doi.org/10.1016/j.clnu.2019.03.016

This publication is licensed under Creative Commons Attribution CC BY.

7. Orlich, M., Singh, P., Sabaté, J., Fan, J., Sveen, L., Bennett, H., Knutsen, S., Beeson, W., Jaceldo-Siegl, K., Butler, T., Herring, R., & Fraser, G. (2015). Vegetarian Dietary Patterns and the Risk of Colorectal Cancers. JAMA Internal Medicine, 175(5), 767. https://doi.org/10.1001/jamainternmed.2015.59

8. Fraser, G., Katuli, S., Anousheh, R., Knutsen, S., Herring, P., & Fan, J. (2014). Vegetarian diets and cardiovascular risk factors in black members of the Adventist Health Study-2. Public Health Nutrition, 18(3), 537–545. https://doi.org/10.1017/s1368980014000263

9. Redman 1, R. (2020, March 4). Plant-based food retail sales reach $5 billion. Supermarket News. Retrieved August 2, 2021, from https://www.supermarketnews.com/consumer-trends/plant-based-food-retail-sales-reach-5-billion

10. Ensaff, H., Coan, S., Sahota, P., Braybrook, D., Akter, H., & McLeod, H. (2015). Adolescents' Food Choice and the Place of Plant-Based Foods. Nutrients, 7(6), 4619–4637. https://doi.org/10.3390/nu7064619

11. Morton, A., Furtado, J., Mendivil, C., & Sacks, F. (2019). Dietary unsaturated fat increases HDL metabolic pathways involving apoE favorable to reverse cholesterol transport. JCI Insight, 4(7). https://doi.org/10.1172/jci.insight.124620

12. Trinidad, T., Mallillin, A., Valdez, D., Loyola, A., Askali-Mercado, F., Castillo, J., Encabo, R., Masa, D., Maglaya, A., & Chua, M. (2006). Dietary fiber from coconut flour: A functional food. Innovative Food Science & Emerging Technologies, 7(4), 309–317. https://doi.org/10.1016/j.ifset.2004.04.003

13. Rupasinghe, H. P. V., Davis, A., Kumar, S. K., Murray, B., & Zheljazkov, V. D. (2020). Industrial Hemp (Cannabis sativa subsp. sativa) as an Emerging Source for Value-Added Functional Food Ingredients and Nutraceuticals. Molecules, 25(18), 4078. https://doi.org/10.3390/molecules25184078

14. Industrial Hemp Market Size | Industry Report, 2020-2027. (2020). Grand View Research. Retrieved August 5, 2021, from https://www.grandviewresearch.com/industry-analysis/industrial-hemp-market

15. El-Sayed, S. M., & Youssef, A. M. (2019). Potential application of herbs and spices and their effects in functional dairy products. Heliyon, 5(6), e01989. https://doi.org/10.1016/j.heliyon.2019.e01989

16. Viuda-Martos, M., Ruiz-Navajas, Y., Fernández-López, J., & Pérez-Álvarez, J. A. (2010). Spices as Functional Foods. Critical Reviews in Food Science and Nutrition, 51(1), 13–28. https://doi.org/10.1080/10408390903044271

17. Kamil, A., & Chen, C. Y. O. (2012). Health Benefits of Almonds beyond Cholesterol Reduction. Journal of Agricultural and Food Chemistry, 60(27), 6694–6702. https://doi.org/10.1021/jf2044795

18. Wang, Q., & Xiong, Y. L. (2019). Processing, Nutrition, and Functionality of Hempseed Protein: A Review. Comprehensive Reviews in Food Science and Food Safety, 18(4), 936–952. https://doi.org/10.1111/1541-4337.12450

19. Gajula, D., Verghese, M., Boateng, J., Walker, L., Shackelfor, L., Mentreddy, S., & Cedric, S. (2009). Determination of Total Phenolics, Flavonoids and Antioxidant and Chemopreventive Potential of Basil (Ocimum basilicum L. and Ocimum tenuiflorum L.). International Journal of Cancer Research, 5(4), 130–143. https://doi.org/10.3923/ijcr.2009.130.143

20. Benzie, I. F., & Strain, J. (1996a). The Ferric Reducing Ability of Plasma (FRAP) as a Measure of "Antioxidant Power": The FRAP Assay. Analytical Biochemistry, 239(1), 70–76. https://doi.org/10.1006/abio.1996.0292

21. Miller, N. J., Rice-Evans, C., Davies, M. J., Gopinathan, V., & Milner, A. (1993). A Novel Method for Measuring Antioxidant Capacity and its Application to Monitoring the Antioxidant Status in Premature Neonates. Clinical Science, 84(4), 407–412. https://doi.org/10.1042/cs0840407

22. Sakat, S.S., Juvekar, A.R., & Gambhire, M.N. (2010). In-Vitro Antioxidant and Anti-Inflammatory Activity Of Methanol Extract Of Oxalis Corniculata Linn.

23. Mutai, E., Sunkara, R., Vizcarra, J., Walker, L. T., & Verghese, M. (2015). Antioxidant, Enzyme Inhibitory and Anti-Obesity Potential of Sorrel Calyx Extracts in 3T3-L1 Adipocytes. Food and Nutrition Sciences, 06(05), 452–465. https://doi.org/10.4236/fns.2015.65047

This publication is licensed under Creative Commons Attribution CC BY.

This publication is licensed under Creative Commons Attribution CC BY.