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Soluble chickpea and lentil powders: a solution for elderly consumers interested in enriching their meals with protein†

Celia Badia-Olmos,[a] Laura Laguna,[a] Catalina Daniela Igual[b] and Amparo Tárrega*[a]

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Protein intake in the elderly is often inadequate; one solution is to enrich meals with sustainable proteins. This can be difficult, especially when aiming to retain the product's sensory appeal. In this study, we investigated the use of a novel soluble pulse powder derived from pre-cooked and dried chickpea or lentil grains. The composition, rheological, and sensory properties of chickpea and lentil powders were studied as potential ingredients for enriching protein and fibre purees. Two types of powder were initially selected: whole powder and sieved powder (containing particles <354 μm). The composition of these powders varied in terms of the fibre and protein content. The viscosity of the purees increased linearly with powder addition, depending on whether it was the whole or sieved powder, which contained only particles with a diameter of less than 354 μm. Compared with the control puree, the addition of 7.5% sieved pulse powder did not affect consumer preference and transformed the purees into a source of protein and high-fibre food. Therefore, 7.5% sieved powder was selected to study the perceptions of the elderly consumers. The liking of, and willingness to eat purees enriched with chickpea powder was not significantly different from that of the control puree, but was significantly higher than purees with lentil powder. A significant increase in the perception of healthiness was observed with enriched purees. Elderly individuals who were protein-concerned and non-neophobic had a favourable reaction to the soluble pulse product. Therefore, chickpea powder could be an easy and sustainable option for improving and increasing protein and pulse intake in elderly individuals.

Introduction

The World Health Organization (WHO) has estimated that by 2030, one in six individuals will be over the age of 60.[1] This is a significant demographic shift that should be considered when considering the nutritional requirements of the elderly. Protein intake is of paramount importance for this age group, as it plays a crucial role in maintaining muscle mass and quality.[2] As individuals age, it is essential to increase their protein intake to prevent the loss of muscle mass and associated functional decline, such as the ability to stand or walk independently.[3] However, inadequate protein intake is prevalent among the elderly due to several physiological changes that occur with age. These include a reduction in appetite, difficulties chewing due to deteriorating teeth, swallowing difficulties and a lack of motivation to cook.[4,5]

Several studies have demonstrated that consuming at least 30 g of protein in two or more meals a day improves muscle mass and strength in elderly individuals, while reducing their risk of physical disability.[6,7] In other words, encouraging the elderly to consume more protein can help them maintain independence for a longer time.[8] A research conducted by Banovic *et al.*[9] indicated that the elderly have a negative view towards products with artificially increased protein content and prefer to enhance their protein intake from natural protein-rich foods. This may be attributed to the tendency of elderly individuals to exhibit more resistance to novel products, as they are a population group that displays a relatively high level of neophobia, indicating a reduced willingness to purchase and consume new products.[10]

Pulses represent an affordable and nutrient-dense alternative to animal protein.[11] They contain high levels of protein and are rich in dietary fibre, carbohydrates, vitamins, and minerals.[12,13] However, because of the long cooking time involved, the consumption of pulses is lower than desired.[12]

[a]*Institute of Agrochemistry and Food Technology (IATA-CSIC), C/Agustín Escardino Benlloch 7, 46980 Paterna, Valencia, Spain. E-mail: atarrega@iata.csic.es*
[b]*Faculty of Bromatology, National University of Entre Rios (UNER), Perón 64, 2820 Gualeguaychú, Argentina*

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The development of alternative pulse-based products easy to prepare and digest for the elderly population is a promising strategy to increase the consumption of pulses by favouring the intake of plant proteins.

Over the past decade, there have been a growing number of investigations into the study of pulses and their components as ingredients for protein enrichment.[14,15] Most of this research has focused on the impact of applying different physical (soaking, cooking, boiling, roasting, or drying) or biological (fermentation or germination) treatments to pulse grains or flours. This research was conducted to ascertain how pulses can be processed and to develop new pulse-based ingredients with improved qualities.[16–18] Thermal treatments applied to pulse grains or pulse flours have also been investigated to develop ingredients with improved nutritional or functional properties. Most of these studies have focused on the nutritional aspects of cooking chickpeas, beans, and lentil grains, with the results indicating this process results in an improvement in the dietary fibre and phenolic compound content, as well as improved protein digestibility.[19,20] Furthermore, some studies have demonstrated a reduction in starch digestibility and an enhancement of the resistant starch content, with the precooking of pulse grains.[21,22]

The application of thermal processing (boiling or roasting) to flour results in modifications to its technological functionalities. These modifications lead to an improvement in the flours' water absorption ability.[23] When flours are cooked through a steam jet cooker, they exhibit an increase in their water solubility and particle size, whereas viscosity decreases.[24] Some research studies have demonstrated the potential of ingredients obtained by roasting or boiling pulse grains for flour production. These studies have shown that flours obtained from these heat treatments possess unique functionalities.[22,25,26] The application of different heat treatments results in ingredients with enhanced solubility that can be used at higher concentrations for protein enrichment. This reduction is due to a decrease in thickening and gelling abilities.

In summary, new sustainable protein-rich ingredients are needed to enrich foods for the elderly. When doing it, is important to consider different factors, as the amount needed to obtain a protein-rich product and the consequent rheological changes, the resulting sensory attributes, and the product perception of the elderly population. All considered, it is hypothesised that protein enrichment can be much higher by using cooked pulse powders to enrich purees than by using the pulses directly in the preparation of a puree, as pulse powders may produce lower viscosity due to lower thickening and gelling ability. Also, the milling of these cooked pulse powders may not be the same in size, composition and adding viscosity to purees.

The objective of this study was to assess the suitability of cooked pulse powders as protein-enriched products for elderly consumers. Therefore, the composition of the cooked chickpea and lentil powder fractions and their impact on the rheological and sensory characteristics of the purees were studied. Second, the investigation focused on the perception of the concept and use of soluble pulse powders as a product to enrich their meals instantly with protein and fiber.

Materials and methods

Materials

Chickpeas (*Cicer arietinum*) and lentils (*Lens culinaris var. variabilis*) were purchased from a supermarket. Baby carrots (Hacendado, Spain), chopped onions (El Corte Inglés, Spain), commercial vegetable broth (El Corte Inglés, Spain) containing different ingredients (water, vegetables 10.6% (celery, carrot, celeriac, spinach, leek, mushroom, onion, tomato), salt, corn starch, spices, olive oil 0.2%, maltodextrin and natural flavourings), salt (Hacendado, Spain), and sunflower oil (Hacendado, Spain) were used to prepare the purees.

Production of chickpea and lentil powders

A total of 150 g of chickpea or lentil grain was weighed and poured into a can with 300 g of mineral water (Cortes, Spain). The cans were passed through a steam tunnel for 10 min to preheat the content of the cans. The cans were then sealed and placed in an autoclave (Model CFS 110 V, Terra Food Tech by RAYPA, R. Espinar S.L., Barcelona, Spain) for 30 min at a temperature of 110 °C. Chickpea and lentil thermally treated grains were dried at 50 °C for 14 h in a dehydrator (Model SDC-S101, Corrupad Korea Co., Ltd, Korea). Dried chickpea and lentil grains were milled with three sieves (3 mm, 2 mm, and 1 mm) in a miller (Model D comminuting machine, The Fitzpatrick Company Chicago, Fitzmill, USA) to obtain a powder (<1000 μm).

Fractions of chickpea and lentil powders by sieving

Chickpea and lentil powders were separated into three fractions using two sieves corresponding to Mesh no. 45 and 120. Pulse powders were divided into three fractions: Fraction 1, particle size >354 μm; Fraction 2, particle size between 125 μm and 354 μm; and Fraction 3, particle size <125 μm. The granulation (particle size distribution) of the chickpea and lentil powders is presented in Table 1.

Proximate composition of chickpea and lentil powders

The total dietary fibre content of chickpea and lentil powders was determined using an assay kit (K-TDFR-200A, Megazyme International Ltd, Wicklow, Ireland) in accordance with the method 991.43 AOAC.[27] One gram of each fraction was suspended in a MES/TRIS buffer. To facilitate digestion of the

Table 1 Flour particle size distribution (%)

Flour granulation (%) for each mesh size	Chickpea	Lentil
Fraction 1: >354 μm	24.7%	40.9%
Fraction 2: 125–354 μm	17.2%	25.0%
Fraction 3: <125 μm	58.1%	34.1%

sample, 50 µL of thermostable α-amylase, 100 µL of protease, and 200 µL of amyloglucosidase were added to remove starch and protein. The sample was initially precipitated to remove the fibre content, which was then filtered with ethanol and allowed to dry overnight at 103 °C. The total dietary fibre content was calculated after correcting for residual ash and protein contents. The fat content was determined in accordance with the specifications outlined in the AACC method 30.10.[28] The fat was extracted from the powders using the Soxhlet technique with petroleum ether. The ether was then evaporated, after which the fat residue was weighed and expressed as a percentage of fat content. The protein content was determined in accordance with the International Organization for Standardization (ISO)/Technical Specification (TS) 16634-2 using the Dumas combustion procedure.[29] The total nitrogen content of the powders was quantified using a Rapid N exceed analyser (Elementar, Langenselbold, Germany) using a thermal conductivity cell. Protein content was determined by converting the percentage of nitrogen to protein using a conversion factor of 6.25. The carbohydrate content of the powders was calculated by subtracting the percentages of moisture, fat, protein, and total dietary fibre from 100. All measurements were performed in duplicate.

Puree preparation

The puree was prepared in 1.5 L batches using a food processor (Mambo, Cecotec, Spain). The composition of the puree was as follows: 45.6% baby carrots, 10% chopped onions, 42% commercial vegetable broth, 0.3% salt, and 2.1% sunflower oil. Initially, sunflower oil and chopped onions were heated to 100 °C at a speed of 1 for 4 min. Subsequently, the remaining ingredients were incorporated and cooked for 20 min at 100 °C at a speed of 1. Upon completion of cooking, all ingredients were ground at a speed of 10 for 4 min. The final step involved the introduction of a butterfly whisk to mix the puree for 10 min at 80 °C at a speed of 2. The puree was stored at 4 °C in a refrigerator until required (24 h before use).

For the enrichment of the puree, two chickpea (C) powders were considered: whole (W) powder obtained directly after milling (CW-Powder) and sieved (S) powder (without particles >354 µm; CS-Powder). Similarly, two lentil (L) powders were also considered: whole (LW-powder) and sieved (LS-powder).

As for the concentrations, for each powder four concentrations were studied (7.5%, 10%, 12.5%, and 15%).

Rheological properties of puree enriched with chickpea and lentil powders

The rheological behaviour of the puree was investigated when it was enriched with each of the four types of pulse powders (CW, CS, LW, and LS) at four concentrations (7.5%, 10%, 12.5%, and 15%). The sample preparation procedure was as follows: 100 g of puree was heated to 40 °C in a microwave oven (Samsung M1727, UK) for 30 s at 700 W. The corresponding amount of pulsed powder was then added and manually mixed for 30 s.

The flow behaviour was quantified using a controlled stress rheometer (AR-G2, TA Instruments, Crawley, England) with a 60 mm parallel plate system and a 1 mm gap between the plates. The enriched puree was poured into the plate and conditioned for 30 s at 40 °C, the temperature at which a puree is typically served. Flow curves were obtained by registering the shear stress values while increasing the shear rate from 1 to 200 s^{-1} and then decreasing it from 200 to 1 s^{-1} at 40 °C.

Sensory evaluation of purees enriched with chickpea and lentil powders

The impact of pulse powders of varying types and quantities on the sensory characteristics of the puree was evaluated using ranking tests by a panel of 60 assessors (38 females and 22 males) aged between 22 and 62 years.

The sample preparation procedure was as follows: 250 g of puree was heated to 40 °C using a microwave oven (Samsung M1727, UK) for 1 min and 30 s at a power setting of 700 W. The corresponding amount of pulse powder was then added and manually mixed for 30 s, after which 30 g of puree were served in a glass.

Two sets of five samples were analysed. The first set of samples comprised the control puree (without flour) and four purees enriched with the two chickpea powders (CW and CS) at two concentrations: 7.5% and 12.5%. The second set of five purees also included the control puree and four purees enriched with lentil powders (LW and LS) at the same two concentrations.

Two sets of samples (chickpeas and lentils) were evaluated separately. For each set of samples, the participants were asked to rank the samples according to the intensity of each sensory attribute, namely, brightness, orange-brown colour, homogeneity, vegetable flavour, legume flavour, sweetness, salty taste, spice flavour, thickness, sandiness, creaminess, and preference. In the event of a tie, participants could select the same option. Before the second set of samples, the participants were instructed to rinse their mouths with water and wait for 1 min. The attributes were selected according to a previous session with 10 participants, during which differences were observed among the purees presented in pairs.

Participants' responses were collected using a Compusense Cloud (Compusense Inc., Guelph, Canada). This study was approved by the Ethics Committee of the CSIC (Ref: 086/2022). Before the commencement of the study, participants were required to sign an informed consent form.

Elderly perception of soluble pulse powders as a new enrichment product

The response of elderly consumers to pulse powders as a soluble product to enrich their meals with protein and fibre was studied. A total of 102 participants (51 females and 51 males) aged between 60 and 80 years were recruited. Participants were recruited from the consumer database of the Institute of Agrochemistry and Food Technology of Valencia and through advertisements posted in different senior and elderly associations. Before commencing the study, participants were required to sign an informed consent form. Participants were remunerated for their involvement in the study.

First, participants were requested to consider the food products they typically selected for purchase or consumption and to indicate the characteristics of the composition to which they were most attentive. Participants were requested to select the most appropriate option from the following list: low sugar, low salt, low fat, high vitamin and mineral content, protein, fibre, or no particular preference.

The participants then evaluated their purees. First, the participants tasted and evaluated the control group. Participants were asked to indicate how much they liked the puree using a 9-point hedonic scale (ranging from "1 = *dislike extremely*" to "9 = *like extremely*"), their willingness to eat the puree for dinner or lunch using a 5-point scale (ranging from "1 = *definitely would not eat this puree*" to "5 = *definitely would eat this puree*") and the healthiness perception of the puree using a 5-point scale (ranging from "1 = *not healthy at all*" to "5 = *very healthy*"). Finally, the participants were asked to imagine having a bowl of the puree for dinner and indicate their agreement (7-point scale) with three statements related to post-ingestion sensations (*I think… 1. I'll stay hungry, 2. it will agree with me, and 3. a bowl of puree will be sufficient for dinner*).

Subsequently, participants evaluated the purees enriched with chickpea and lentil powders. Before tasting the puree, the pulse powder product was introduced through an image that included the following information (ESI Fig. 1†): "this product is soluble chickpea powder (or lentil powder), ready to add to any meal! Enrich your meals with protein and fibre, with one sachet you turn your puree into a source of protein and high in fibre". The puree was served (30 g in glass), indicating that it was enriched with the pulse powder product. Participants were then asked to taste the enriched puree and evaluate it by answering the same questions formulated for the control puree. The order of evaluation of the two products differed between consumers following a balanced design.

After tasting and evaluating the enriched purees, participants were asked to think about this new product of soluble chickpea or lentil powders to enrich meals and indicate their level of agreement with the statements (ESI Table 1†) using a 7-point Likert scale.

The participants' protein knowledge was measured using the questionnaire proposed by Carrillo *et al.* (2023).[30] It included the first part to assess the knowledge of the protein content of different products and the second part to assess the knowledge of the function or relevance of proteins (ESI Table 2†). Finally, the participants completed the food neophobia questionnaire[31] including ten statements. Each participant indicated their agreement on a 7-point scale (ESI Table 3†). The Spanish version of Barrios & Costell (2004) was used.[32]

Participants' responses were collected using Compusense Cloud (Compusense Inc., Guelph, Canada). This study was approved by the Ethics Committee of the CSIC (Ref: 199/2020).

Data analysis

Differences in proximate composition variables (moisture, ash, fat, protein, fibre, and carbohydrates) among the three studied fractions of the pulse powder were analysed separately for chickpeas and lentils using a one-way analysis of variance (ANOVA).

The effects of the type of pulse powder (whole or sieved) and enrichment level on the rheological properties of the purees were analysed using a two-way ANOVA with interactions. For each parameter, the *post-hoc* Fisher test was used to determine significant differences ($\alpha = 0.05$) among the mean values.

For each sensory attribute, Friedman analysis was applied to the rank test data to determine whether the intensity varied with the type and amount of soluble powder. Nemenyi's test was performed to determine significant differences ($\alpha = 0.05$) among the samples.

To examine the impact of consumer characteristics on their reactions to new soluble chickpea and lentil products, four individual variables were studied: being concerned about protein content, fibre, protein knowledge, and neophobia degree.

Consumers were classified as concerned about protein if they had selected protein in the multiple-choice question regarding the components they focused on when buying or eating food. Similarly, they were classified as concerned by fibre had they selected the fibre.

According to the total score obtained in the protein knowledge questionnaire (10 items), consumers were classified as having low (0–4), medium (5–6) and high (7–10) protein knowledge. According to the average score obtained from the neophobia questionnaire, participants were classified as having a low (0–2.9), medium (3–3.5) or high (3.6–7) degree of neophobia.

ANOVA was applied to study the variation in liking, willingness to eat, healthiness perception, and post-ingestive sensations, including factors such as the type of pulse (chickpea or lentil) and the consumers' characteristics (protein, fibre, protein, and degree of neophobia).

Similarly, ANOVA was applied to study the variability in the variables measuring consumers' perception of the usability of the products considering the consumer characteristics (protein-concerned, fibre concerned, protein knowledge and degree of neophobia). For the effect of the four variables, Fisher's *post-hoc* test was applied to determine significant differences ($\alpha = 0.05$) among the mean values.

All data analyses were performed using the XLSTAT version 2020.4.1 software (Addinsoft, Paris, France).

Results and discussion

Proximate composition of chickpea and lentil powders

Powders of pre-cooked lentils and chickpeas were found to contain particles of varying sizes (Table 1). In the case of chickpea powder, the fraction of small particles with a diameter of <125 μm represented the majority (58%), followed by the fraction of large particles with a diameter of >354 µm (42%). In the case of the lentil powders, the fraction of large particles was the predominant component (41%), followed by the fine fraction (34%).

The proximate composition of each fraction of chickpea and lentil powders (fraction 1, >354 µm; fraction 2, 125–354 µm; and fraction 3, <125 µm) is presented in Fig. 1. For chickpeas, there was a significant difference ($p = 0.029$) in moisture content between fractions, with the fraction of large particles exhibiting a slightly higher moisture content (11.6%) than fine particles (10.9%). The fat content values (4.5% to 6.2%) did not exhibit a significant variation ($p > 0.08$). Significant variations were observed in the protein, fibre, and carbohydrate content among the fractions ($p < 0.05$). The protein content was higher for the fine particle fraction (24.2%) than for the large-particle fraction (23%). The large-particle fraction exhibited a higher fibre content (28.5%) and a lower carbohydrate content (29.1%) than the fractions of fine and medium-sized particles (12.8%–14.3% for fibre; 44.1%–43.7% for carbohydrates).

For lentil powder, moisture, fat and protein contents exhibited statistically significant ($p < 0.05$) variation among the fractions. The moisture content was marginally higher for the small-particle fraction (8.6%) than for the large-particle fraction (7.5%). The protein content was higher for the large-particle fraction (26.3%) than for the fine particle fraction (23.0%).

These results show that when whole-grain flours are milled, some of the main components, in especial the fiber in this case, are not equally distributed. Previous research shown that fractions of small particles are more enriched in starch (carbohydrates), whereas protein and especially fibre remain in larger size fractions.[33] Most of the fibre in pulses is derived from the seed coat and hull, which contain complex structural components such as cellulose, hemicellulose, or lignin resistant to break down, remaining in larger fractions.[33,34]

The content of the fractions indicated that two pulse powder products should be included in subsequent parts of the study: the whole powder and the powder containing only particles below 354 µm (sieved powder). The chickpea whole powder exhibited a fibre content of 16.9% and a protein content of 23.9%, whereas the chickpea-sieved powder exhibited a fibre content of 13.1% and a protein content of 24.2%. In the case of lentils, the whole powder contained 19.5% fibre and 25.8% protein, whereas the sieved powder contained 11.1% fibre and 25.4% protein.

Rheological properties of puree enriched with chickpea and lentil powders

Rheological measurements of purees enriched with chickpea and lentil powders at four concentrations (7.5%, 10%, 12.5%, and 15%) were carried out in order to assess viscosity changes. The rheological measurements are shown in Table 2 that presents the mean values of the apparent viscosity (η_{50}) of purees enriched with chickpea and lentil powders at these four concentrations (7.5%, 10%, 12.5%, and 15%). The apparent viscosity values of the purees enriched with chickpea powder increased from 2.7 Pa s (7.5%) to 6.5 Pa s (15%), whereas those of the purees enriched with lentil powder increased from 2.9 Pa s (7.5%) to 8.6 Pa s (15%). A comparison of the control puree (0% pulse powder added) with the enriched purees containing pulse powders revealed that the viscosity values increased with the concentration of the pulse powders. The η_{50} values of the enriched purees with pulse-sieved powders were higher than those of the enriched purees with pulse whole powders. Comparing concentrations of pulse powders addition (7.5% *vs.* 15%), the viscosity of purees increased double when enriching with chickpea powders and tripled when enriched with lentil sieved powders.

Rheological behaviour of purees with raw chickpea or raw lentil flours (with no treatment) was also measured and compared to the values of the purees enriched with chickpea and lentil powders (Table 2). At 7.5% and 10%, the viscosity values of the purees enriched with pulse powders were approximately half the viscosity values of the purees with pulse raw flours. Consequently, soluble pulse powders do not require additional

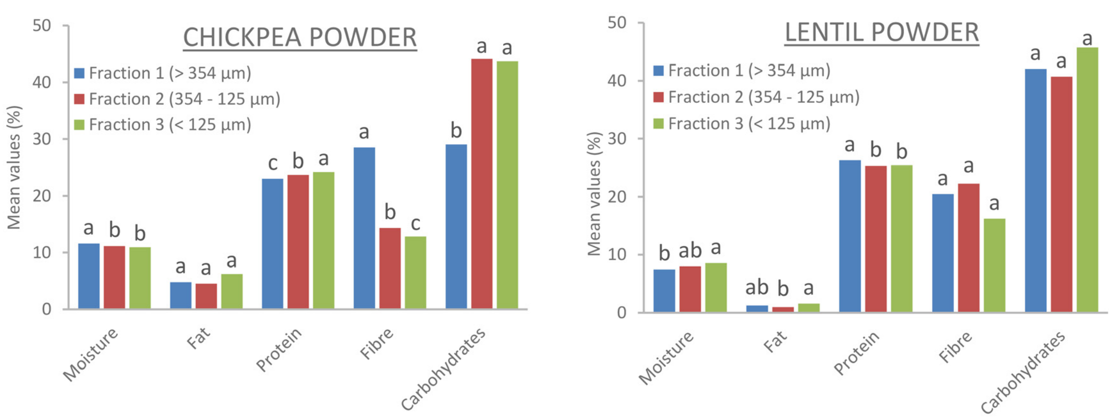

Fig. 1 Mean values of the proximate composition of chickpea and lentil powders (fraction 1: >354 µm, fraction 2: 354–125 µm and fraction 3: <125 µm). Values not sharing letters are significantly different according to Fisher's LSD test ($p < 0.05$).

Table 2 Mean values of apparent viscosity (η_{50}, Pa s) of puree enriched with chickpea and lentil powder (sieved or whole) or with raw flour added while cooking at different concentrations (0%, 5%, 7.5%, 10%, 12.5% and 15%)

	Chickpea			Lentil		
Concentrations (%)	Sieved powder	Whole powder	Raw flour	Sieved powder	Whole powder	Raw flour
0% (Control puree)	1.7^{d} (0.4)	1.7^{c} (0.4)	1.7^{c} (0.4)	1.7^{d} (0.4)	1.7^{c} (0.4)	1.7^{c} (0.4)
5%	—	—	2.1^{c} (0.0)	—	—	2.4^{c} (0.1)
7.5%	3.1^{c} (0.2)	2.7^{bc} (0.3)	5.8^{b} (0.0)	2.9^{cd} (0.1)	3.4^{b} (0.1)	5.8^{b} (0.2)
10%	4.0^{c} (0.2)	3.7^{b} (0.1)	10.1^{a} (0.2)	4.7^{bc} (0.0)	4.3^{b} (1.0)	10.7^{a} (0.9)
12.5%	5.3^{b} (0.4)	4.4^{b} (0.7)	—	6.1^{b} (0.7)	6.1^{a} (0.2)	—
15%	6.5^{a} (0.3)	6.3^{a} (1.2)	—	8.6^{a} (1.7)	7.0^{a} (0.7)	—

Values not sharing letters per column are significantly different according to Fisher's LSD test ($p < 0.05$). Standard deviation is included in brackets.

incorporation during cooking because they are already soluble and can be added when the puree or meal is already cooked. Furthermore, they permit the addition of a higher concentration than that possible with raw pulse flour. Enrichment of purees with raw pulse flours was possible up to a concentration of 7.5% flour. However, a higher concentration (10%) resulted in a product that was too thick or almost solid, rendering it unsuitable for defining a puree. Nevertheless, up to 12.5% cooked pulse powders can be incorporated into the mixture without adversely affecting the viscosity, which is within the expected range for a puree.

By cooking the pulses (chickpea and lentil grains) and further drying and milling, the pulse powder product is soluble in water.[26] The solubility of pulse powders allows them to be easily added to purees with little increase in viscosity, unlike raw pulse flours which would need to be cooked before being added and would considerably increase the viscosity of the meal. The possibility of incorporating a higher amount of pulse powder indicates that the protein enrichment is much higher. Higher solubility and lower viscosity are because, in the powder, starch is already pre-gelatinised, and the protein denatured.

During cooking, starch is heated by excess water, but its swelling is limited as the granules are located inside the legume cells.[35] When cooking, protein denaturation produces the unfolding of the protein structure, exposing the functional groups and their surface charges that produce aggregation between proteins. This aggregation between proteins results in less interaction between them, but a greater affinity for water molecules.[36]

Sensory evaluation of purees enriched with chickpea and lentil powders

The addition of soluble chickpea powder had a significant impact on the brightness, orange colour, homogeneity, legume flavour, sweetness, vegetable flavour, thickness, sandiness, creaminess, and preference of the purees (Table 3). The orange colour of the puree exhibited a slight decrease in intensity with increasing levels of enrichment, and its appearance became less homogeneous as the quantity of chickpea powder increased. Similarly, legume flavour increased with the amount of chickpea powder, whether the powder was whole or sieved. Conversely, the sweetness and vegetable flavour decreased with the amount of chickpea powder. Regarding texture, an increase in thickness was observed with the level of enrichment, and this was similarly observed for both types of powders (sieved or whole). The puree's sandiness increased with higher enrichment levels, particularly for the whole

Table 3 Differences in sensory attributes for purees when enriched with chickpea (C) and lentil (L) powders at two concentrations (7.5% and 12.5%) and two types of powder (sieved: S; and whole powder: W) compared to control puree (Control). Values not sharing letters are significantly different according to Nemenyi's test (α = 0.05)

	Soluble chickpea powder					Soluble lentil powder				
Sensory attributes	Control	7.5% CS	7.5% CW	12.5% CS	12.5% CW	Control	7.5% LS	7.5% LW	12.5% LS	12.5% LW
Brightness	211.5^{b}	173.5^{ab}	182.0^{ab}	160.5^{a}	172.5^{ab}	62.0^{a}	175.0^{b}	137.5^{b}	270.5^{c}	255.0^{c}
Orange colour	239.5^{d}	209.5^{cd}	182.5^{bc}	153.5^{ab}	115.5^{a}	—	—	—	—	—
Orange-brown colour	—	—	—	—	—	61.0^{a}	164.0^{b}	144.5^{b}	272.5^{c}	258.0^{c}
Homogeneity	263.0^{d}	210.0^{c}	184.0^{bc}	136.5^{ab}	106.5^{a}	245.0^{c}	197.0^{b}	177.0^{b}	153.0^{ab}	128.0^{a}
Sweetness	246.5^{c}	215.0^{bc}	172.0^{ab}	131.5^{a}	135.0^{a}	251.0^{c}	201.0^{b}	168.5^{ab}	136.0^{a}	143.5^{a}
Spice flavour	—	—	—	—	—	109.0^{a}	184.5^{b}	189.0^{b}	196.0^{b}	221.5^{b}
Vegetable flavour	217.5^{b}	190.0^{ab}	176.5^{ab}	156.0^{a}	160.0^{a}	—	—	—	—	—
Legume flavour	99.0^{a}	161.5^{b}	163.5^{b}	228.0^{c}	248.0^{c}	77.0^{a}	168.0^{b}	176.0^{b}	232.5^{c}	246.5^{c}
Thickness	79.0^{a}	138.0^{b}	172.0^{b}	246.0^{c}	265.0^{c}	69.0^{a}	151.5^{b}	159.0^{b}	252.0^{c}	268.5^{c}
Sandiness	70.0^{a}	128.0^{b}	200.0^{c}	221.0^{c}	281.0^{d}	74.0^{a}	139.5^{b}	190.5^{c}	227.5^{cd}	268.5^{d}
Creaminess	198.0^{bc}	226.0^{c}	175.0^{ab}	167.5^{ab}	133.5^{a}	219.5^{c}	215.0^{c}	181.0^{bc}	157.5^{ab}	127.0^{a}
Preference	199.5^{bc}	217.0^{c}	186.5^{bc}	164.0^{ab}	133.0^{a}	209.5^{bc}	234.5^{c}	175.5^{ab}	147.5^{a}	133.0^{a}

powder. Adding the powder to the puree decreased its creaminess significantly.

The addition of soluble lentil powder to enrich purees has been found to significantly affect several characteristics, including brightness, colour, homogeneity, flavour, sweetness, spice flavour, thickness, sandiness, creaminess, and preference (Table 3). The concentration of lentil powder increased both the brightness and brown colour. The homogeneity of the purees decreased, particularly when whole powder was used. The concentration of lentil powder resulted in an increase in legume flavour and a decrease in sweetness, regardless of the type of powder (sieved or whole). The spicy flavour was more intense in all purees enriched with lentil powder than in the control puree. The thickness of the purees increased in direct proportion to the quantity of the lentil powder added. Moreover, the enriched purees became sandier, particularly when using the whole powder. The creaminess of the puree exhibited a significant decline only when 12.5% lentil powder was incorporated. The puree enriched with 7.5% LS demonstrated comparable sensory attributes to the control puree and was also the most preferred.

The incorporation of whole-pulse powders at either level (7.5% and 12.5%) led to notable alterations in the sensory properties of the purees, including an increase in sandiness and a decrease in creaminess. These changes negatively affected the overall acceptability of the meals. These sensory properties indicate that the use of whole-pulse powders is not an appropriate method for enriching purees. Compared with purees containing sieved powder, purees containing the whole fraction exhibited more sandiness. This was due to the larger and coarser fractions present in the powder. Furthermore, during the preparation of the powder, the grains were dried, which likely resulted in the formation of hard fractions that are easily detected in the mouth.[37] Besides hardness, particle size, shape, concentration, and particle surface roughness influencing the sandiness sensation.[38–40] Modifying these particle-related attributes, such as reducing particle size or concentration, can help to reduce the perception of sandiness. Thus, using pulse powders with particles under 354 μm is a better choice. It reduces sandiness without affecting creaminess or preference. For semi-solid products such as purees, the sensation of sandiness is of particular importance, as the product is expected to be creamy and the circular mouth motions facilitate the perception of heterogeneities.[41,42]

The incorporation of sieved powders at 7.5% into purees results in the formation of a protein-rich and high-fibre foodstuff, in accordance with the stipulations of Regulation (EC) No 1924/2006.[43] As previously stated, the enrichment of foodstuffs with protein is of particular importance in maintaining muscle mass, particularly in the elderly.[44] In contrast, the enrichment of foodstuffs with fibre is beneficial for gut health and reduces the risk of heart disease.[45] Thus, the addition of at least 7.5% pulse powder to any meal results in an increase in protein content by 15% and a greater than 4 g of fibre per 100 kcal.

This soluble pulse product (sieved powder at 7.5%) represents an alternative ingredient that can be used to enhance protein levels in other meals or products, including those prepared at home, catering, or in the food industry. Further investigation was conducted to ascertain the suitability of this product for use by the elderly to enrich a meal with its nutritional claims as a source of protein and fibre.

Elderly consumers' perception of soluble pulse powders for protein enrichment

Impact of puree enrichment on elderly consumers' perception of purees. The acceptability, palatability, and perceived healthiness of purees enriched with soluble chickpea and lentil products were initially evaluated in comparison with a control puree (Fig. 2). There was a statistically significant difference ($p < 0.01$) in consumer liking and willingness to eat for the different purees. The perception of healthiness also exhibited significant variation ($p = 0.048$), albeit to a lesser extent. Consumer liking and willingness to eat were significantly lower when the puree was enriched with lentil powder; however, when the puree was enriched with chickpea powder, there was no significant difference in liking and willingness to eat compared to the control group. Elderly consumers perceived the control puree as healthy, with an average rating of 4.0 out of 5. However, they perceived the enriched purees, particularly those with soluble chickpea powder, to be even healthier.

Previous studies have shown that elderly prefer to consume protein from naturally protein-rich foods (such as meat, pulses, eggs, *etc.*) because they believe that are healthier and a more natural option over commercial products with added protein.[9] The explanation for it being considered healthier, in this case, can be because it is not a commercially enriched product "*per se*", but a normal meal with the pulse powder added by the consumers themselves, together with the fact that pulses are a vegetal source considered a traditional food. Further, previous studies have found that elderlies preferred to enrich traditional healthy meals than novel ones, therefore, puree as a protein carrier can be a good candidate for this age group.[46]

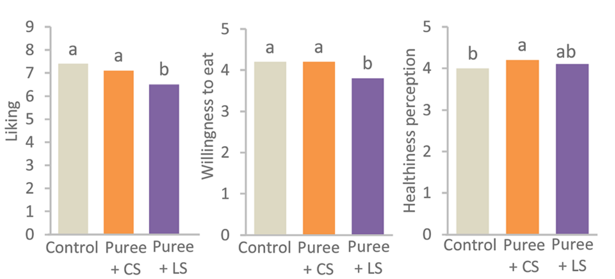

Fig. 2 Consumers liking, willingness to eat and healthiness perception of the purees enriched with chickpea powder (puree + CS) and lentil powder (puree + LS) compared to control puree. Values not sharing letters are significantly different according to Fisher's LSD test ($p < 0.05$).

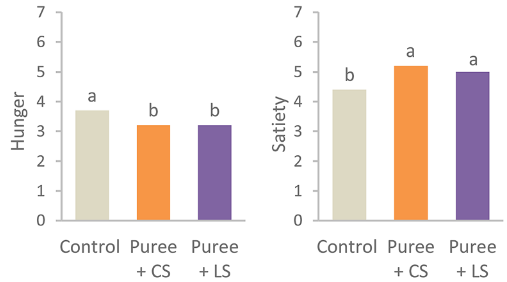

Fig. 3 Consumers hunger and satiety of the purees enriched with chickpea powder (puree + CS) and lentil powder (puree + LS) compared to control puree. Values not sharing letters are significantly different according to Fisher's LSD test ($p < 0.05$).

Fig. 3 illustrates the consumer hunger and satiety expected from a bowl of purees enriched with chickpea and lentil powders compared to the control puree. The values of consumer hunger and satiety expected from a bowl of enriched purees demonstrated significant variation with puree type ($p < 0.01$).

Upon tasting the enriched purees, elderly consumers expressed greater agreement with the notion that, following the consumption of a bowl, they would not experience hunger and would be satiated. The participants were aware of the protein-enriched puree, which can explain this attribution. Previous studies have demonstrated that foods containing a high protein content are typically perceived as more satiating.[9,47] This has extensively studied and explained as protein stimulate the secretion of GLP-1, CCK and PYY in the intestine inhibiting the appetite, whilst decreased ghreline that increased appetite.[48]

Furthermore, sensory cues may have played a role, as increased thickness of semi-solid products has been linked to an increase in expected satiation and satiety.[49,50] In this specific case, the objective was to increase protein intake. Therefore, the satiating effect of the pulse product could be considered negative if it resulted in a reduction in meal intake or portion size. This point requires further investigation, with additional research in real-life consumption situations necessary to ascertain whether this increased satiety perception translates to a change in the amount consumed. Despite the findings of Stelten *et al.*,[51] who replaced regular products (yoghurt and bread) with protein-enriched substitutes in the diet of elderly institutionalised patients, it was observed that the protein-enriched products were consumed in the same quantities as regular products, thus negating the initial expectation of a satiating effect on the amount of meal consumed.

Individual nutritional needs, knowledge, and neophobia impact on elderly response to the new soluble pulse product

The response of elderly consumers to purees enriched with the new soluble pulse product was also studied in relation to their concerns, knowledge, and interests. The results of the ANOVA demonstrated that the values of liking and healthiness perception were significantly influenced by the level of concern regarding protein ($p = 0.007$ and $p = 0.006$). The elderly participants who concerned about protein (44%) demonstrated a greater liking for the puree enriched with soluble pulses and perceived them as healthier than those elderly participants who were not concerned about protein (56%) (Table 4).

Previous studies with elderly individuals have demonstrated that whereas many are aware of which foods contain protein, few understand the importance of protein in the body.[52] In addition, a study conducted by Carrillo *et al.*[30] found that 40% of 300 elderly Spanish participants were uncertain about the protein content of some foods and only 25% prioritised protein intake in their shopping and eating habits. However, they were more concerned about other food components, such as salt content. It would therefore be interesting to develop strategies to increase the interest and importance of protein consumption for health in older people.

The degree of neophobia exhibited by consumers (30% high degree; 24% medium degree; 46% low degree) was found to have a significant influence on their willingness to eat the puree ($p = 0.05$) and their perception of its healthiness ($p = 0.044$). Elderly consumers with substantial neophobia (30%) were less willing to eat the enriched puree and perceived it as less healthy than those with a lower neophobia level (46%) (Table 4). The other two factors (knowledge of protein and fibre content) did not significantly affect the liking, willingness to eat and healthiness perception of the enriched purees. Consumer hunger and satiety expectations did not significantly vary ($p > 0.05$) with the factors studied (protein and fibre content, protein knowledge and neophobia).

In this study, elderly participants exhibited a lower level of neophobia than the average individual, despite being considered a neophobic group compared to the general population.[10] This may be attributed to them participating in a study in which they were free to taste food, implying that they were already willing to try unfamiliar foods and therefore had minimal neophobia. Nevertheless, a proportion of the elderly participants (30%) who exhibited more neophobia displayed a reduced interest in consuming the soluble pulse product and perceived it to be less healthy. Although the soluble pulse product is minimally processed, as it is made from cooked pulses and comes in powder form, it may appear too novel and unfamiliar to some elderly individuals. For the elderly who

Table 4 Mean values of liking, willingness to eat and healthiness perception for elderly consumers concerned about protein (yes) and non-concerned (no), and their degree of neophobia: low, medium and high. Values not sharing letters are significantly different according to Fisher's LSD test ($p < 0.05$)

	Protein concerned		Degree of neophobia		
	Yes	No	Low	Medium	High
Liking	7.2^{a}	6.5^{b}	6.9^{ns}	6.7^{ns}	6.7^{ns}
Willingness to eat	4.2^{ns}	3.9^{ns}	4.2^{a}	4.0^{ab}	3.8^{b}
Healthiness perception	4.4^{a}	4.0^{b}	4.3^{a}	4.3^{a}	4.0^{b}

exhibit neophobia, elucidating the processes used in the production of the pulse product could also facilitate their consumption.

A recent study has highlighted the necessity for protein-fortified products for the elderly to be realistic and feasible to be prepared at home.[53] Therefore, soluble pulse products are an accessible and healthy option for elderly individuals concerned about their protein intake and those who are not particularly neophobic.

The main limitation of the study was that consumer evaluation was restricted to one tasting session adequate to evaluate acceptance, but where satiety and satiation were based on the assessment of expectations. A longitudinal study including satiety and digestive sensations a few hours after consumption of this type and other protein-enriched products and over different days would provide more realistic information on the acceptance of these products by the elderly in relation to satiety and digestive sensations.

Conclusions

This study addressed the issue of inadequate protein intake among the elderly by examining a new soluble pulse product made from pre-cooked pulses. These pulse products, designed to enhance protein content when incorporated into any meal, were subjected to investigation from a technological, sensory, and consumer perspective.

The milling of cooked chickpea and lentil grains provided powders that are soluble and have a lower thickening capacity than raw chickpea and lentil flours. This allows for the enrichment of meals, such as purees with higher levels of protein and fibre. The soluble pulse powders exhibited varying effects on the sensory properties of the puree, contingent upon the degree of enrichment and the proportion of powder used. Using whole-pulse powders made the purees less creamy and sandier than control puree, which decreased preference. Conversely, the sieved fraction of the pulse powders (exclusive of particles exceeding 354 μm) exhibited a negligible influence on the sensory attributes and did not impact the level of preference.

The soluble pulse product is perceived by most elderly consumers as an accessible means of rapidly enhancing their diets with protein and fibre. The enriched purees, which contained either soluble chickpea or lentils, were similarly liked by the consumers, although the purees enriched with lentils were less well received. Those consumers concerned about protein intake and less neophobic are more willing to consume the product and consider it healthier.

Author contributions

Celia Badia-Olmos: conceptualisation, formal analysis, methodology and writing – original draft. Laura Laguna: conceptualisation, methodology, supervision and writing – review & editing. Catalina Daniela Igual: methodology. Amparo Tárrega: conceptualisation, formal analysis, funding acquisition, methodology, supervision and writing – review & editing.

Data availability

The data supporting this article have been included as part of the ESI.†

Conflicts of interest

There are no conflicts to declare.

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