Pulse ingredients for enrichment of vegetable creams with protein. Rheology, oral breakdown and sensory perception

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INTRODUCTION

Fortification with protein is a nutritional improvement commonly needed in products for groups with some specific needs (elderly nutrition, sport nutrition, dysphagia purees, satiating products, or products for vegan diets). Pulse flours and concentrates are relatively new sources of proteins and a good alternative to whey and soy proteins because they are free from most common allergens, clean label and a sustainable source of protein.

The objective of this study was to evaluate the effect of the addition of pulse flours (lentil and chickpea) with different protein concentration on the rheological properties, the oral structure breakdown and sensory properties of vegetable creams.

MATERIALS & METHODS

Samples

Vegetable creams were prepared by mixing the ingredients in a Thermomix during heating at 80-100°C for 30 min. All formulations contained 81.75 g of puree / 100 g sample. The puree contained 45.9 g carrot, 41.6 g vegetable stock, 9.8 g onion, 2.4 g oil and 0.3 g salt per 100 g puree. Two control samples were prepared: Control 1 (vegetable puree) and Control 2 (vegetable puree with tapioca starch as thickener). The other six samples were prepared using three different pulse flours with different amount of protein: lentil flour (20% protein) Homecraft Pulse 2101, lentil flour (55% protein) Vitessence Pulse 2550, chickpea flour (20% protein) Homecraft Pulse 4101 (all from Ingredion, UK) and the amount of flour added, as indicated in Table 1.

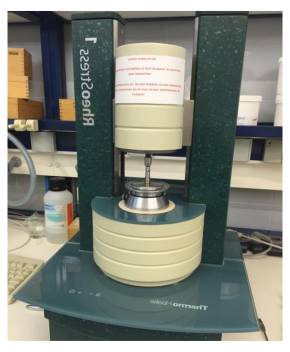
Table 1. Characteristics of composition that differentiate the vegetable cream samples

Sample	Protein level in product (%)	Type of flour	Ingredient added g/100g	
			Tapioca starch	Flour
Control 1	0.37	-	-	-
Control 2	0.38	-	1	-
Lent20-1	1.12	Lentil flour (20% protein)	-	4.31
Lent20-2	1.62	Lentil flour (20% protein)	-	7.18
Chic20-1	1.12	Chickpea flour (20% protein)	-	4.31
Chic20-2	1.62	Chickpea flour (20% protein)	-	7.18
Lent55-1	1.12	Lentil flour (55% protein)	-	1.56
Lent55-2	1.62	Lentil flour (55% protein)	-	2.61

Rheological measurements

Flow behavior:

- Controlled stress rheometer (Rheostress 1, Haake) using parallel-plate sensor.
- Flow curves ➔ shear stress recorded from 1-200 s^{-1} up and down in 60 s.

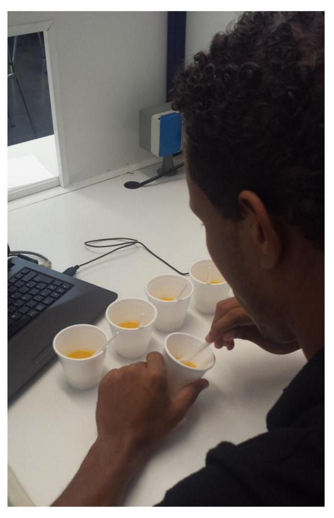


***In vitro* oral processing:**

- Controlled stress rheometer (AR-G2, TA-Instruments) using starch-pasting cell (SPC) 20 g sample + 2 ml artificial saliva, or 2 ml water.
- Apparent viscosity registered for 120 s at a constant shear rate of 10 s^{-1} and temperature of 35°C.

Sensory Evaluation

Sixty-two assessors evaluated the sensory properties of six samples of vegetable cream samples using ranking tests. Assessors evaluated the visual consistency, legume flavour and the consistency in mouth and finally the preference.



Data Analysis

Analysis of variance were applied to instrumental parameters data.

Friedman Analysis of Variance was applied to the sensory data obtained in the rank tests.

RESULTS

Flow Behaviour of Systems

- ✓ All samples showed a shear-thinning flow behaviour (Figure 1). Experimental data of flow curves fitted well to the Ostwald-de Waele model (R^2>0.96), with values of K between 2.23-39.12 Pa.s^n and values of n between 0.12-0.39. Some samples presented thixotropy, being more evident in samples containing flour with low protein content.
- ✓ The addition of lentil or chickpea flour with low protein content (20%) increased the consistency and pseudoplasticity of vegetable creams. Samples with high amount of these flours (Lent20-2 and Chic20-2) were too thick with a rheological behaviour out of the range observed for commercial samples. For this reason both samples were discarded from the study.
- ✓ The addition of lentil flour with high protein content (55%) did not cause significant differences on the rheological behavior of the vegetable puree.

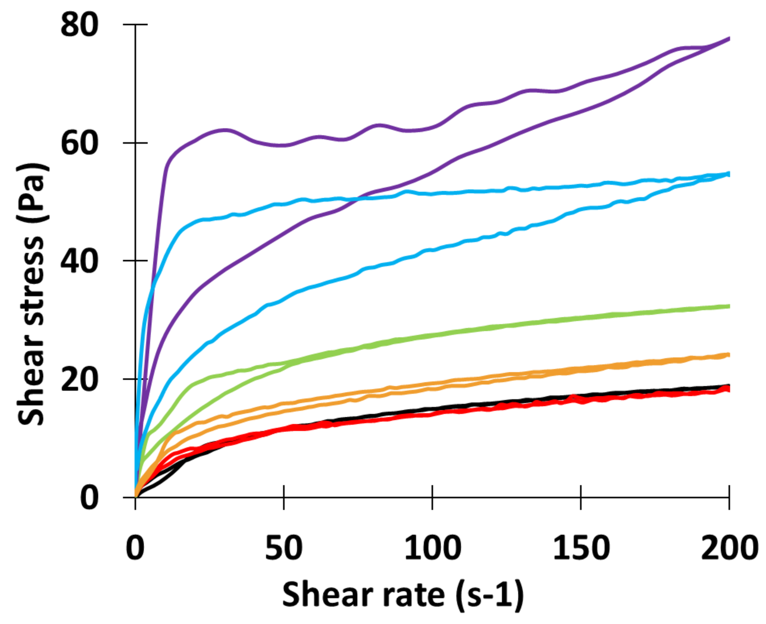


Figure 1. Flow curves of vegetable cream samples at 35 °C and shear rates of 1-200 and 200-1 (s^{-1}). ▬ Control 1, ▬ Control 2, ▬ Lentil20-1, ▬ Chic20-1, ▬ Lent55-1, ▬ Lent55-2.

Structure breakdown during in vitro oral processing

- ✓ The variation of apparent viscosity values at 10 s^{-1} with time are shown in Figure 2. Some samples exhibited a decay on apparent viscosity within the first 40 s of shearing and approached a constant value, corresponding to an equilibrium state.
- ✓ This decay in viscosity reflects the structural changes in the system caused by the shearing, enzymatic activity, and the dilution of saliva.
- ✓ Comparison of results obtained using saliva (Figure 2a) and those obtained using water (Figure 2b) indicates that structural breakdown is in part due to the enzymatic activity of saliva.

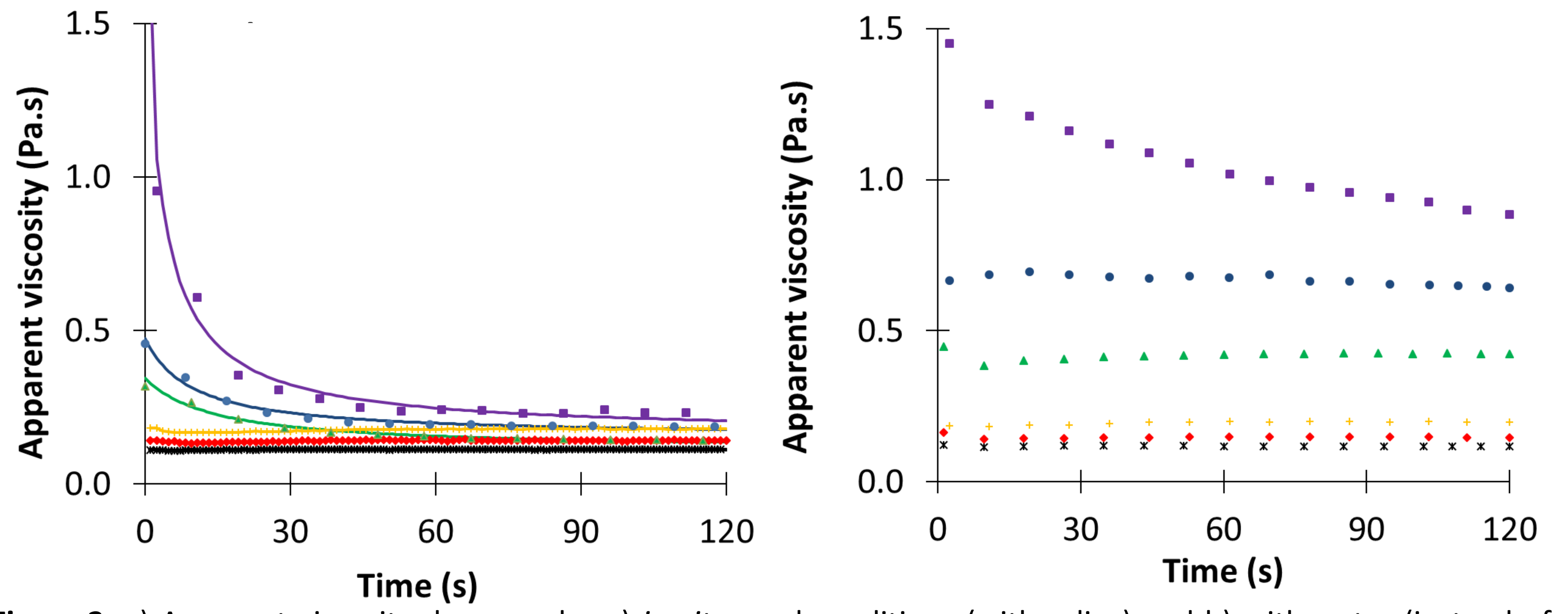


Figure 2. a) Apparent viscosity decay under a) *in vitro* oral conditions (with saliva) and b) with water (instead of saliva) at constant shear rate of 10 s^{-1}. Symbols: experimental values (filter, each six points), and lines: fits to the structural kinetic model. For ⨯ Control 1, ▲ Control 2, ■ Lent20-1 ● Chic20-1, ♦ Lent55-1, ✦ Lent55-2.

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References

1. Nguyen QD, Jensen CTB, Kristensen PG. (1998). Chemical Engineering Journal 70, 165-171

Modelling viscosity decay

- ✓ The kinetics of viscosity decay was modelled using a second-order structural equation:

$$([(\eta_0-\eta_e) / (\eta-\eta_e)] = kt + 1$$

where η_0 (Pa.s) is the initial apparent viscosity at t=0; η_e (Pa.s) is the equilibrium apparent viscosity at $t \rightarrow \infty$ and k (s^{-1}) is structural breakdown rate constant. The values of this parameters were obtained for each sample (Table 2)

Table 2. Mean values of structure breakdown model parameters for vegetables cream*

Sample		Control 1	Control 2	Lent20-1	Chic20-1	Lent55-1	Lent55-2	P
Kinetic model parameters	n_0	0.11 d	0.38 c	1.65 ab	0.50 b	0.13 d	0.18 d	< 0.0001
	n_e	0.11 cd	0.08 d	0.17 ab	0.16 b	0.13 bc	0.18 a	< 0.001
	K	<0.01 c	0.07 bc	0.30 a	0.09 b	<0.01 c	<0.01 c	< 0.0001

**Means within a row with no common letters differ significantly (p>0.05), Tukey test. Initial apparent viscosity (n_0), equilibrium apparent viscosity (n_e), and structural breakdown rate constant (k). Means within a column with common superscripts did not differ significantly (p>0.05), Tukey test.*

- ✓ Structure breakdown under oral conditions was only observed for the control sample thickened with tapioca starch and the samples fortified with low protein content flours probably due to the presence of higher amount of starch. The breakdown rate was significantly higher for the sample with lentil flour.

Sensory Evaluation:

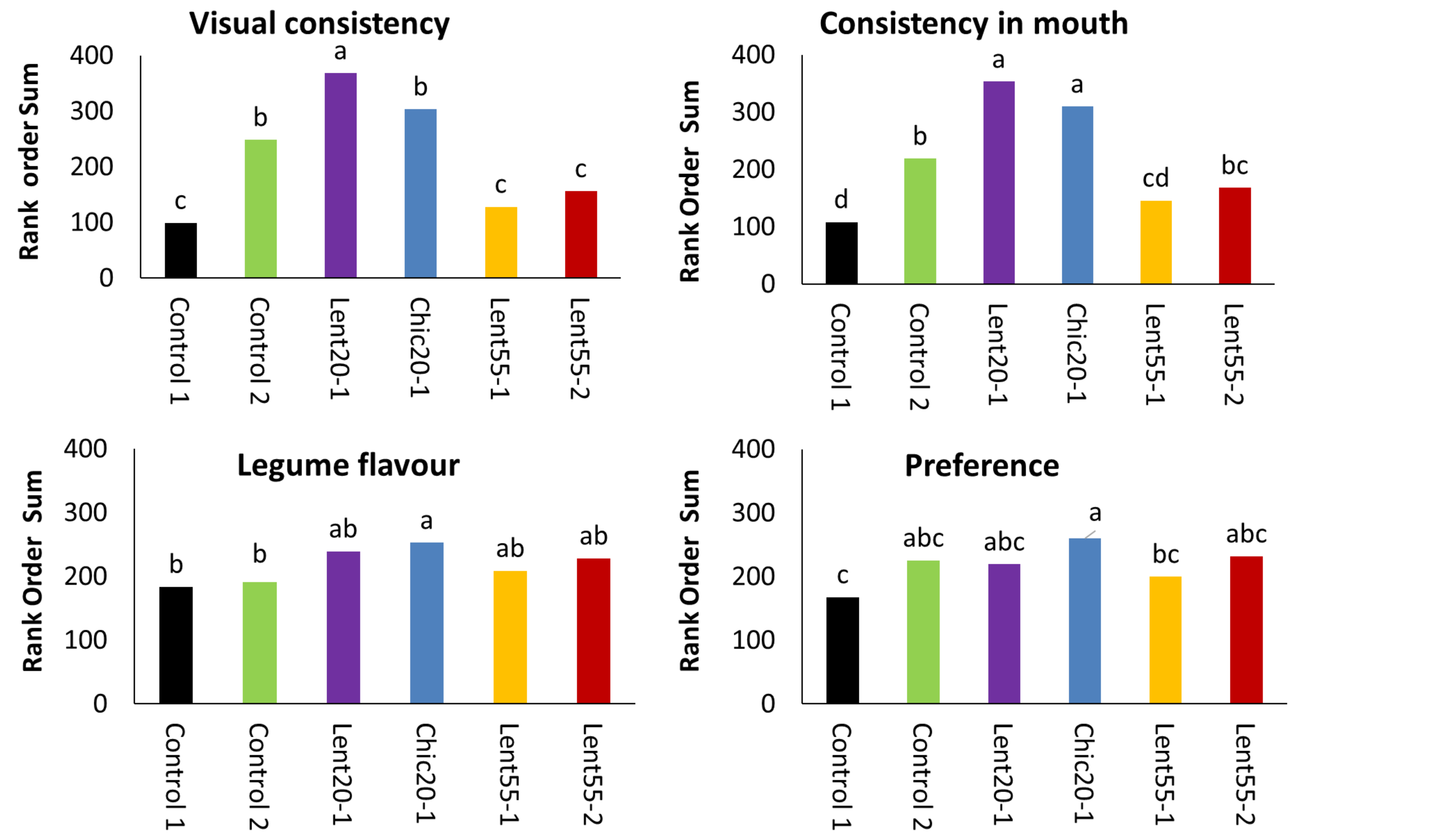

Figure 3. Results of sensory evaluation of different vegetable creams for each attribute and preference Letters on top of bars indicates significant differences according to Tukey test *(p=0.05).*

- ✓ Addition of chickpea or lentil flour with 20% protein increased both vegetable flavor and consistency. However, the lentil flour with 55% protein did not significantly modify the sensory properties of the creams with respect to the control samples. Consumers showed higher preference for the sample enriched with chickpea flour (Chic20-1) than for the Control 1 and Lent55-1 samples (they were those less preferred by consumers).

CONCLUSION: The effects of the addition of legume flours vary depending mainly on the amount of protein in the flour. High-protein flour produces no changes in viscosity, oral behavior or sensory properties of the creams. In contrast, low-protein flours produce an important increase in viscosity, modify the behavior in the mouth and increase the consistency and legume flavor intensity of the cream. However at low concentration, these flours could be a good choice to develop products with new texture and flavor that may present even greater acceptability by consumers.