Article

Not peer-reviewed version

Fermented Cashew Nut Cheese Alternative Supplemented with Red Seaweeds (Chondrus crispus and Porphyra sp.)

Bruno Miguel Campos * , Bruno Moreira Leite , Abigail Salgado , Edgar Ramalho , Isa Marmelo , Manuel Malfeito-Ferreira , Paulo Henrique Sousa , Mário Sousa Diniz , Paulina Mata *

Posted Date: 23 October 2024

doi: 10.20944/preprints202410.1828.v1

Keywords: Plant-based cheese alternatives; Seaweed supplementation; Chondrus crispus; Porphyra sp.; Physicochemical characteristics; Microbiota; Sensory characteristics

Article

Fermented Cashew Nut Cheese Alternative Supplemented with Red Seaweeds (*Chondrus crispus* and *Porphyra* sp.)

Bruno M. Campos [1,2,3]*, Bruno M.-Leite [2], Abigail Salgado [2], Edgar Ramalho [1], Isa Marmelo [4], Manuel M.-Ferreira [5], Paulo H. M. Sousa [6], Mário S. Diniz [1] and Paulina Mata [2]

1 UCIBIO-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, NOVA University of Lisboa, Quinta da Torre, 2829-516, Caparica, Portugal
2 LAQV-REQUIMTE, Department of Chemistry, NOVA School of Science and Technology, NOVA University of Lisboa, Quinta da Torre, 2829-516, Caparica, Portugal
3 SumolCompal. Estrada Nacional, 118, 2080-023, Almeirim, Portugal
4 Division of Aquaculture, Seafood Upgrading and Bioprospection, Portuguese Institute for the Sea and Atmosphere, I.P. (IPMA), 1495-006 Lisboa, Portugal
5 Linking Landscape, Environment, Agriculture and Food (LEAF) Research Center, Associated Laboratory TERRA, School of Agriculture, University of Lisboa, Tapada da Ajuda, 1349-017, Lisboa, Portugal
6 Department of Food Engineering, Federal University of Ceará, 60356-000, Fortaleza, Ceará, Brazil
* Correspondence: brunomiguel.campos@sumolcompal.pt (Bruno Campos) and mpm@fct.unl.pt (Paulina Mata)

Abstract: This study aimed to develop fermented cashew nut cheese alternative supplemented with Chondrus crispus and Porphyra sp. for enhancing their nutritional and sensory characteristics, as well as familiarizing consumers with seaweeds consumption. The impact of seaweeds supplementation was evaluated through analysis of some physicochemical, microbiological and organoleptic properties of the developed food products. The total lipids content decreased with the supplementation with seaweeds. Crude protein content also slightly decreased, while elemental analysis showed that mineral and trace elements (Ca, K, Mg, Na, Fe, I, Se, and Zn) content increased when C. crispus was added to the paste. The analyses of color and textural (TPA) attributes showed that theese were significantly influenced by adding seaweeds to the cashew paste. Generally, the microbiological results comply with the different European guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market, except for aerobic mesophilic bacteria and marine agar counts. Flash Profile analysis allowed to distinguish samples attributes, showing an increased flavor complexity of plant-based cheese alternatives supplemented with seaweeds. Overall, the study indicates that seaweed enrichment mainly influenced the physicochemical and sensory characteristics of plant-based cheese alternatives.

Keywords: Plant-based cheese alternatives; Seaweed supplementation; Chondrus crispus; Porphyra sp.; Physicochemical characteristics; Microbiota; Sensory characteristics

Introduction

The demand for various plant-based cheese alternatives (PBCAs) is gradually gaining importance in the food market [1]. However, this market is in its beginning and needs to progress rapidly [2]. In 2020, the COVID-19 pandemic accelerated this process making consumers re-evaluate their lifestyles and move towards to plant-based diets [1]. This trend is justified by concerns related to the sustainable production of food, especially proteins [2], and/or to ethical reasons [3], such as animal welfare [4-5]. Health related issues, such as food allergies and/or intolerances, also explain the increased consumption of plant-based dairy alternatives [6-7]. Some authors even suggest accelerated growth is driven by increased allergenicity toward cow's milk and lactose intolerance [1,5,8].

 doi:10.20944/preprints202410.1828.v1

Furthermore, commonly reported motivations to adopt plant-based diets also included sensory/taste/disgust aspects and weight loss [6].

The main challenges associated with developing of plant-based alternatives to dairy products are to reach products simultaneously innovative, sustainable, nutritious, and having organoleptic quality [3].

PBCAs are oil-in-water emulsions containing proteins, stabilizers, emulsifiers, flavors (cultures or nutritional yeast), food colourings and preservatives. Usually, all the ingredients are blended to imitate the cheese's appearance and consistency [1]. According to Saraco and Blaxland [9], the primary ingredients used in dairy-free alternatives to cheeses found in the UK were coconut oil, almonds and/or cashew nuts, palm oil, rice, soya, and sunflower oil. Among these ingredients, the cashew nut (*Anacardium occidentale* L.) is one of the main plant-based sources of proteins used in cheese alternatives [3].

In cashew nut-based cheese alternatives, about 50% of the weight is constituted by cashew nuts, followed by water and lemon juice, and sometimes added natural flavourings and phycocolloids such as agar-agar [10]. In other cases, PBCAs are coconut oil based and are formulated using a low percentage of almonds and cashews (10%) along with a high coconut oil content (74%) [3]. Usually, cashew nut-based products present the highest protein levels and the lowest sodium and saturated fat contents [5]. For this reason, the replacement of dairy cheese with cashew nut-based options can help reduce the intake of salt and total fats, playing a special role in replacing the intake of saturated fats with unsaturated ones, thereby providing health benefits to consumers [10].

This study aimed to develop fermented cashew nut cheese alternatives (FCNCAs) supplemented with Irish Moss (*Chondrus crispus*) and Nori (*Porphyra* sp.) seaweeds. Other objectives included the characterization of the impact of seaweeds supplementation in terms of their physicochemical, color, textural, microbiological, and sensory properties. Furthermore, according to the authors no research has addressed the production of fermented cashew nut cheese alternatives with these characteristics. Thus, this is the first study conducting a comprehensive assessment of a plant-based cheese alternative supplemented with seaweeds. Therefore, results can help consumers to be better decision-makers about their food purchases in the future, as well as contribute to increasing their familiarity with seaweeds as food.

Materials and Methods

2.1 Manufacture of FCNCAs Supplemented with Seaweeds And Sampling Strategies

The dehydrated seaweeds used in the experiments were the red seaweeds (division Rhodophyta) *Chondrus crispus* (Stackhouse, 1797) (Irish Moss; Gigartinales, Gigartinaceae), and *Porphyra* sp. (C.A. Agardh, 1824) (Nori; Bangiales, Bangiaceae), both collected in Atlantic coastal waters and industrially air-dried (ALGAplus, Ltd., Ílhavo, Portugal). Seaweeds were ground into small pieces (*C. crispus* (2.87 ± 0.99 mm); *Porphyra* sp. (1.47 ± 0.49 mm)) using a mechanical grinder (Orbegozo BV 9600, Murcia, Spain), submitted to UV (DNA/RNA UV-Cleaner Box, UVC/T-AR, Biosan, Latvia) for 48 h to avoid contamination, vacuum packaged (Sammic SU-316G, Azkoitia, Spain), and held at room temperature for a maximum of three days until use in the manufacture of FCNCAs as described below.

Cashew nuts (Alesto®) were soaked in water for about 12 h at 6-7 °C. They were then boiled in water (~ 88 °C) for about 2 min, drained, and processed in a thermomix (Bimby®) with 3% nutritional yeast flakes supplemented with vitamin B12 (Marigold Health Foods® Engevita), 3% unpasteurized white miso paste (Clearspring®), and mineral water (Luso®), until obtaining a thick paste. Then, 0.1% of Advanced Acidophilus Plus (Solgar®), which contained *Lactobacillus acidophilus* LA-5® (250 million organisms), and *Bifidobacterium lactis* BB-12® (250 million organisms) was added. The paste obtained was transferred to a cheesecloth and pressed to remove the excess water and/or fat.

Two percent (2 %) of the choosen seaweed (*Chondrus crispus* or *Porphyra* sp.) was then added to the paste. This mixture was then shaped using steel molds (Ø10 cm and 6-6.5 cm in height), stored in a hermetically closed container and reserved at 6-7 °C. Two days later, the product was removed

 doi:10.20944/preprints202410.1828.v1

from the molds and the entire surface was sprinkled with 2% refined salt (Saldomar®). The fermented cashew nut cheese alternatives were placed into a drying oven at 40 °C for 30 h (TS 9135, Termaks AS®, Bergen, Norway). Finally, the FCNCAs, uncovered, were ripened in a refrigerator (7.25 ± 1.50 °C at 59.17 ± 14.52% RH) (Thermo Meter KTJ®, Max-Min Thermo Hygro TA318), being flipped daily for 15 days.

Three different types of FCNCAs were manufactured: fermented cashew nut cheese alternative-control (FCNCA-C), fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC), and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) (Figure 1).

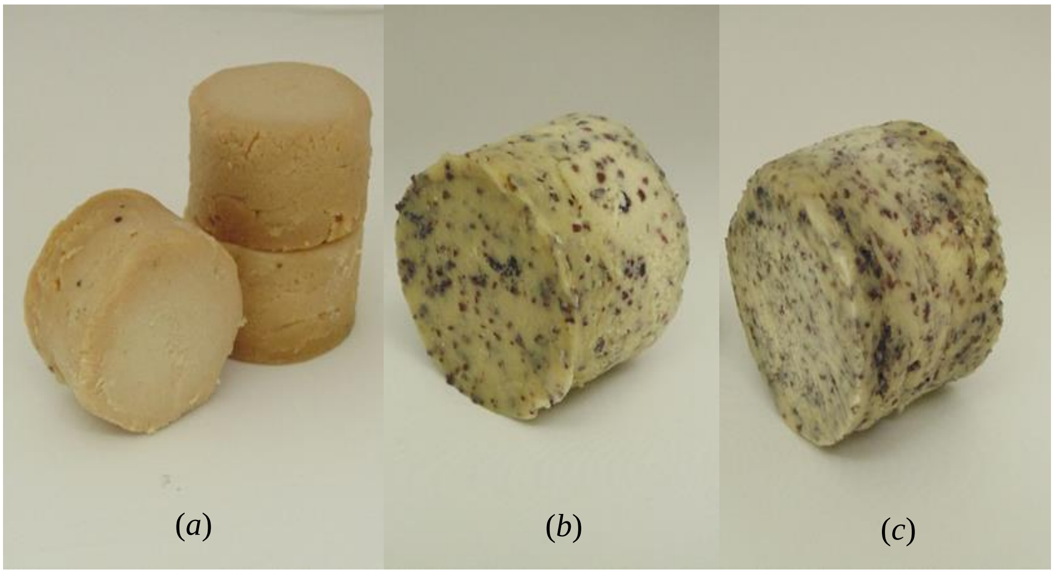

Figure 1. Representative images of the fermented cashew nut cheese alternatives (FCNCAs) after 15 days of ripening. From left to right: (*a*) fermented cashew nut cheese alternative control (FCNCA-C); (*b*) fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and (*c*) fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P).

After manufacturing, FCNCAs were refrigerated (4-6 °C), frozen (– 18 °C), or freeze-dried. Freeze-drying was processed in a laboratory freeze-dryer (ScanVac Cool Safe 4 L, LaboGene, Denmark), operating at a working temperature of – 50 °C under a pressure of 0.0005-0.002 mBar, for 48 h. Subsequently, all FCNCAs were vacuum-packed (Sammic SU-316G, Azkoitia, Spain) in labeled polypropylene bags (90µm, 180 × 300 mm, PA/PE, Azkoitia, Spain) and stored at – 18 °C until further analysis.

The experimental design and general sampling strategy of the FCNCAs are summarized in Figure 2.

 doi:10.20944/preprints202410.1828.v1

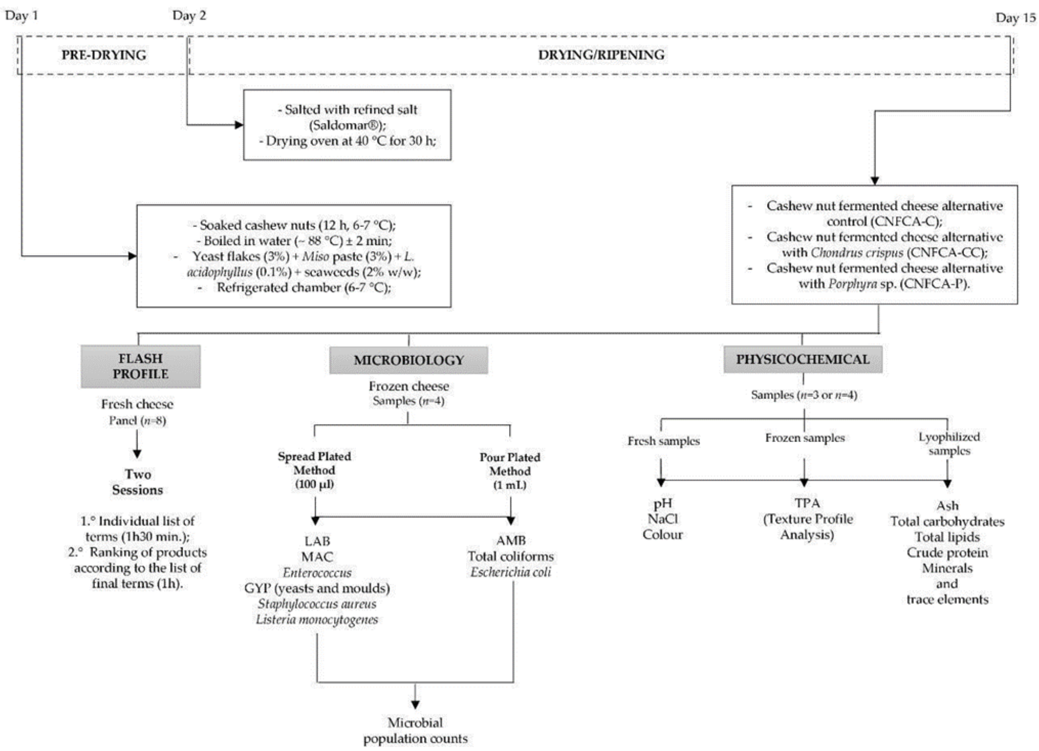

Figure 2. Scheme of the procedure followed for the production and analysis of fermented cashew nut cheese alternatives (FCNCAs).

2.2 Physicochemical Analysis

2.2.1 Total Solids and Moisture Content

The total solids (TS) were determined gravimetrically by measuring refrigerated samples (3 g) weight loss in a drying oven (TS 9135, Termaks AS®, Bergen, Norway) at 102 °C using 20 g of sea sand (PanReac AppliChem ITW Reagents) until constant weight. Then, TS and moisture were calculated and expressed as percentage of wet weight (% WW).

2.2.2 Ash Content

The ash content (AC) was assessed gravimetrically after the combustion of lyophilized samples (5 g) at 550 °C using a laboratory muffle (LV 15/11/P320, Nabertherm GmbH, Bremen, Germany) until constant weight. Ashes were cooled in a desiccator for at least one hour before weighing. The AC was quantified as the residue from combustion and expressed as a percentage of dry weight (% DW).

2.2.3 NaCl and pH

Ten grams (10 g) of refrigerated samples were homogenized in 90 mL Milli-Q water at 70 °C, and NaCl was determined using a Digital Salinity-615 Salt Content Meter 0~199.9 ppt (Yieryi, China). For the pH, 20 g of refrigerated samples were blended with 12 mL of distilled water and the pH was measured using a pH meter (Nahita Model 903, Auxilab S.L., Beriáin, Spain) equipped with a glass electrode (XS Sensor Food S7, XS Instruments, Carpi, Italy).

2.2.4 Total Lipids Content

The gravimetric lipids assay was carried out according to the procedures previously described by Kumari et al. [12]. Briefly, to 500 mg of lyophilized samples, 3.0 mL of a mixture of chloroform/methanol/50 mM phosphate buffer (Honeywell, Germany; Fisher Scientific, UK) in the proportions of 2:1:0.8, v/v/v was added, vortexed for about one min, and then centrifuged (Domel, Centric 150, Slovenia) at 2,057 × g for 15 min. Next, the residues were reextracted three times with 2

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 October 2024 doi:10.20944/preprints202410.1828.v1

mL of chloroform/methanol/buffer (1:1:0.8, v/v/v), and centrifuged as stated above. The supernatants were then combined, filtered, washed with 2 mL of 50 mM phosphate buffer, and centrifuged at 2,057 × g for 5 min. Finally, the organic phase was dried under a regular nitrogen flow. NIST Standard ReferenceMaterial® 3232 - Kelp powder (*Thallus laminariae*) was used to validate the methodology and results. The total lipids content was weighed (Radwag®, Model PS 450/X, Bracka, Poland) and expressed as a percentage of dry weight (% DW).

2.2.5 Crude Protein Content

Crude protein was determined on a FP-528 combustion N analyzer (LECO Corporation, St. Joseph, MI, USA). Briefly, a pre-weighted freeze-dried sample (100 mg) was placed into the loading head of the combustion analyzer, sealed, and flushed with pure oxygen, being covalently bound nitrogen (N) converted into nitrogen gas (N_2) and measured by a thermal-conductivity cell. An air blank and the calibration standard curve were built with ethylenediaminetetraacetic acid (EDTA, LECO 502-896, St. Joseph, MI, USA). Protein content was calculated by multiplying the nitrogen (N_2) content (%) by a conversion factor of 5.30 [13]. The analyses were performed, and the results were expressed as a percentage of dry weight (% DW).

2.2.6 Elemental Analysis

In brief, 250 mg of samples were digested in 5 mL nitric acid 65% (Merck, KGaA, Germany) and 1 mL of hydrochloric acid 37% (Honeywell, Germany) for 48 h using 15 mL Falcon tubes (DeltaLab, Spain). The mixture was then placed in a fluoropolymer PFA (perfluoroalkoxy alkanes) microwave vessel, sealed, and heated on a digital dry bath (AccuBlock™, Labnet International, Inc., NJ, USA) at 100 °C for 24 hours until complete digestion. After cooling, 100 µL of hydrogen peroxide 30% (Sigma-Aldrich®, Germany) was added to each sample, vortexed, filtered, and diluted to a final volume of 10 mL. Blanks were prepared with ultrapure water under the same digestion conditions. The elemental analysis was performed by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) using an Ultima model (Horiba Jobin Yvon, France). A calibration curve was constructed for all elements. The minerals were expressed as $g \cdot kg^{-1}$ DW and trace elements as $mg \cdot kg^{-1}$ DW. The methodology was validated by analyzing certified reference materials from the National Institute of Standards and Technology (NIST), namely, Kelp powder (*Thallus laminariae*) Standard Reference Material® (CRM) 3232.

2.2.7 Color

Color parameters were determined in six distinct zones of the internal surface of FCNCAs using a PCE-CSM 4 chroma meter (PCE Instruments™, UK), with light source D65 (standard daylight) through coordinates CIELAB: L^* (degree of lightness perceived, $L^* = 0$, black, $L^* = 100$, diffuse white), a^* (degree of redness, $a^* > 0$, or greenness, $a^* < 0$), and b^* (degree of yellowness, $b^* > 0$, or blueness, $b^* < 0$). The colorimeter was calibrated against a standard white reference tile ($L^* = 93.97$; $a^* = -0.88$ and $b^* = 1.21$).

2.2.8 Texture Profile Analysis (TPA)

The texture profile analysis (TPA) was performed using a two-bite compression test using a TA4/1000-cylinder probe (Ø 38.1 mm, 20 mm in height), and a 4500 g force load cell. The pre-test and post-test speed were set at 2.0 mm/s; trigger force, 2.0 g; compression, 20%; and time pause between cycles, 5 s. Defrosted FCNCAs were cut into cubes (20×20×20 mm) and allowed to equilibrate at room temperature (~ 22 °C) for about two hours. From the compression, curves were obtained and parameters such as hardness (N), adhesiveness (J), cohesiveness (—), springiness (mm), and gumminess (N) were derived using the software TexturePro CT Software (AMETEK Brookfield, Hadamar-Steinbach, Germany).

2.3 Microbial Load

Frozen samples were prepared in a horizontal laminar airflow cabinet (Aeolus H, Telstar®, Terrasa, Spain) for the purposes of microbial analysis. Each sample, according to the test (10 g or 25 g), was weighed (Radwag®, Model PS 450/X, Bracka, Poland), taken aseptically, placed in a BagLight Poly-Silk sterile blender bag (Interscience, Saint-Nom-la-Bretèche, France), and homogenized in 90 mL of Ringer's solution (Biokar Diagnostics, Pantin, France) during 90 s in a stomacher apparatus (BagMixer® 400 P, Interscience, Saint-Nom-la-Bretèche,France). Serial dilutions in sterile ¼ strength Ringer solution was spread-plated (100 µL) or dispersed by pour plate method (1 mL) in Petri dishes Ø90 mm (Frilabo; Maia, Portugal) for viable counts.

The following analyses were carried out: *a*) total Aerobic Mesophilic Bacteria (AMB) on Plate Count Agar (PCA, Biokar Diagnostics, Pantin, France) incubated at 30 °C for 72 h; *b*) Lactic Acid Bacteria (LAB) on De Man, Rogosa and Sharpe agar (MRS broth, Biokar Diagnostis,Pantin, France), acidified to a final pH of 5.4 ± 0.1 with acetic acid (Sigma-Aldrich®, Germany) and incubated at 30 °C for 72 h; *c*) *Enterococcus* on Compass® *Enterococcus* agar (Biokar Diagnostics, Pantin, France) incubated at 44 °C for 24 h; *d*) total coliforms and *Esherichia coli* on Compass® ECC agar (Biokar Diagnostics, Pantin, France) incubated respectively at 37 °C and 44 °C for 24 h; *e*) coagulase-positive staphylococci (*Staphylococcus aureus*) on Baird-Parker RPF agar (BP; Biokar Diagnostics, Pantin, France) incubated at 37 °C for 48 h; *f*) yeasts and molds on Chloramphenicol Glucose Agar (CGA; Biokar Diagnostics, Pantin, France) incubated at 25 °C for 5 days; *g*) marine bacteria on Marine agar (Condalab, Madrid, Spain) incubated at 20-25 °C for 72 h; *h*) *Salmonella* spp. on Buffered Peptone Water (BPW), Rappaport-Vassiliadis Soja (RVS) Broth (RAP), Muller-Kauffmann Tetrathionate-Novobiocin (MKTTN) broth, Xylose Lysine Desoxycholate (XLD) agar, and Brilliant Green Agar (BGA) (Biokar Diagnostics, Pantin, France) at 37 °C for 5 days; *i*) *Listeria monocytogenes* on half-fraser broth, fraser broth, and Palcam agar (Biokar Diagnostics, Pantin France) incubated at 37 °C for 5 days.

After the counting, means and standard deviations (SD) were calculated and expressed in log CFU·g^{-1} and interpreted according to the United Kingdom's Health Protection Agency guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market [14], the INSA Portuguese guidelines [15], as well the European Commission Regulation (EC) No 2073/2005 [16]. The test methods used in the various microbiological parameters are shown in supplementary material (Table S1).

2.4 Flash profile (FP)

2.4.1 Panel and Procedure

The panel comprised eight trained panel members (seven women and one man), 50% aged 18 to 30 and and 50% aged 30 to 65 years old. Panel members were recruited among students and academic staff of the Chemistry Department, NOVA School of Science and Technology, NOVA University, Lisbon, Portugal, in 2020.

The FP test consisted of two sessions in which samples were coded with three-digit random numbers and presented simultaneously to the panel members. The members were instructed to rinse their mouths with tap water at room temperature before and between each sample.

During the first session (1 h 30 m), the panel members were given a brief outline of the procedures, and asked to provide an individualy list that best describe differences between each sample to defined attributes (appearance, aroma, flavor, texture, and after-taste). They were instructed to avoid the use of hedonic terms. Each panelist was given the opportunity to compare his own list of sensory attributes with a joint list of attributes selected by all members of the panel. They were then allowed to modify their list by adding, renaming, or deleting any of their own attributes.

In the second session, panelists were asked to rank the FCNCAs on their own attributes according to differences in intensity. Per sensory attribute, a line scale anchored at their extreams with the lower and higher degree of intensity was used and ties were allowed. The session lasted about 1 h. In both cases all sessions were individual

 doi:10.20944/preprints202410.1828.v1

2.5 Statistical Analysis

A non-parametric Mann–Whitney U test was carried out to assess any significant differences between the means. In all cases, the criterion for statistical significance was $p < 0$.All statistical analyses were carried out using the statistical software STATISTICA (STAT. version 8.0, StatSoft Inc. Tulsa, OK, USA). All data were expressed as mean ± standard deviation (SD) ($n = 3$) and reported on a dry matter basis, unless stated otherwise.

Flash Profile (FP) results were analyzed through Generalized Procrustes Analysis (GPA) using Microsoft Office Excel add-in software, XLSTAT (version 2022, Addinsoft, New York, USA), to get the optimal configuration in individual scaling data [17], thus minimizing the differences between the panellists. After the GPA consensus configuration, the FP data generates biplot maps showing the products' differences and similarities of the products according to the graphic interpretation.

Results and Discussion

3.1 Physicochemical Characterization of FCNCAs

Table 1 shows the FCNCAs physicochemical parameters (mean ± SD), and Table S2 (Supplementary material) the *p*-values.

3.2 Total Solids and Moisture Content

Total solids (TS) values ranged from 65-70% WW, and statistical analyses revealed significant differences among all samples ($p < 0.05$). The TS content of supplemented products increased by 3-5% WW. In general, the values found are higher than those reported for formulated processed dairy cheese (44.25%), or formulations with different ratios (2.5-10%) of a vegetable blend, where values vary from 47 to 53% [18].

The moisture content ranged from 30-35% WW, with significant differences between all samples ($p < 0.05$). These values are lower than those reported by Chen et al. for fermented cashew cheese brie (43.4%), and by Grasso et al. for commercial plant-based block-style alternative products (46-54%).

3.3 Ash Content

The ash content (AC) shows significant differences among all samples ($p = 0.0495$). When seaweeds are added, the AC of the samples increases from 2.81% (FCNCA-C) to 3.12% (FCNCA-P), and to 3.63% (FCNCA-CC). In fact, as reported by Campos et al. [20], *C. crispus* has a higher AC content (26.0%) than *Porphyra* sp. (13.9%). Also, the AC of dried cashew nuts reported by other researchers ranges from 2.02% to 2.7% [22], within the range found in the present study.

Table 1. Physicochemical characterization of fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P).*.

 doi:10.20944/preprints202410.1828.v1

Physicochemical	Control	Supplemented products	
parameters	FCNCA-C	FCNCA-CC	FCNCA-P
Total solids (% WW)	64.63 ± 0.88	67.96 ± 0.53	69.79 ± 0.59
Moisture (% WW)	35.37 ± 0.88	32.04 ± 0.53	30.21 ± 0.59
Ash (% DW)	2.81 ± 0.08	3.63 ± 0.15	3.12 ± 0.09
NaCl (g/100 g)	2.67 ± 0.21	2.50 ± 0.10	2.43 ± 0.15
pH	5.27 ± 0.12	5.07 ± 0.15	5.07 ± 0.06
Total lipids (% DW)	37.45 ± 0.44	34.51 ± 3.85	32.91 ± 0.16
Crude protein (% DW)	18.92 ± 0.00	18.26 ± 0.45	18.73 ± 0.20

* Data are presented as mean ± SD (n=3) except for crude protein (n=4).

3.4 NaCl and pH

NaCl content ranged from 2.43 to 2.67 g/100 g; no significant differences were found for FCNCAs ($p > 0.05$). Other studies reported lower values for plant-based alternatives, namely 0.6 (0.5-0.6) g/100 g (expressed as median (min.-max.) in cashew nut-based cheese alternative [10], or 1.25 ± 0.115 (g/100 g) for plant-based alternatives made of almond, sunflower, and cashew [7]. The determined values are within the levels of NaCl for dairy cheeses produced by rennet coagulation, namely 0.7-4 g/100 g [23].

The pH ranged from 5.07 to 5.27, showing a significant difference between FCNCA-C and FCNCA-P ($p = 0.0431$). Despite this, in all FCNCAs the accumulation of organic acids was not enough to achieve a final pH ≤ 4.4, which is a safe threshold to minimize the growth of *L. monocytogenes* [24-25].

3.5 Total Lipids Content

Total lipids (TL) content differs significantly for FCNCA-C *vs*. FCNCA-CC and FCNCA-C *vs*. FCNCA-P ($p = 0.0495$). The cashew nut kernels are rich in lipids [26], showing a high-fat content in the whole seed (43-50%) [27]. Other researchers reported *ca*. 66 g/100 g of DW in raw cashew nut kernels [28]. In this study, the TL content of FCNCAs ranged from 33-37%, decreasing 3-5% when seaweeds were added to the matrix — this is likely due to the very low lipid content of seaweeds [20,29].

3.6 Crude Protein Content

Crude protein contents ranged from 18.26 to 18.92% and showed significant differences between all samples ($p = 0.0180$), although the values are similar, with less than 1% of difference between them. Albeit red seaweeds have high levels of protein (14-47 g/100 g of dry weight) [30-31], their supplementation does not contribute to protein improvement in FCNCAs, as cashew nuts have a similar protein content (21.3%) [32].

Proteins have many functionalities in foods, namely, solubility, gelling, foaming, and flavor creation. Plant proteins have a different structure, composition, and food functionality than animal proteins [33]. In general, alternative cashew nut-based cheese products were considered energy-dense and presented a protein median of 11 g/100 g, representing a good source of proteins [10].

Nowadays, developed countries raise health and environmental concerns about the consumption of animal-protein. A high animal protein intake has been associated with an increased risk of several diseases (*e.g.* cardiovascular, carcinogenic, diabetes and obesity) [34]. Therefore, nut kernels can be an important source of protein for plant-based diets [35]. The replacement of dairy cheese with cashew nut-based options was suggested to moderate the high protein intake by Spaniard consumers, for example, since they have an excessive protein intake [10].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 October 2024 doi:10.20944/preprints202410.1828.v1

3.7 Elemental Analysis

The concentrations of minerals and trace elements for seaweed and the FCNCAs are presented in Table 2, and the *p*-values of supplemented products in supplementary material (Table S3).

Table 2. Contents for minerals and trace elements in each seaweed analyzed (Irish Moss (Chondrus crispus) and Nori (Porphyra sp.), and fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with Chondrus crispus (FCNCA-CC); and fermented cashew nut cheese alternative with Porphyra sp. (FCNCA-P).*.

Minerals and trace elements	***C. crispus***	***Porphyra* sp.**	**FCNCA-C**	**FCNCA-CC**	**FCNCA-P**	**Certified values ****
Ca (g·kg^{-1} DW)	4.29 ± 0.17	1.77 ± 0.05	0.81 ±	1.07 ±	1.77 ± 0.19	12.35 ± 0.22
K (g·kg^{-1} DW)	36.24 ±	16.55 ±	2.59 ±	3.79 ±	2.79 ± 1.05	75.18 ± 1.66
Mg (g·kg^{-1} DW)	6.82 ± 0.07	4.26 ± 0.12	3.13 ±	3.51 ±	3.19 ± 0.50	6.08 ± 0.21
Na (g·kg^{-1} DW)	31.81 ±	22.40 ±	6.19 ±	9.53 ±	7.38 ± 1.10	16.56 ± 0.49
P (g·kg^{-1} DW)	1.70 ± 0.05	2.31 ± 0.09	7.59 ±	6.64 ±	7.98 ± 0.66	4.58 ± 0.48
Fe (mg·kg^{-1} DW)	123.95 ±	79.96 ±	49.48 ±	60.14 ±	48.21 ±	661.03 ± 33.11
I (mg·kg^{-1} DW)	29.33 ±	15.80 ±	– 0.11 ±	1.26 ±	– 0.07 ±	918.05 ± 49.52
Mn (mg·kg^{-1} DW)	26.18 ±	20.77 ±	15.03 ±	15.84 ±	14.88 ±	23.90 ± 1.81
Se (mg·kg^{-1} DW)	0.84 ± 0.10	2.49 ± 0.10	2.05 ±	2.54 ±	2.15 ± 0.19	n.a.
Zn (mg·kg^{-1} DW)	66.24 ±	48.05 ±	40.13 ±	65.76 ±	46.78 ±	26.52 ± 0.63

* Values are presented as mean ± standard error (*n*=3). ** Certified reference materials (CRMs) from the National Institute of Standards and Technology (NIST) through Kelp powder (*Thallus laminariae*) Standard Reference Material® (CRM) 3232. n.a. (not analyzed as no values are available in the Standard Reference Material® (CRM) 3232 certificate of analysis.

For the FCNCAs, calcium (Ca) ranged from 0.81 to 1.77 g·kg^{-1}, showing a significant difference between FCNCA-C and FCNCA-CC ($p = 0.0495$). The results also show *that C. crispus* has higher levels of Ca (4.29 g·kg^{-1}) than *Porphyra* sp. (1.77 g·kg^{-1},), and this ends up having a decisive impact on the paste of FCNCA-CC (1.07 g·kg^{-1}). As Boukid et al. reported, plant-based products have lower calcium content when compared to dairy products. However, the values determined in this study are higher than those observed for cashew cheese brie (0.41 g·kg^{-1}) without any type of supplementation [19].

Potassium (K) content in FCNCAs ranged from 2.59 to 3.79 g·kg^{-1}, showing significant differences between FCNCA-C and FCNCA-CC (p=0.0495) reflecting the higher K content found in *C. crispus*. When compared to fermented cashew cheese brie (1.76 g·kg^{-1}) [19], all FCNCAs levels are higher, especially when supplemented with *C. crispus* (3.79 g·kg^{-1}).

Magnesium (Mg) ranges from 3.13 to 3.51 g·kg^{-1}, showing a significant difference between FCNCA-C and FCNCA-CC ($p = 0.0495$), with *C. crispus* exhibiting a positive effect when added to the paste, which is by the obtained results for seaweeds, namely 4.26 for *Porphyra* sp. and 6.82 for *C. crispus*. Magnesium (Mg) deficiency is common in humans [36], playing an important role in the pathogenesis of ischemic heart disease, congestive heart failure, cardiac arrhythmias, and hypertension, among others [37], and as such is a critical mineral in the human body [38].

Sodium (Na) ranged from 6.19 to 9.53 g·kg^{-1} and showed significant differences between all samples (p = 0.0495) with supplemented products presenting higher values than control, which are directly related to the contents determined for seaweeds, namely, 31.81 g·kg^{-1} for *C. crispus* and 22.40

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 October 2024 doi:10.20944/preprints202410.1828.v1

g·kg^{-1} for *Porphyra* sp. The values obtained for control (6.19 g·kg^{-1}) are in agreement with values reported by Chen et al. for cashew cheese brie (6.26 g·kg^{-1}).

Phosphorus (P) ranged from 6.64 to 7.98 g·kg^{-1} and showed significant differences between FCNCA-C and FCNCA-CC (p = 0.0495), since the P levels measured in *C. crispus* are very low (1.70 g·kg^{-1}).

Regarding trace elements, iron (Fe) levels range from 48.21 to 60.14 mg·kg^{-1}, showing significant differences between FCNCA-C and FCNCA-CC, and FCNCA-CC and FCNCA-P (p = 0.0495). The high Fe content found in *C. crispus* (123.95 mg·kg^{-1}) significantly impacted the supplemented cheese, contrary to *Porphyra* sp. (79.96 mg·kg^{-1}). However, all values obtained for FCNCAs are higher than the value reported by Chen et al. for cashew cheese brie (17 mg·kg^{-1}).

Iodine (I) ranged from – 0.07 to 1.26 mg·kg^{-1} and showed significant differences between FCNCA-C and FCNCA-CC, and FCNCA-CC and FCNCA-P (p = 0.0495), which can be attributed to the higher iodine content of *C. crispus* (29.33 mg·kg^{-1}). The results for FCNCA-C and FCNCA-P are below the detection limit, and the low percentage (2%) of *Porphyra* sp. seaweed used for supplementation can justify this.

In a recent study carried out by Clegg et al. [7], of 109 cheese alternatives available in the UK, none of them were fortified with iodine, an essential nutrient required to produce thyroid hormones, which play a crucial role in growth mechanisms and the development of tissues [7, 39].

Manganese (Mn) ranged from 14.88 to 15.84 mg·kg^{-1} and did not show significant differences among analyzed samples ($p > 0.05$).

Selenium (Se) ranges from 2.05 to 2.54 mg·kg^{-1}, showing a significant difference between FCNCA-C and FCNCA-CC (p = 0.0495). Although *Porphyra* sp. content is higher (2.49 mg·kg^{-1}) than that of *C. crispus* (0.84 mg·kg^{-1}), its addition to the paste had no enrichment effect, contrary to *C. crispus*. Selenium (Se) is an important oligoelement playing a crucial role in the antioxidant defense system due to its requirement by the Se-dependent GSH-Px, which is involved in cellular antioxidant protection [40].

Zinc (Zn) ranged from 40.13 to 65.76 mg·kg^{-1}, showing significant differences between FCNCA-C and FCNCA-CC, and FCNCA-CC and FCNCA-P (p = 0.0495), with FCNCA-CC presenting the best results, which are in agreement with the content found in *C. crispus* (66.24 mg·kg^{-1}).

3.8 Color

The color of FCNCAs was significantly influenced by adding seaweeds (Table 3). The p-values are presented in supplementary material (Table S4). Lightness (L*) is significantly different for FCNCA-C *vs*. FCNCA-CC and FCNCA-C *vs*. FCNCA-P (p = 0.0002), and FCNCA-CC *vs*. FCNCA-P (p = 0.0012). Fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) recorded the lowest value (38.30) for L*, followed by FCNCA-CC (43.77), being the highest for FCNCA-C (53.33), *i.e.*, the pigments from red seaweeds affected the lightness of FCNCAs, specially *Porphyra* sp..

Table 3. Color parameters of fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P).*.

	Control	**Supplemented products**	
Parameters	**FCNCA-C**	**FCNCA-CC**	**FCNCA-P**
L*	53.33 ± 1.91	43.77 ± 2.25	38.30 ± 2.21
a*	10.56 ± 0.47	3.19 ± 0.50	6.68 ± 0.94
b*	25.74 ± 0.46	15.62 ± 2.28	13.71 ± 1.43
C	27.83 ± 0.52	15.95 ± 2.29	15.26 ± 1.50

* Values of color parameters (L* (lightness); a* (redness to greenness); b* (yellowness to blueness); and C* (chroma)) are presented as mean ± SD (n=4).

The redness to greenness (*a**) shows significant differences among all the samples (*p*=0.0002). Fermented cashew nut cheese alternative with *C. crispus* (FCNCA-CC) exhibits the lowest value (3.19), followed by FCNCA-P (6.68) with the highest value for FCNCA-C (10.56). Seaweeds of the division Rhodophyta are a valuable source of chlorophyll *a* and *d*, phycobilins (allophycocyanin (APC), R-phycoerythrin (R-PE), and R-phycocyanin (R-PC)), carotenoids (*α*-, and *β*-carotene) and xanthophylls (lutein) which influenced the color of FCNCAs [41-42].

C. crispus has a lower value of total pigment content (0.52 mg/g), with *β*-carotene (73.76%) as the main pigment, followed by chlorophyll *a* (26.17%), and lutein (0.061%) [43]. However, in dried form (DF) and after hydration treatment (HT), *β*-carotene is not detectable in *C. crispus*. At the same time, phycoerythrin ($\Delta\lambda$=10) decreases from 528.3 ± 69.0 mg/Kg dry matter (DF) to 525.6 ± 74.2 mg/Kg dry matter (HT); phycocyanin ($\Delta\lambda$=40), increases from 149.2 ± 22.8 mg/Kg dry matter (DF) to 232.5 ± 27.0 mg/Kg dry matter (HT); and lutein from not detected (DF) to 1.80 ± 0.17 mg/Kg dry matter (HT) [44]. In the case of *Porphyra* spp., besides phycobiliproteins such as phycoerythrin (PE) and phycocyanin (PC) pigments, chlorophylls *a* and *d* are also present, as well as several carotenoids (*β*-carotene, *α*-carotene, lutein, zeaxanthin, violaxanthin, and fucoxanthin) [45]. In the present case, the pigments of both seaweeds affect the redness to greenness (*a**) parameter, being the values for the FCNCAs closer to the greenish direction. Due to the high fat content and the lower polarity of chlorophylls (compared to phycobiliproteins), it is possible that there was better solubilization of chlorophylls in the cashew paste.

Yellowness to blueness (*b**) is positive in all FCNCAs, therefore in the yellow range of color values, but significant differences were found between FCNCA-C and FCNCA-CC, between FCNCA-C and FCNCA-P (*p*=0.0002), and between FCNCA-CC and FCNCA-P (*p*=0.0494). Fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) presents the lowest value (13.71), followed by FCNCA-CC (15.62), and the highest by FCNCA-C (25.74). These values also result from the presence of the various seaweed pigments referred to, contributing to less yellowness.

Chroma (*C**) values, measuring color purity and intensity, reveal significant differences between FCNCA-C and FCNCA-CC and between FCNCA-C and FCNCA-P (*p*=0.0002), with the lowest value being found in FCNCA-P (15.26), followed by FCNCA-CC (15.95), and the highest values determined in FCNCA-C (27.83), reflecting the effect of the various pigments present in the seaweeds.

Overall, FCNCA-C presents the highest value in all parameters. In general, FCNCAs exhibited mean levels of *L** (≤53), with component *b** predominant over component *a**, suggesting that the degree of lightness and yellowness mostly contributed to the color features of the FCNCAs, as well reported by other authors [46-47].

3.9 Texture Profile Analysis (TPA)

The textural properties of the FCNCAs are reported in Table 4 and *p*-values in supplementary material (Table S5). TPA results are difficult to discuss as there is little or no data from other studies.

Table 4. TPA parameters (hardness (N), adhesiveness (J), cohesiveness (—), springiness (mm), and gumminess (N)) for fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P).*.

	Control	**Supplemented products**	
Parameters	**FCNCA-C**	**FCNCA-CC**	**FCNCA-P**
Hardness (N)	6.01± 0.56	7.90 ± 0.68	9.69 ± 0.66
Adhesiveness (J)	0.07 ± 0.06	0.17 ± 0.09	0.03 ± 0.04
Cohesiveness (—)	0.33 ± 0.04	0.37 ± 0.03	0.42 ± 0.02
Springiness (mm)	1.70 ± 0.25	1.91 ± 0.30	2.29 ± 0.19
Gumminess (N)	2.00 ± 0.23	2.93 ± 0.18	4.08 ± 0.45

* Data are expressed as mean ± SD (n=4).

The hardness of the FCNCAs ranged from 6.01 to 9.69 N, showing statistical differences between FCNCA-C and FCNCA-CC (p=0.0065), between FCNCA-C and FCNCA-P, and between FCNCA-CC and FCNCA-P (p=0.0039). Hardness can be defined as the force require to attain a given deformation [48]. Increasing the moisture content has the opposite effect on hardness [49], and in fact, there is an inverse relationship between the hardness and moisture content of the FCNCAs.

An inverse relationship with lipid content can also be observed which can explain hardness differences. The lowest total lipids resulted in FCNCAs with higher hardness. A possible explanation for this might be that the fat in these alternative cheeses is mainly unsaturated. In fact, a study conducted by Devi and Khatkar concluded that saturated fatty acids contribute to dough hardness and fats rich in unsaturated fatty acids such as sunflower oil produced the softest cookie dough.

Adhesiveness ranged from 0.03 to 0.17 J but did not exhibit significant differences between samples (p > 0.05). The slightly higher value attributed to FCNCA-CC (0.17 J) can be due to the carrageen's polysaccharides in *C. crispus* [51-52].

Adhesiveness can be defined as the work necessary to overcome the attractive forces between the surface of the food and the surface of other materials with which the food comes into contact [48]. The positive low adhesiveness values show that FCNCAs are not very sticky or adhesive.

Cohesiveness values range from 0.33 to 0.42, showing significant differences between FCNCA-C and FCNCA-P (p = 0.0035), and between FCNCA-CC and FCNCA-P (p = 0.0240). Cohesiveness indicates the strength of the internal bonds making up the body of the product [53]. The mean cohesiveness values for FCNCA-P indicate that the structure is not easily disintegrated [54]. The fibre content can also justify the highest cohesiveness values for supplemented products. The reported insoluble dietary fibre content of Spanish seaweeds for *C. crispus* (12.04%), and for *Porphyra* sp. (19.22%) [55], is directly related to the values found in the present study. Other factors contributing to these differences may be the moisture and lipids contents.

Springiness (elasticity) is defined as the distance recovered by the sample during the time that elapsed between the end of the first compression and the start of the second one [48,56]. Springiness results revealed that the minimum (1.70 mm) was found in FCNCA-C, while the maximum value (2.29 mm) is for FCNCA-P. Significant differences between FCNCA-C and FCNCA-P (p = 0.0103), and between FCNCA-CC and FCNCA-P (p = 0.0245) were found.

Grasso et al. reported values for different commercial plant-based block-style al- ternatives to cheese, ranging from 0.32 to 0.57 (unitless).

Gumminess values ranged from 2.00 to 4.08 N, showing significant differences between all samples (p = 0.0039). Gumminess is the denseness that persists through chewing, or the energy needed to disintegrate a semisolid food until it is ready for swallowing [56]. Since supplemented products present higher values, more chews are required before swallowing. There is also a clear correlation between gumminess and hardness, cohesiveness, and springiness, as well as an inverse correlation with total lipids content and moisture.

3.Microbial Load

The microbiological evaluation of FCNCAs is presented in Table 5, and the p-values are in supplementary material (Table S6). The mean counts of *Enterococcus* exceed 4.0 log CFU·g^{-1} for all samples and do not show significant differences between them (p > 0.005).

Lactic Acid Bacteria (LAB) showed a significant difference for FCNCA-C *vs*. FCNCA-CC and FCNCA-CC *vs*. FCNCA-P (p=0.0139). The LAB predominated over other microbiological groups, achieving the same counts for FCNCA-CC and FCNCA-P (5.48 CFU·g^{-1}), and slightly exceeding by 1.0 log CFU·g^{-1} for FCNCA-C. In all cases, the values obtained were higher than the limits referred by Saraiva et al. [15]. These elevated counts can be related to the addition of Advanced Acidophilus Plus (Solgar®), which contained a large number of *Lactobacillus acidophilus* and *Bifidobacterium lactis*. In fact, Lactobacillus is a genus with important applications in food fermentation, as it is also capable of producing lactic acid due to the metabolism of sugars [58]. Apart from that, LAB is responsible for producing substances that improve flavor, texture, nutritional value, shelf-life and safety of foods [59].

Aerobic mesophilic bacteria (AMB) are the most represented group, ranging from 7.36 to 7.83 log CFU·g-The statistical analyses revealed significant differences among all FCNCAs (p < 0.05). Usually, cashew nut or cashew nut products present a higher AMB activity. For example, Muniz et al. reported 4.0 to 7.0 log CFU·g^{-1} for cashew nut, whereas Göçer and Koptagel reported 8.84 ± 0.26 log CFU·g^{-1} for a cashew nut-based beverage fermented with kefir. According to Saraiva et al. [15], all FCNCAs are rated as unsatisfactory (>107 CFU·g^{-1}) (see supplementary material, Table S7).

Counts on marine agar achieved similar values among FCNCA-CC (6.18 log CFU·g^{-1}) and FCNCA-P (6.08 log CFU·g^{-1}). Fermented cashew nut cheese alternative control (FCNCA-C) does not show microbiological activity (<2 log CFU·g^{-1}). A plausible justification for this is that the values for the supplemented products are due to seaweeds.

Molds were deemed satisfactory, presenting the same values for all samples (<2 log CFU·g^{-1}), and did not show significant differences between them (p>0.05). Some authors suggest that contamination of cashew nuts by molds can occur early in the field or during a prolonged storage time [62], which was not the case. Simultaneously, the previous blanching of cashew nuts in hot water helps destroy microorganisms such as bacteria, yeasts, and molds [63].

Concerning yeasts, FCNCA-CC, and FCNCA-P register <2 log CFU·g^{-1}, whereas FCNCA-C exceeded 3.0 log units, showing statistical differences for FCNCA-C *vs*. FCNCA-CC and FCNCA-C *vs*. FCNCA -P (p = 0.0139). The results indicated that seaweeds could inhibit yeast's activity, which is unsurprising since some demonstrate anti-fungal capacity against yeast strains [64].

Table 5. Levels of *Enterococcus*, Lactic Acid Bacteria (LAB), Aerobic Mesophylic Bacteria (AMB), Marine Agar Counts (MAC), Glucose-Yeast-Peptone (GYP) molds and yeasts, *Escherichia coli*, Total Coliforms (TC), *Staphylococcus aureus*, *Salmonella* spp., and *Listeria monocytogenes* for fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P).*.

Microbiological parameters (Log CFU·g^{-1})	Control	Supplemented products	
	FCNCA-C	**FCNCA-CC**	**FCNCA-P**
Enterococcus	4.48 ± 0.00	4.48 ± 0.00	4.48 ± 0.00
LAB	6.56 ± 0.00	5.48 ± 0.00	5.48 ± 0.00
AMB	7.83 ± 0.86	7.36 ± 0.80	7.48 ± 0.00
MAC	<2	6.18 ± 1.63	6.08 ± 0.18
GYP (Molds)	<2	<2	<2
GYP (Yeasts)	3.76 ± 1.64	<2	<2
E. coli	2.11 ± 0.33	<1	1.9 ± 1.89
TC	0.7 ± 0.15	0.7 ± 0.15	2.57 ± 0.00
S. aureus	2.18 ± 1.63	2.54 ± 0.37	2.72 ± 0.42
***Salmonella* spp.**	Abs. in 25 g	Abs. in 25 g	Abs. in 25 g
L. monocytogenes	Abs. in 25 g	Abs. in 25 g	Abs. in 25 g

* Counts are expressed as log CFU·g$_{-1}$ and data as mean ± SD (n=4).

Results of *Escherichia coli* ranged from <1 log CFU·g^{-1} to 2.11 log CFU·g^{-1}, showing statistical differences for FCNCA-C *vs*. FCNCA-CC and FCNCA-CC *vs*. FCNCA-P (p = 0.0126). Mendes et al. demonstrate that ethyl acetate and diethyl ester extracts of *C. crispus* from the wild and from an integrated multi-trophic aquaculture system possess antimicrobial activity against the growth of bacteria such as *E. coli* and others.

Total coliforms (TC) ranged from 0.7 to 2.57 log CFU·g^{-1}, revealing differences for FCNCA-C *vs*. FCNCA-P and FCNCA-CC *vs*. FCNCA-P (p = 0.0126). The FCNCA-P shows a high content of total coliforms.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 October 2024 doi:10.20944/preprints202410.1828.v1

Counts of coagulase-positive *S. aureus* reached similar counts between samples, ranging from 2.18 to 2.72 log CFU·g-The statistical analyses revealed significant differences for FCNCA-C *vs.* FCNCA-P (p = 0.0194). The low values for *S. aureus* were considered satisfactory from a safety point of view since the production of toxins only occurs at higher counts (>104) [14].

Salmonella spp. was absent through the plating count (not present per 25 g). In fact, a US surveillance study shows that the prevalence of *Salmonella* (95% of confidence interval) in cashew nuts was minimal (0.55%), *i.e.*, it occurred in just 4 of 733 samples [66].

Listeria monocytogenes was also absent through the plating count (not present per 25 g). Eglezos reported that «there are no data available on the prevalence of *L. monocytogenes* in cooked edible nut kernels or any foodborne illness lined to the presence of *L. monocytogenes* in this kind of product». On the other hand, LAB, which is one of the best represented groups in the FCNCAs (5.48-6.56 log CFU·g^{-1}), has shown bactericidal and bacteriostatic properties against foodborne pathogens such as *Salmonella* spp. and *L. monocytogenes* [19].

3.Flash Profile Methodology

Results obtained in the second session of the Flash Profile from the eight panellists ranking for the FCNCAs (FCNCA-C, FCNCA-CC, and FCNCA-P) per attribute, according to the final list of terms defined, were analyzed by Generalized Procruste Analysis (GPA).
FCNCA-C showed the most consensual rankings as it presents the lowest residual variance for all attributes, except for texture, for which it presents the highest residual variance (20.6%) (Table 6).

Table 6. Residual variance values for each fermented cashew nut cheese alternatives from Flash Profile´s Generalyzed Procrustes Analysis.

Attributes	Object	Residual (%)
	FCNCA-C	12.412
Appearance	FCNCA-CC	29.920
	FCNCA-P	13.578
	FCNCA-C	9.729
Aroma	FCNCA-CC	11.096
	FCNCA-P	17.230
	FCNCA-C	6.051
Flavor	FCNCA-CC	18.133
	FCNCA-P	13.764
	FCNCA-C	20.604
Texture	FCNCA-CC	16.473
	FCNCA-P	15.811
	FCNCA-C	7.781
After-taste	FCNCA-CC	22.348
	FCNCA	12.737

Fermented cashew nut cheese alternative with *C. crispus* (FCNCA-CC) had the highest residual variances for appearance (29.9%), flavor (18.1%), and after-taste (22.3%). In comparison, FCNCA-P had the highest residual variance for aroma (17.2%), showing that the supplementation of seaweeds, an ingredient that is not very common, influences the sensory characteristics of products and consequently affects the consensus.

Residual variances values for each panellist calculated by GPA reveals the panellists with higher residual variance values: a higher percentage for appearance for panellist 7 (14.1%), aroma for panellist 8 (10.2%), flavor for panellist 1 (15.0%), texture for panellist 4 (22.2%), and after-taste for panellist 1 (13.4%), indicating that these panellists were further from the consensus (see supplementary material, Table S8).

The values of consensus index (Rc) (Table 7) were as follows: appearance (33.8%), aroma (31.2%), flavor (29.1%), texture (11.6%), and after-taste (23.4%). All attributes show an inadequate consensus in the performance of the panellists, particularly on texture and after-taste.

Figure 3 shows the coordinates of the objects (FCNCAs) after GPA analysis and the correlations between the attributes (appearance, aroma, flavor, texture, and after-taste), and the dimensions F1 (first axis) and F2 (second axis).

For the appearance attribute *(a)*, the FCNCA-C is perceived as cohesive, porous, and with holes, whereas FCNCA-CC is brownish, greasy, purple, rose/rosy, and soft, and FCNCA-P is opaque. Although there is a discrepancy between the terms used to describe FCNCA-C, the terms porous and with holes are in line with TPA findings, with FCNCA-C showing the lowest values for hardness (6.01 N) and cohesiveness (0.33). FCNCA-CC is described by terms such as purple, rose/rosy and pink seaweeds, corresponding with its value (3.19) for the color parameter a^*. The opacity related to FCNCA-P concords with results for lightness (L^*) and chroma (C^*) since it shows the lowest values for this parameter, namely 38.30, and 15.20, respectively.

Table 7. Consensus index (Rc (%)) determined among the panellists for each attribute (appearance, aroma, flavor, texture, and after-taste) of the fermented cashew nut cheese alternatives.

Attributes	Rc (%)
Appearance	33.8%
Aroma	31.2%
Flavor	29.1%
Texture	11.6%
After-taste	23.4%

Regarding aroma *(b)*, FCNCA-C was mainly characterized by cheese, dried fruits, *Flamengo* cheese, fermented, and yogurt, whereas FCNCA-CC was characterized by cigar, *nam pla,* salty, straw of coffee, and wood, and FCNCA-P by dry herbs.

Terms such as cheese, *Flamengo* cheese, fermented or even yogurt suggest a similitude between FCNCA-C and dairy cheese, due to the addition of *L. acidophilus* LA-5®. In fact, FCNCA-C is the sample that shows the higher count of LAB (6.56). The aroma of dried fruits attributed to FCNCA-C is desirable since dried fruit is at the product's base. Lima et al. (2012) reported an analog term, nutty, to a cashew nut butter made with different grades of kernel quality.

In red seaweeds, the formation of apocarotenoids such as *β*-ionone contributes significantly for the aroma of algae and marine environments [69], as suggested by terms such seaweeds, shellfish and sea air. The fishy aroma of *nam pla* may arise from compounds such as 1-octen-3-one, from various aldehydes, for example, when combined, hexanal, (2E,4E)-decadienal and (2E,4E)-heptadienal, heptanalmcan create a strong and penetrating fishy odor, often associated with seaweeds [70]. Furthermore, dry herbs described for FCNCA-P can be associated with a green odor related to esters [71].

The results for flavor *(c)* show that FCNCA-C was mainly characterized by bread and nauseating; FCNCA-CC by sour; and FCNCA-P by Dulse, Nori, and spices.

It can be inferred that some of the panellists, despite being trained, were confused about the flavor of seaweeds, since FCNCA-P was described as Dulse (*Palmaria palmata*) and Nori (*Porphyra* sp.); which is quite understandable, as sometimes aromas and flavours can be very complex and difficult to distinguish from each other's. Another term attributed to FCNCA-P, 'spices', is related to carboxylic acids [71].

Regarding texture *(d)*, FCNCA-C was characterized mainly by cohesiveness, hardness and adhesiveness, while FCNCA-CC by terms such as arenaceous, dry, hardness of particles, and light, and FCNCA-P by brittle. The cohesiveness described for FCNCA-C agrees with the value obtained in this study (0.33).

Dry and brittle terms described for FCNCA-CC and FCNCA-P also comply with the founded hardness values, namely 7.90 and 9.69 N, respectively. Particles hardness for FCNCA-CC can be attributed to the texture of *C. crispus*, which is generally firm, or cartilaginous-like [72]. On the other hand, the size of the particles (2.87 mm) may also have influenced the sensation described.

For after-taste *(e)*, FCNCA-C is characterized by several terms, such as aromatic persistence (temporal), lactic fat, and dry fruits. In contrast, FCNCA-CC by acidic and rancid, and FCNCA-P by bitter, Dulse, Nori, smoked, and sour.

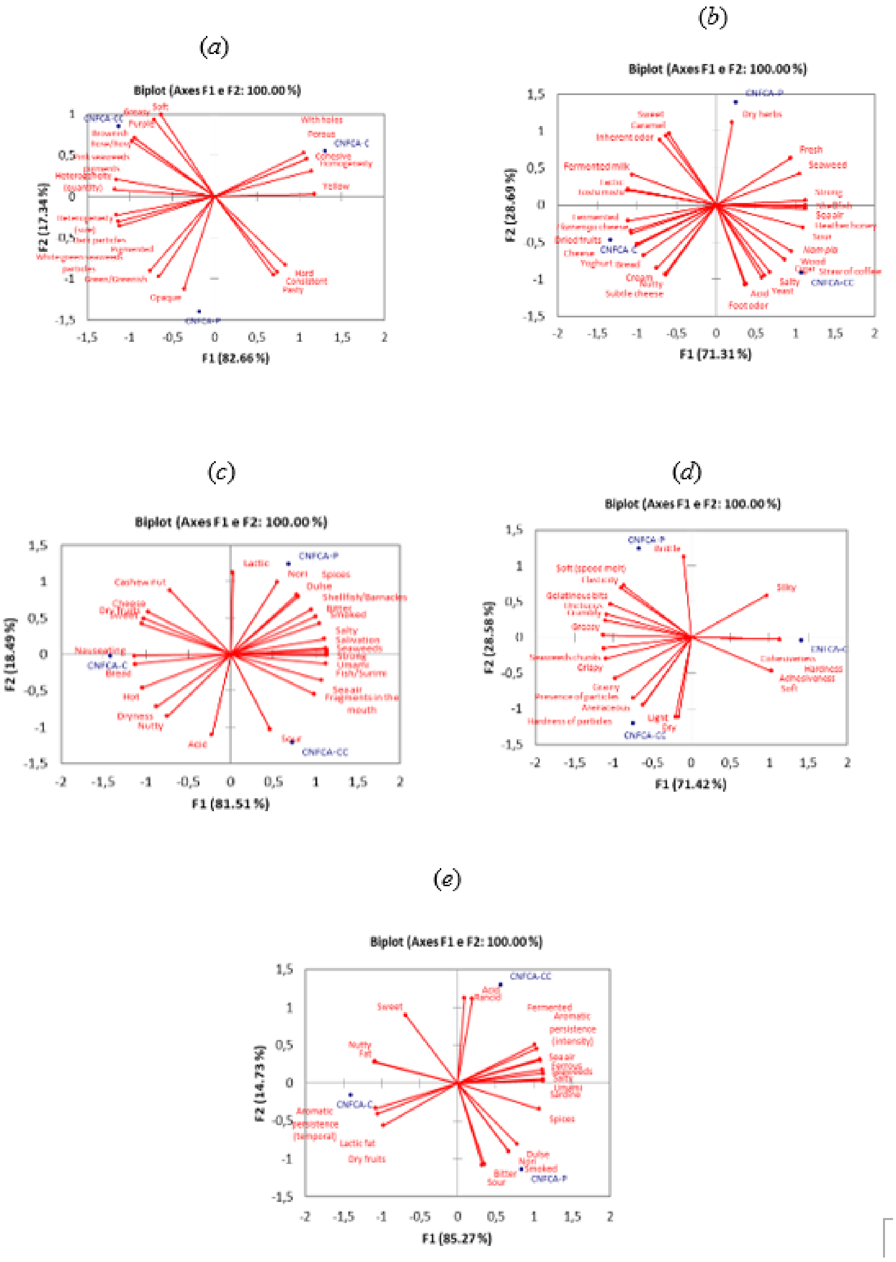

Figure 3. Biplot map of Generalized Procrustes Analysis (GPA) performed on Flash Profile (FP) data and the lexicon used to describe the various attributes of the fermented cashew nut cheese alternatives at the F_1 and F_2 dimensions: *a*) appearance; *b*) aroma; *c*) flavor; *d*) texture; and *e*) after-taste.

During the fermentation, lactic acid is produced through sugar metabolism, which is responsible for the increasing sourness as the sweetness reduces [58]. In general, the supplementation of food products with seaweeds compromises their sensory attributes due to the appearance of off-flavors

[73]. For example, rancidity, as described for FCNCA-CC. This rancidity can be attributed to aldehydes, including heptanal and octanal, which contribute to undesirable rancid odour and flavour during spoilage of fat and fatty foods [74-75]. Also, aldehydes such as heptanal and 2-octenal are associated with 'smoked' and 'sour' [75], respectively, both attributed to FCNCA-P.

In summary, seaweeds have a decisive role in various attributes, especially aroma, flavour, and after-taste, which changed the descriptions of all the attributes, making it possible to distinguish FCNCAs clearly.

Conclusions

The FCNCAs are an interesting alternative to dairy cheese consumption providing a good nutritional profile. Supplementation with seaweeds influenced the technological/sensory characteristics of the FCNCAs and thus contributed to conferring different characteristics to the products, enhancing diversity, and ensuring good quality. Total lipids and crude protein contents show lower values, revealing that seaweeds do not contribute significantly to these parameters. Macro- and micro minerals increased mainly for the FCNCA-CC, namely Ca, K, Mg, Na, Fe, I, Se, and Zn. Adding seaweeds to the food matrix significantly influenced the instrumental color and some of the textural parameters (hardness, springiness, and gumminess). Concerning microbiota, all parameters comply with the European guidelines, except for AMB in all samples and MAC in both supplemented products. Furthermore, the data obtained suggest the presence of a spontaneous lactic fermentation possibly due to the addition of capsules containing *Lactobacillus acidophilus*, which was responsible for the production of substances that can improve several aspects of products (*e.g.*, flavor, texture, nutrition, shelf-life, and hygienic quality).

The supplemented products had very distinguishable characteristics by panelists participating in the Flash Profile sessions, having thus high potential to contribute to increase diversity of products available for consumers that require alternatives to dairy products, as well as allowing the familiarization of consumers with seaweeds.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org. Figure S1: Methods used for the various microbiological parameters (*Enterococcus*, Lactic Acid Bacteria (LAB), Aerobic Mesophylic Bacteria (AMB), Marine Agar Counts (MAC), Glucose-Yeast-Peptone (GYP) molds and yeasts, *Escherichia coli*, Total Coliforms (TC), *Staphylococcus aureus*, *Salmonella* spp., and *Listeria monocytogenes*); Figure S2: Mann-Whitney U test pairwise comparisons between fermented cashew nut cheese alternatives (FCNCA): fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. FCNCA-P) for general physicochemical parameters; S3: Mann-Whitney U test pairwise comparisons between fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) for minerals and trace elements; S4: Mann-Whitney U test pairwise comparisons between fermented cashew nut cheese alternatives (FCNCAs): fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) for color parameters; S5: Mann-Whitney U test pairwise comparisons between fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) for TPA parameters (hardness (N), adhesiveness (J), cohesiveness (—), springiness (mm), and gumminess (N)); S6: Mann-Whitney U test pairwise comparisons between fermented cashew nut cheese alternatives: fermented cashew nut cheese alternative control (FCNCA-C); fermented cashew nut cheese alternative with *Chondrus crispus* (FCNCA-CC); and fermented cashew nut cheese alternative with *Porphyra* sp. (FCNCA-P) on microbiological parameters (*Enterococcus*, Lactic Acid Bacteria (LAB), Aerobic Mesophylic Bacteria (AMB), Marine Agar Counts (MAC), Glucose-Yeast-Peptone (GYP) molds and yeasts, *Escherichia coli*, Total Coliforms (TC), *Staphylococcus aureus*, *Salmonella* spp., and *Listeria monocytogenes*); S7: Guidance criteria on the interpretation of microbiological results in ready-to-eat foods placed on the market (*Enterococcus*, Lactic Acid Bacteria (LAB), Aerobic Mesophylic Bacteria (AMB), Marine Agar Counts (MAC), Glucose-Yeast-Peptone (GYP)

 doi:10.20944/preprints202410.1828.v1

molds and yeasts, *Escherichia coli*, Total Coliforms (TC), *Staphylococcus aureus*, *Salmonella* spp., and *Listeria monocytogenes*); S8: Residual variance values, scaling factors, and the percentage variation explained by the first two principal components (F1 and F2) of Generalyzed Procrustes Analysis (GPA) for fermented cashew nut cheese alternatives (FCNCAs) flash profile analysis.

Author Contributions: Conceptualization, P.M., M.S.D. and B.M.C.; methodology, P.M., M.S.D. and B.M.C.; software, M.S.D. and B.M.-L.; validation, P.M. and M.S.D.; formal analysis, B.M.C., B.M.-L., A.S., E.R., I.M., M.M.-F. and P.H.M.S; investigation, B.M.C.; data curation, P.M., M.S.D., M.M.-F. and P.H.M.S; writing—original draft preparation, B.M.C.; writing—review and editing, B.M.C., P.M. and M.S.D.; supervision, P.M. and M.S.D.; funding acquisition, P.M., M.S.D. and B.M.-L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the European Maritime and Fisheries Fund and co-funded by the Operational Program Mar2020 through the project Alga4Food (MAR-01.03.01-FEAMP-0016). This research was also supported by the Applied Molecular Biosciences Unit (UCIBIO) and the Associate Laboratory for Green Chemistry (LAQV), both funded by national funds from FCT/MCTES (10.54499/UIDB/04378/2020) and (10.54499/UID/50006/2020), respectively. This study was also co-financed by the ERDF under the PT2020 Partnership Agreement (POCI-01-0145-FEDER - 007265).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statemen: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Boukid, F.;Lamri, M.; Dar, B.N.; Garron, M.; Castellari, M. Vegan alternatives to processed cheese and yogurt launched in the European market during 2020: A nutritional challenge? *Foods* **2021**, 10(11), DOI: 10.3390/foods10112782
2. Jeske, S.; Zannini, E.; Elke K.; Arendt, E.K. Past, present and future: The strength of plant-based dairy substitutes based on gluten-free raw materials. *Food Res. Int.* **2017**, 110, 42–DOI: 10.1016/j.foodres.2017.03.045
3. Mefleh, M.; Pasqualonea, A.; Caponioa, F.; Faccia, M. Legumes as basic ingredient in the production of dairy-free cheese alternatives: A review. *J. Sci. Food Agric.* **2021**, 102(1), 8–DOI: 10.1002/jsfa.11502
4. Short, E.C.; Kinchla, J.; Nolden, A.A. Plant-based cheeses: A systematic review of sensory evaluation studies and strategies to increase consumer acceptance. *Foods* **2021**, 10(4), DOI: 10.3390/foods10040725
5. Craig, W.J.; Mangels, A.R.; Brothers, C.J. Nutritional profiles of non-dairy plant-based cheese alternatives. *Nutrients* **2022**, 14(6), DOI: 10.3390/nu14061247
6. Miki, A.J.; Livingston, K.A.; Karlsen, M.C.; Folta, S.C.; McKeown, N.M. Using evidence mapping to examine motivations for following plant-based diets. *Curr. Dev. Nutr.* **2020**, 4(3), nzaa013. DOI: 10.1093/cdn/nzaa013
7. Clegg, M.E.; Ribes, A.T.; Reynolds, R.; Kliem, K.; Stergiadis, S.. A Comparative assessment of the nutritional composition of dairy and plant-based dairy alternatives available for sale in the UK and the implications for consumers' dietary intakes. *Food Res. Int.* **2021**, 48, DOI: 10.1016/j.foodres.2021.110586
8. Munekata, P.E.S.; Domínguez, R.; Budaraju, S.; Roselló-Soto, E.; Barba, F.J.; Mallikarjunan, K.; Roohinejad, S.; Lorenzo, J.M. Effect of innovative food processing technologies on the physicochemical and nutritional properties and quality of non-dairy plant-based beverages. *Foods* **2020**, 9(3), DOI: 10.3390/foods9030288
9. Saraco, M.N.; Blaxland, J. Dairy-free imitation cheese: Is further development required? *Br. Food J.* **2020**, 122(12), 3727–DOI: 10.1108/BFJ-11-2019-082
10. Frésan, U.; Rippin, H. Nutritional quality of plant-based cheese available in Spanish supermarkets: How do they compare to dairy cheese? *Nutrients* **2021**, 13(9), DOI: 10.3390/nu13093291
11. Bahrami, M.; Ahmadi, D.; Beigmohammadi, F.; Hosseini, F. Mixing sweet cream buttermilk with whole milk to produce cream cheese. *Irish J. Agric. Food Res.* **2015**, 54(2), 73–DOI: 10.1515/ijafr-2015-0008
12. Kumari, P.; Reddy, C.R.K.; Jha, B. Comparative evaluation and selection of a method for lipid and fatty acid extraction from macroalgae. *Anal. Biochem.* **2011**, 415(2), 134–DOI: 10.1016/j.ab.2011.04.010

13. Mariotti, F.; Tomé, D.; Mirand, P. Converting nitrogen into protein – Beyond 6.25 and Jones' factors. *Crit. Rev. Food Sci. Nutr.* **2008**, 48(2), 117–184. DOI: 10.1080/10408390701279749
14. Health Protection Agency. *Guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market*, Health Protection Agency: London, 2009; 33 pp.
15. Saraiva, M.; Correia, C.B.; Cunha, I.C.; Maia, C.; Bonito, C.C.; Furtado, R.; Calhau, M.A. *Interpretação de resultados de ensaios microbiológicos em alimentos prontos para consumo e em superfícies do ambiente de preparação e distribuição alimentar: Valores-guia*. Instituto Nacional de Saúde Doutor Ricardo Jorge: Lisboa, 2019; 35 pp.
16. European Commission. Regulation (EC) No 2073/2005 of 15 november 2005 on microbiological criteria for foodstuffs. *OJEU* **2005**, 338, 1–26.
17. Wender, L.P.; Liu, J.; Dehlholm, C.; Heymann, H. Flash profile method. In *Descriptive analysis in sensory evaluation,* Kemp, S.E.; Hort, J., Hollowood, T., Eds.; John Wiley & Sons Ltd.: Hoboken, USA, 2018; pp. 513–533.
18. Farahat, E.S.A.; Mohamed, A.G.; El-Loly, M.M.; Gafour, W.A.M. Innovative vegetables-processed cheese: I. Physicochemical, rheological and sensory characteristics. *Food Biosci.* **2021**, 42(3), 01128. DOI: 10.1016/j.fbio.2021.101128
19. Chen, J.M.; Al, K.F.; Craven, L.J.; Seney, S.; Coons, M.; McCormick, H.; Reid, G.; O'Connor, C.; Burton, J.P. Nutritional, microbial, and allergenic changes during the fermentation of cashew 'cheese' product using a quinoa-based rejuvelac starter culture. *Nutrients* **2020**, 12(3), 648. DOI: 10.3390/nu12030648
20. Campos, B.M.; Ramalho, E.; Marmelo, I.; Noronha, J.P.; Malfeito-Ferreira, M.; Mata, P.; Diniz, M. Proximate composition, physicochemical and microbiological characterization of edible seaweeds available in the Portuguese market. *Fronti. Biosci.* (Elite Ed) **2022**, 14(4), 26. DOI: 10.31083/j.fbe1404026
21. Salehi, B.; Gültekin-Özgüven, M.; Kırkın, C.; Özçelik, B.; Morais-Braga, M.F.; Carneiro, J.N.; Bezerra, C.F.; Gonçalves da Silva, T.; Coutinho, H.D.; Amina, B.; Armstrong, L.; Selamoglu, Z.; Sevindik, M.; Yousaf, Z.; Sharifi-Rad, J.; Muddathir, A.M.; Devkota, H.P.; Martorell, M.; Jugran, A.K.; Martins, N.; Cho, W.C. *Anacardium* plants: Chemical, nutritional composition and biotechnological applications. *Biomolecules* **2019**, 9(9), DOI: 10.3390/biom9090465
22. Perren, R.; Escher, F.E. Impact of roasting on nut quality. In *Improving the safety and quality of nuts* 1st ed.; Harris, L.J. (Ed.),. Woodhead Publishing Limited: Cambridge, UK, 2013; pp. 173–197.
23. El-Bakry, M. Salt in cheese: A review. *Curr. Res. Dairy Sci*. **2012**, 4(1), 1–DOI: 10.3923/crds.2012.1.5
24. Medina, E.; de Castro, A.; Romero, C.; Ramirez, E.M.; Brenes, M. Safety of fermented fruits and vegetables. In *Regulating safety of traditional and ethnic foods*, 1 st ed.; Vishweshwaraiah, P.; Martín-Belloso, O.; Keener, L.; Astley, S.; Braun, S., McMahon, H.; Lelieveld, H., Eds.; Academic Press: Waltham, USA, 2016; pp. 355–367.
25. Tabanelli, G.; Pasini, F.; Riciputi, Y.; Vannini, L.; Gozzi, G.; Balestra, F.; Caboni, M.F.; Gardini, F.; Montanari, C. Fermented nut-based vegan food: Characterization of a home made product and scale-up to an industrial pilot-scale production. *J. Food Sci.* **2018**, 83(3), 711–DOI: 10.1111/1750-3841.14036
26. Carvalho, J.M.; Figueiredo, R.W.; Machado de Sousa, P.H.; Tavares de Luna, F.M.; Maia, G.A. Cashew nut oil: Effect of kernel grade and a microwave preheating extraction step on chemical composition, oxidative stability and bioactivity. *Int. J. Food Sci. Technol.* **2018**, 53(4), 930–937. DOI: 10.1111/ijfs.13665
27. Toschi, T.G.; Caboni, M.F.; Penazzi, G.; Lercker, G.; Capella, P. A study on cashew nut oil composition. *J. Am. Oil Chem. Soc.* **1993**, 70(10), 1017–DOI: 10.1007/BF02543029
28. Trox, J.; Vadivel, V.; Vetters, W.; Stuetz, W.; Scherbaum, V.; Gola, U.; Nohr, D.; Biesalski, H.K. Bioactive compounds in cashew nut (*Anacardium occidentale* L.) kernels: Effect of different shelling methods. *J. Agric. Food Chem.* **2010**, 58(9), 5341–DOI: 10.1021/jf904580k
29. Sakthivel, R.; Devi, P. Evaluation of physiochemical properties, proximate and nutritional composition of *Gracilaria edulis* collected from Palk Bay. *Food Chem.* **2015**, 174(1), 68–DOI: 10.1016/j.foodchem.2014.10.142
30. Cian, R.E.; Drago, S.R.; de Medina, S.F.; Martínez-Augustin, O. Proteins and carbohydrates from red seaweeds: Evidence for beneficial effects on gut function and microbiota. *Mar. Drugs.* **2015**, 13(8), 5358–DOI: 10.3390/md13085358
31. Leandro, A.; Pacheco, D.; Cotas, J.; Marques, J.C.; Pereira, L.; Gonçalves, A.M.M. Seaweed's bioactive candidate compounds to food industry and global food security. *Life* **2020**, 10(8), DOI: 10.3390/life10080140
32. Rico, R.; Bulló, M.; Salas-Salvadó, J. Nutritional composition of raw fresh cashew (*Anacardium occidentale* L.) kernels from different origin. *Food Sci. Nutr.* **2015**, 4(2), 329–DOI: 10.1002/fsn3.294
33. Loveday, S.M. Plant protein ingredients with food functionality potential. *Nutr. Bull.* **2020**, 45(3), 321–DOI: 10.1111/nbu.12450
34. Lonnie, M.; Hooker, E.; Brunstrom, J.M.; Corfe, B.M.; Green, M.A.; Watson, A.W.; Williams, E.A.; Stevenson, E.J.; Penson, S.; Johnstone, A.M. Protein for life: Review of optimal protein intake,

sustainable dietary sources and the effect on appetite in ageing adults. *Nutrients* **2018**, 10(3), DOI: 10.3390/nu10030360
35. Lima, J.R.; Bruno, L.M.; Wurlitzer, N.J.; Machado de Sousa, P.H.; Holanda, S.A. Cashew nut-based beverage: Development, characteristics and stability during refrigerated storage. *Food Sci. Technol.* **2020**, 41(6), 60–DOI: 10.1590/fst.33819
36. Mohammed, H.O.; O'Grady, M.N.; O'Sullivan, M.G.; Hamill, R.M.; Kilcawley, K.N.; Kerry, J.P. An assessment of selected nutritional, bioactive, thermal and technological properties of brown and red Irish seaweed species. *Foods* **2021**, 10(11), 2784. DOI: 10.3390/foods10112784
37. Nakamura, E.; Yokota, H.; Matsui, T. The in vitro digestibility and absorption of magnesium in some edible seaweeds. *J. Sci. Food Agric.* **2012**, 92(11), 2305–2309. DOI: 10.1002/jsfa.5626
38. Pelczyńska, M.; Moszak, M.; Bogdański, P. The role of magnesium in the pathogenesis of metabolic disorders. *Nutrients* **2022**, 14(9), 1714. DOI: 10.3390/nu14091714
39. Bougma, K.; Aboud, F.E.; Harding, K.B.; Marquis, G.S. Iodine and mental development of children 5 years old and under: A systematic review and meta-analysis. *Nutrients* **2013**, 5(4), 1384–1416. DOI: 10.3390/nu5041384
40. Batool, M.; Naddem, M.; Imran, M.; Gulzar, N.; Shahid, M.Q.; Shahbaz, M.; Ajmal, M.; Khan, I.T. Impact of vitamin E and selenium on antioxidant capacity and lipid oxidation of cheddar cheese in accelerated ripening. *Lipids Health Dis.* **2018**, 17(1), 79. DOI: 10.1186/s12944-018-0735-3
41. Bonanno, G.; Orlando-Bonaca, M. Chemical elements in Mediterranean macroalgae. A review. *Ecotoxicol. Environ. Saf.* **2018**, 148(3), 44–DOI: 10.1016/j.ecoenv.2017.10.013
42. Freitas, M.V.; Pacheco, D.; Cotas, J.; Mouga, T.; Afonso, C. Red seaweed pigments from a biotechnological perspective. *Phycology* **2022**, 2(1), 1–DOI: 10.3390/phy- cology2010001
43. Carpena, M.; Caleja, C.; Pereira, E.; Pereira, C.; Ćirić, A.; Soković, M.; Soria-Lopez, A.; Fraga-Corral, M.; Simal-Gandara, J.; Ferreira, I.C.F.; Barros, L.; Prieto, M.A. Red seaweeds as a source of nutrients and bioactive compounds: Optimization of the extraction. *Chemosensors* **2021**, 9(6), DOI: 10.3390/chemosensors9060132~
44. Pina, A.L.; Costa, A.R.; Lage-Yusty, M.A.; López-Hernández, J. An evaluation of edible red seaweed (*Chondrus crispus*) components and their modification during the cooking process. *LWT - Food Sci. Technol.* **2014**, 56(1), 175–DOI: 10.1016/j.lwt.2013.08.006
45. Osório, C.; Machado, S.; Peixoto, J.; Bessada, S.; Pimentel, F.B.; Alves, R.C.; Oliveira, M.B. Pigments content (chlorophylls, fucoxanthin and phycobiliproteins) of different commercial dried algae. *Separations* **2020**, 7(2), Doi: 10.3390/separations7020033
46. Queiroga, R.; Santos, B.M.; Gomes, A.M.; Monteiro, M.J.; Teixeira, S.M.; Leite de Souza, E.; Pereira, C.J.; Pintado, M.M. Nutritional, textural and sensory properties of coalho cheese made of goats', cows' milk and their mixture. *LWT - Food Sci. Technol.* **2013**, 50(2), 538–DOI: 10.1016/j.lwt.2012.08.011
47. Paz, N.F.; Gonçalvez de Oliveira, E.; Villalva, F.J.; Armada, M.; Ramón, A.N. Effect of pH at drainage on the physicochemical, textural and microstructural characteristics of Mozzarella cheese from goat milk. *Food Sci. Technol.* **2017**, 37(2), 193–DOI: 10.1590/1678-457X.05116
48. Gunasekaran, S.; Ak, M.M. *Cheese rheology and texture*, 1st ed.; CRC Press, New York, USA, 2003.
49. Lepesioti, S.; Zoidou, E.; Lioliou, D.; Moschopoulou, E.; Moatsou, G. Quark-type cheese: Effect of fat content, homogenization, and heat treatment of cheese milk. *Foods* **2021**, 10(1), DOI: 10.3390/foods10010184
50. Devi, A.; Khatkar, B.S. Effects of fatty acids composition and microstructure properties of fats and oils on textural properties of dough and cookie quality. *J. Food Sci. Technol.* **2017**, 55(1), 321–330. DOI: 10.1007/s13197-017-2942-8
51. Lomartire, S.; Marques, J.C.; Gonçalves, A.M.M. An overview to the health benefits of seaweeds consumption. *Mar. Drugs.* **2021**, 19(6), DOI: 10.3390/md19060341
52. El-Beltagi, H.S.; Mohamed, A.A.; Mohamed, H.I.; Ramadan, K.M.A.; Barqawi, A.A.; Mansour, A.T. Phytochemical and potential properties of seaweeds and their recent applications: A review. *Mar. Drugs* **2022**, 20(6), 342. DOI: 10.3390/md20060342
53. Fox, P.F.; Guinee, T.P.; Cogan, T.M.; McSweeney, P.L.H. *Fundamentals of cheese science*, 2nd ed.; Springer: New York, USA, 2017; pp. 494–503.
54. Sołowiej, B.; Cheung, I.W.Y.; Li-Chan E.C.Y. Texture, rheology and meltability of processed cheese analogues prepared using rennet or acid casein with or without added whey proteins. *Int. Dairy J.* **2014**, 37(2), 87–94. DOI: 10.1016/j.idairyj.2014.03.003
55. Rupérez, P; Saura-Calixto, F. Dietary fibre and physicochemical properties of edible Spanish seaweeds. *Eur. Food Res. Technol.* **2001**, 212(3), 349–DOI: 10.1007/s002170000264
56. Bourne, M. *Food texture and viscosity: Concept and measurement*, 2 nd ed. Academic Press, New York, USA, 2002; pp. 259–276.

57. Grasso, N.; Roos, Y.H.; Crowley, S.V.; Arendt, E.K.; O'Mahony, J.A. Composition and physicochemical properties of commercial plant-based block-style products as alternatives to cheese. *Future Foods* **2021**, 4, DOI: 10.1016/j.fufo.2021.100048
58. Swain, M.R.; Anandharaj, M.; Ray, R.C.; Rani, R.P. Fermented fruits and vegetables of Asia: A potential source of probiotics. *Biotechnol. Res. Int.* **2014**, 2014(1), DOI: 10.1155/2014/250424
59. Pisano, M.B.; Deplano, M.; Fadda, M.E.; Cosentino, S. Microbiota of Sardinian goat's milk and preliminary characterization of prevalent LAB species for a starter or adjunct cultures development. *Biomed Res. Int.* **2019**, 2019(1), 1–7. DOI: 10.1155/2019/6131404
60. Muniz, C.R.; Freire, F.-C.; Lemos, É.H.; Pinto, G.A.S.; Teixeira de Figueiredo, E.A.; Figueiredo, R.W. Effect of processing conditions on the microbiological quality of cashew nuts. *Braz. J. Food Technol.* **2006**, 9(1), 33–38.
61. Göçer, E.M.; Koptagel, E. Microbiological and rheological properties of nut-based beverages fermented with kefir. *SSRN Journal* DOI: 10.2139/ssrn.4156590
62. Schmitt, N.; Yu, G.; Greve, R.; McIntyre, L. Outbreak of S. Weltevreden linked to fermented cashew nut cheese in Victoria, BC. *Environ. Health Rev.* **2018**, 61(3), 74–DOI:10.5864/d2018-017
63. Renard, C.M.; Maingonnat, J.F. Thermal processing of fruits and fruit juices. In *Thermal food processing: New technologies and qualities issues*, 2nd ed.; Sun, D.-W. (Ed.),. CRC Press: New York, USA, 2012; pp. 413–438.
64. Pérez, M.J.; Falqué, E.; Domínguez, H. Antimicrobial action of compounds from marine seaweed. *Mar. Drugs* **2016**, 14(3), 52. DOI: 10.3390/md14030052
65. Mendes, M.; Pereira, R.; Sousa Pinto, I.; Carvalho, A.P.; Gomes, A.M. Antimicrobial activity and lipid profile of seaweed extracts from the North Portuguese Coast. *Int. Food Res. J.* **2013**, 20(6), 3337–3345. DOI: 10400.14/14303
66. Zhang, G.; Hu, L.; Melka, D.; Wang, H.; Laasri, A.; Brown, E.W.; Strain, E.; Allard, M.; Bunning, V. K.; Musser, S.M.; Johnson, R.; Farakos, S.M.S.; Scott, V.N.; Pouillot, R.; van Doren, J.M.; Hammack, T.S. Prevalence of salmonella in cashews, hazelnuts, macadamia nuts, pecans, pine nuts, and walnuts in the United States. *J. Food Prot.* **2017**, 80, 45–DOI: 10.4315/0362-028X.JFP-16-396
67. Eglezos, S. The bacteriological quality of retail-level peanut, almond, cashew, hazelnut, Brazil, and mixed nut kernels produced in two Australian nut-processing facilities over a period of 3 years. *Foodborne Pathog. Dis.* **2010**, 7(7), 863–866. DOI: 10.1089/fpd.2009.0471
68. Lima, J.R.; Garruti, D.S.; Bruno, L.M. Physicochemical, microbiological and sensory characteristics of cashew nut butter made from different kernel grades-quality. *LWT-Food Sci. Technol.* **2012**, 45(2), 180–185. DOI: 10.1016/j.lwt.2011.08.018
69. Baldermann, S.; Yamamoto, M.; Yang, Z.; Kawahashi, T.; Kuwano, K.; Watanabe, N. C 13 - Apocarotenoids: more than flavor compounds? In *Carotenoid Cleavage Products*; Winterhalter, P., Ebeler, S.E., Eds.,; American Chemical Society, Washington, DC, USA, 2013; pp. 73–80.
70. Du, X.; Xu, Y.; Jiang, Z.; Zhu, Y.; Li, Z.; Ni, H.; Chen, F. Removal of the fishy malodor from *Bangia fusco-purpurea* via fermentation of *Saccharomyces cerevisiae*, *Acetobacter pasteurianus*, and *Lactobacillus plantarum*. *J. Food Biochem.* **2021**, 45(5), e13728. DOI: 10.1111/jfbc.13728
71. Vilar, E.G.; O'Sullivan, M.G.; Kerry, J.P.; Kilcawleya, K.N. Volatile compounds of six species of edible seaweed: A review. *Algal Res.* **2020**, 45, DOI: 10.1016/j.algal.2019.101740
72. Figueroa, V.; Bunger, A.; Ortiz, J.; Aguilera, J.M. Sensory descriptors for three edible Chilean seaweeds and their relations to umami components and instrumental texture. *J. Appl. Phycol.* **2022**, 34(6), 3141-3156. DOI: 10.1007/s10811-022-02848-2
73. Afonso, N.C.; Catarino, M.D.; Silva, A.M.; Cardoso, S.M. Brown macroalgae as valuable food ingredients. *Antioxidants* **2019** 8(9), DOI: 10.3390/antiox8090365
74. Giri, A.; Osako, K.; Ohshima, T. Identification and characterisation of headspace volatiles of fish miso, a Japanese fish meat based fermented paste, with special emphasis on effect of fish species and meat washing. *Food chem.* **2010**, 120(2), 621–631. DOI: 10.1016/j.food-chem.2009.10.036
75. Peinado, I.; Girón, J.; Koutsidis, G.; Ames, J.M. Chemical composition, antioxidant activity and sensory evaluation of five different species of brown edible seaweeds. *Food Res. Int.* **2014**, 66, 36–DOI: 10.1016/j.foodres.2014.08.035