**INFLUENCE OF HYDROCOLLOID TYPE ON STRUCTURAL BREAKDOWN
OF VEGETABLE PUREES DURING *IN VITRO* DIGESTION**

Ana Salvador* and Teresa Sanz

Instituto de Agroquímica y Tecnología de Alimentos (IATA-CSIC).

Agustín Escardino, 7. 46980 Paterna (Valencia), Spain

Corresponding Author e-mail: asalvador@iata.csic.es

Running title: Changes of purees during in vitro digestion

Summary

The aim of this study is to evaluate the effects of the addition of hydrocolloids on the reformulation of pureed zucchini to obtain a healthy food. Changes in the rheological properties after in vitro digestion and in the sensory acceptability of purees were studied. After saliva addition the carrageenan puree was the sample that kept its structure more stable with similar G' and G'' values, whereas the guar gum and HPMC purees exhibited a very small decrease in the viscoelastic functions after mixing with saliva and the starch puree was completely degraded due to the effect of amylase. Regarding sensory properties, the scores of the carrageenan puree were the ones that were closest to the starch puree, so carrageenan puree is a good option for preparing a healthy food without any significant modification in its structure after digestion and in the sensory acceptability properties of a traditional puree.

Keywords: gastric structuring, rheology, hydrocolloids, zucchini puree, acceptability.

Introduction

Nowadays, demand for vegetable juices and purées are increasing reflecting the worldwide interest in natural, healthy foods. However, the juices or purees have a semiliquid consistency that means the diet have to be supplemented with other foods to get a feeling of fullness. Increasing the viscosity of non-nutrient meals, such as purees, would delay gastric emptying, increase satiety and decrease hunger (Fizman & Varela, 2013).

Hydrocolloids, such as guar gum, agar, carrageenan or alginates are some of the ingredients that may be used as stabilisers/thickeners in foods. They are complex polysaccharides, water soluble and able to absorb up to 100 times their weight in water; they also have the capacity to form gels under certain conditions, which is why they are widely-used in the food industry for their stabilising effect. In fact, their high water-absorbing capacity makes increase viscosity of foods, which could delay gastric emptying and slow down the absorption of glucose and other nutrients through the small intestine (Nieuwenhoven et al., 2001; Kovacs et al., 2002). These papers investigated nutritional aspects studying if the addition of guar gum to a semisolid meal might be able to be effective on appetite by modifying the response of blood glucose and other blood parameters and by slowing gastric emptying and intestinal transit, thus inducing an increased feeling of satiety. This delay gastric emptying could be related to an increase in satiety. Several human studies have indicated that meals containing solids typically have a greater effect on satiety than liquid meals of equivalent size and energy content (Haber et al., 1977; Bolton et al., 1981; Himaya & Louis-Sylvestre, 1998, C.L. Campbell et al., 2017). Besides, another property of hydrocolloids is their ability to thicken dietary fluids. This property can be used to prepare semi-solid foods for dysphagia (Casanovas et al., 2011; Ross et al, 2019).

Rheological properties are one of the most important physical properties that can define the structure of a food system and they contribute to the characterization of the texture when different formulations are used (Liu et al., 2007; Djordjević et al., 2019). Besides, good correlations between rheological parameters and sensory properties of food have been usually found, so rheology can be used as a tool to improve food formulations (Nakauma et al, 2011; Ross et al, 2019). Therefore, the investigation of the structural changes occurring during the *in vitro* digestion of purees stabilized by polymeric matrices of different nature, will allow a deep assessment of the type of structural changes suffered by the puree during digestion depending on its composition. In this sense, Borreani et al. (2019) studied the influence of different types of molecules (tween, lecithin, xanthan gum, and methylcellulose) on the physical properties (flow behavior and particle size) and microstructure of oil-in-water (o/w) emulsions before and during *in vitro* intestinal digestion but they do not used this emulsions to develop foods. Morell et al. (2014) analyse the effect of adding different hydrocolloids on the expected satiety of milkshakes relating it with the rheological and microstructural studies before and after an *in vitro* oral digestion. On the other hand, Sharma et al. (2017) studied the texture of different hydrocolloids addition on carrot puree by evaluating rheological, textural and sensorial properties. However, a complete study on changes in the puree structure after *in vitro* digestion was evaluated was not found.

Thus, the aim of this work is to evaluate the effect of four different hydrocolloids on the rheological properties of purees after mouth and stomach *in vitro* digestion as a measurement to quantify the degree of structure breakdown. The consumers' sensory acceptability and expected satiety of the different purees and their relation with the rheological properties was also studied.

Materials and methods

84 Materials

Green zucchini of the variety *Cucurbita pepo subsp. pepo* were bought in a local
86 supermarket. The powdered skimmed milk was purchased from Central Lechera
Asturiana (Asturias, Spain). Olive oil was purchased from Fontaliva (Sevilla, Spain).
88 Modified waxy corn starch (half crosslinked) (C*Tex – 06214), λ -carrageenan
(Satiagum BDC 20, molecular weight 579.46 g/mol) and guar gum (Viscogum MP
90 41230, molecular weight 535.15 g/mol) were supplied by Cargill (France).
Hydroxypropyl methyl cellulose F4M (viscosity of 4000 mPa s, 2 % aqueous solution at
92 20 °C measured by The Dow Chemical Company following reference methods ASTM
D1347 and ASTM D2363, molecular weight of 9500 Da) was supplied by the Dow
94 Chemical Company. Hydrochloric acid (6 N) was purchased from Scharlab S.L.
(Spain). Sodium hydroxide (0.1 N), calcium chloride anhydrous, potassium chloride
96 pure and sodium carbonate anhydrous (1M) was provided by Panreac Química S.L.U.
(Spain). Pepsin from porcine gastric mucosa (P7000) was supplied by Sigma-Aldrich
98 Chemical Company (St Louis, MO).

100 Vegetable puree elaboration

The vegetable puree formulation consisted of zucchini (33.3% w/w), powdered
102 skimmed milk (6% w/w), olive oil (5% w/w), salt (0.23% w/w), one of the following
thickening agents: starch (3.5% w/w) or λ -carrageenan (1.7% w/w) or guar gum (0.9%
104 w/w) or hydroxypropylmethyl cellulose (HPMC) (1.6% w/w) and water up to 100%
w/w. The concentrations of the different hydrocolloids were selected to obtain a similar
106 apparent viscosity (≈ 4000 mPa.s). The apparent viscosity of the final vegetable purees
was measured in triplicate using a viscometer (Haake Viscotester 6 R Plus, Thermo

Scientific, Waltham, Mass., U.S.A.), equipped with spindle R5, at 60 rpm at a temperature of 40°C. The zucchini were cut into pieces (cubes 1 cm on each side, approximately) mixed with the oil and heated to 90°C at 100 rpm for 1min in a cooking device (Thermomix TM 31). After that, the rest of the ingredients were placed in the cooking device and heated to 90 °C at 600 rpm for 20 min, which allows the uniform cooking of the ingredients, while achieving the correct hydration of the hydrocolloid. Finally, the mix was stirred at 2000 rpm at 90°C for 3 min for a homogenization of the puree.

It should be pointed out that the procedure followed in the case of HPMC is different as hydration conditions for this hydrocolloid are different. The HPMC puree was elaborated over two steps: firstly, all of the chopped zucchini was mixed with the oil at 90°C at a speed of 100 rpm for 1 minute and, subsequently, the water and half the milk were added. Meanwhile, the weighed quantity of HPMC along with the other half of the milk and all of the salt was prepared by mixing it with a rod (a long thin pole made of metal); then it was mixed with a part of the total amount of weighed water under constant stirring in a magnetic stirrer (Heidolph) to prevent the formation of lumps. Once the two parts were ready, the puree cooked and the HPMC prepared with the ingredients, everything was mixed in a Heidolph stirrer at speed 2 until the product was homogeneous.

All purees were placed in a 600 mL airtight plastic container, covered with plastic film and cooled to 37°C. Measurements were taken at 37°C on the same day the puree was prepared.

In vitro digestion

The digestion process in the human gastrointestinal tract is simulated through an *in vitro* digestion model which was a modified version of that described by Borreani et al. (2017) and Qiu, Zhao et al. (2015).

Mouth in vitro digestion

For *in vitro* mouth incubation, 25 g of puree were mixed with 0.5ml human-stimulated saliva for 5 min at 37°C to obtain a final ratio of 1:45 (v/v). The saliva/emulsion ratio was selected according to the saliva flow data provided by Humphrey and Williamson (2001), considering a short retention time of the puree in the mouth. The saliva used in the experiment was always fresh, human-stimulated saliva from the same donor. The procedure to obtain saliva was the same as Sanz et al. (2007) and Engelen et al. (2003). The mouth of the donors was rinsed three times with water; subsequently, saliva stimulation was performed by chewing a 5 cm × 5 cm sheet of tasteless parafilm(Parafilm American National Can, Greenwich, CT, USA). Saliva was always employed within 1 h and was stored at 4 °C and the rest was discarded. Also a informed consent was obtained from her.

The same testing protocol was also followed replacing the total volume of saliva fluid by the same volume of water in saliva dilution samples in order to compare the effects caused by the volume of dilution with the effects caused by the presence of enzymes.

Stomach in vitro digestion

For *in vitro* stomach incubation, 25 g of puree were mixed with 0.5ml human-stimulated saliva and with 8 mL of simulated gastric fluid (SGF). The pH of the mixture was adjusted to 2.0 with 100 µl HCl (6N). Simulated Gastric Fluid (SGF) was prepared according to a previous study (Espert et al., 2018).

Rheological measurements

Rheological measurements were made using a controlled stress rheometer (AR-G2, TA Instruments, Crawley, England), using a special geometry that uses an innovative impeller designed with blades at the bottom to ensure mixing the sample, water loss reduction and sedimentation control during the test. This geometry is named the starch pasting cell (SPC, TA Instruments, Crawley, England). The temperature selected was 37°C.

Rotational test

The evolution of puree viscosity over time at a constant shearing rate was measured in fresh samples and during mouth and stomach *in vitro* digestion. For the mouth incubation, 25 g of puree were placed in the rheometer canister and 0.5 ml of human-stimulated saliva was added and immediately mixed at 15s⁻¹ for 1.5 min. For the stomach incubation, the 25 g of puree in the canister were mixed with 0.5 ml saliva, 8 mL of SGF and the pH was adjusted to 2.0 with HCl (6N); subsequently, the canister was placed in the rheometer and sheared at 1s⁻¹ for 30 minutes and the viscosity changes over time were measured during mixing.

Dynamic test

The linear viscoelastic properties were measured in the fresh purees and after both mouth and stomach *in vitro* incubation. Mouth incubation was carried out by mixing 25 g of puree with 0.5ml human-stimulated saliva for 1.5 min at 37°C. For the stomach incubation, the measurements were taken after the 30-minute incubation in the starch pasting cell. Frequency sweeps in the linear region from 10 to 0.01 Hz at 37 °C were carried out in every sample. The stress was selected according to previous stress sweeps

carried out in the same conditions and a stress value of 0.2 Pa was chosen. The values of the storage modulus (G'), loss modulus (G''), complex modulus (G^*) and loss tangent ($\tan\delta = G''/G'$) were recorded.

Sensorial analysis

A sensory analysis of purees was carried out by 80 untrained assessors recruited among the students and employees of the Institute for Agrochemistry and Food Technology (IATA-CSIC), in a sensory laboratory equipped with individual booths designed in accordance with ISO 8589 (2007), under artificial daylight and temperature control (22°C).

The participants were asked to taste the four samples of purees and rate their overall acceptability and acceptability of their appearance, consistency and taste on a 9-point hedonic scale from 1 = “dislike extremely” to 9 = “like extremely”. In order to evaluate the expected satiety, the participants were asked to eat a spoonful of the sample and to answer the question: “How much do you think this puree will satiate you?” in a 10-cm non-structure scale labelled from 0 (not very satiating) to 10 (very satiating). Subsequently, they were asked the following question “How much of this puree would you eat: a large, medium-sized or small bowl?” After that, the consumers were asked to answer a Check-All-Data-Apply (CATA) questions that included 5 sensory terms: lumpy, gummy, creamy, thick, strange taste, and 2 non-sensory terms “unappetising” and “satiates”. Each consumer was asked to check the terms that he/she considered appropriate for describing the puree sample. The four puree samples were served at 45°C in thermostatic glasses identified with random three-digit codes and were presented monadically following a Williams design. The consumers were asked to rinse

their mouths with water between each sample. Data acquisition and analysis was performed by Compusense five release 5.0.

Statistical analysis

An analysis of variance (one-way ANOVA) was applied to study the effects of digestion on the different instrumental and sensorial parameters studied. The least significant differences were calculated by the Tukey test and the significance at $p < 0.05$ was determined. The non-parametric Cochran's test analysis of variance was performed for each descriptor to evaluate whether the CATA question was able to detect differences in the consumer perception of the purees. A descriptor was no longer considered when Cochran's test found that the differences between samples were not significant. The variability in the frequencies of mention of significant attributes was analysed by using a Correspondence Analysis (CA) and a Multiple Factor Analysis (MFA) was performed on the frequency of mention of the CATA question to assess the relationship between CATA question responses and puree acceptability scores. Every calculation was carried out using XLSTAT 2009.4.03 (Addinsoft, Barcelona, Spain).

Results and discussion

Evolution of viscosity during in vitro digestion

In order to perform a real-time evaluation of the effect of saliva on the puree structure, its viscosity was recorded while being mixed with saliva, just after the first second of mixing. The viscosity values versus time are shown in Figure 1A.

As expected, the starch and the other hydrocolloids were observed to exhibit completely different profiles. The starch was selected as a model of an easily digested thickener that confers the ideal, appreciated creaminess expected in a puree. A complete structural

breakdown is observed in the gelatinized puree with starch. The first second that the saliva was added, a marked decrease in viscosity was observed, reaching a value close to 0 after 40 s. This breakdown of the gelatinized starch is due to the enzymatic effect of the alfa amylase present in saliva as it is reported before by many authors (Sanz & Luyten, 2006; Janssen et al., 2007; Hanson et al., 2012; Yousevi & Razavi, 2016).

In the other three purees, no enzymatic structural breakdown was observed and only a mild initial decrease in viscosity was observed during the first few seconds, associated with the shearing effect more than the effect of protein found in saliva. No studies about the effect of protein in saliva over hydrocolloids were found.

The structural changes undergone by the different purees during mixing with the simulated gastric fluid (SGF) can be seen in Figure 1B. A base line was found in the case of the puree with starch, as its structure was completely broken during the first few seconds of mixing with saliva, as explained before. The evolution of viscosity over time does not reveal a significant effect of the stomach conditions on the guar gum, carrageenan or HPMC. After the first 500s of mixing, the viscosity values of the three purees remain stable and similar.

HPMC and guar gum are non-ionic hydrocolloids; their structure, however, should be stable over a wider pH range than the structure of gums that are ionic in nature, such as carrageenan. The evolution of the viscosity values during their mixing with saliva and the stomach fluid reveal little change in viscosity, similarly to the effect found after mixing with saliva. In HPMC and guar gum, the viscosity values remained practically unaffected during the 30-minute mixing. In the carrageenan puree, a mild decrease in viscosity was found during the first 10 minutes of mixing; subsequently, a steady value was observed. This gentle decrease in viscosity in the puree with carrageenan could be associated with a decrease in its charge density due to the protonation of the carboxyl

groups. Lambda carrageenan is negatively charged under a wide range of pH values, and the pH of the medium has a significant impact on its charge density due to the protonation of the carboxyl groups.

Effect of *in vitro* digestion on the linear viscoelastic properties

The effect of *in vitro* digestion on the puree structure was also measured by studying the changes in the linear viscoelastic properties. The effect of frequency on the G' and G'' values of the guar, fresh purees with HPMC and carrageenan, prior to mixing with saliva, is shown in Figure 2A. Although the purees had a similar apparent viscosity, each one has its own particular viscoelastic properties conferred by the corresponding hydrocolloid. Before digestion, the puree with starch exhibited the highest viscoelasticity ($p < 0.05$) (lower $\tan\delta$ value and $G' > G''$ in all the frequencies studied) followed by the puree with carrageenan, the puree with guar gum and the puree with HPMC (Table 1). In the puree with guar gum, the end of the plateau zone at lower frequencies was observed in the available frequency sweep with the crossover of G' and G'' . In the HPMC, the G'' values were higher ($p < 0.05$) than the G' along the complete frequency sweep, with the crossover of G' and G'' denoting the start of the plateau zone observed at the highest available frequency. This predominance of G'' over G' in the puree with HPMC corresponds to an entangled solution and agrees with previous research into aqueous solutions of cellulose ethers where G'' values higher than G' were found below the gelling temperature (Sanz et al., 2005; Lodge et al., 2018).

In Figure 2 (B, C, D), the G' and G'' values of the purees with guar gum, HPMC and carrageenan, after their mixing with saliva, are shown. The sample with starch was not measured because a liquid slurry was obtained due to the effect of amylase, as has already been commented before. No effect of saliva was observed on the puree with

carragenan (Figure 2B). The puree with guar gum (Figure 2C) and the puree with HPMC (Figure 2D) exhibited a very small decrease in the viscoelastic functions after mixing with saliva although this decrease was not significant ($p>0.05$) (Table 1); this decrease could be due to dilution effect and not to the enzymes addition as can be shown in Table 1, where no significant differences ($p>0.05$) were found between saliva and saliva dilution (only water addition) in these samples. Similar results were found by Choi et al. (2014).

After 30 minutes of stomach incubation, a decrease was found in the viscoelastic properties of all the purees with hydrocolloid (Figure 2, (B, C, D)). A significant decrease ($p<0.05$) in G' , G'' and $\tan\delta$ was observed in all the purees (Table 1), although the differences were more noticeable for the purees with guar and HPMC than for the puree with carrageenan, especially in $\tan\delta$. In the puree with guar gum, the viscoelasticity went from a predominantly elastic system prior to digestion ($\tan\delta=0.63$) to a predominantly viscous system after digestion ($\tan\delta=1.4$). On the other hand, although a marked decrease ($p<0.05$) in the viscoelastic function was observed in the puree with carrageenan, the system remained predominantly elastic after stomach digestion ($\tan\delta$ passes from 0.51 in the fresh puree to 0.66 after digestion). The reason for the higher resistance of the puree with carrageenan, despite its ionic nature, may be associated with the establishment of any type of interaction of the carrageenan with the courgette constituents. Under simulated stomach digestion, carrageenan was able to form gels in combination with WPI, whereas guar gum was not (Zhang et al., 2014; Soukoulis et al., 2016).

In conclusion, the viscoelastic properties of the puree with carrageenan were the least affected after *in vitro* digestion, implying that it would produce a higher satiety effect in terms of stomach distension and delay of emptiness. The complete structural breakdown

of the puree with starch indicates that no effect of satiety associated with stomach distension or a delayed gastric emptying could be expected.

Sensory acceptability

The results of the acceptability of the four purees are shown in Figure 3. The puree with starch was the most acceptable as regards taste, consistency and global acceptability, exhibiting a significant difference ($p < 0.05$) with the other purees. The fact that the puree with starch obtained the highest acceptability ($p < 0.05$) values was expected, as this sample was selected as control because of its satisfactory sensory properties associated with the modification of starch (half crosslinked waxy modified corn starch) that gives the puree a great creaminess. In fact, it has been demonstrated that starches can provide enhanced creaminess in milk products, possibly because their enzymatic breakdown may also have beneficial effects on lubrication, due to the release of fat droplets from the starch matrix (de Wijk et al. ,2006). The puree with HPMC was the lowest-rated puree ($p < 0.05$). On the contrary, the taste, consistency and global acceptability scores of the puree with carrageenan were the closest to the puree with starch, followed by the puree with guar gum and then the puree with HPMC, which was the least acceptable ($p < 0.05$). As far as sample appearance is concerned, no significant differences were found ($p > 0.05$).

The results of expected satiety revealed no significant differences ($p > 0.05$) between the purees with carrageenan, HPMC and starch. To understand the effect of the puree with starch on expected satiety, one should consider the relationship between creaminess and expected satiety. In the case of the puree with starch, the expected satiety results found should be associated with its greater creaminess perceived in the mouth. Similar results

were found by Morell et al. (2014) when evaluating the expected satiety of milkshakes prepared with starch, guar gum and carrageenan.

When the percentages of consumers that would eat the purees in the different bowls were analyzed, it was found that 90%, 77% and 63% of consumers would eat a little bowl of HPMC, guar gum and carrageenan purees, respectively. As regards purees with starch, however, only 43% of the consumers would eat a little bowl and just 47% would eat a medium-sized bowl of this puree. This result could be related with expected satiety. The lower volume of bowl that consumers can eat, the more satiating the puree will be. Therefore, although no significant differences on expected satiety between the purees with carrageenan, HPMC and starch were found, only puree with carrageenan kept its structure more stable after the in vitro digestion, as can be seen in the results of the viscoelastic properties of purees.

CATA analysis

Check-all-that apply (CATA) questions is a technique that is being increasingly applied in food research. It consists of multiple-choice lists of words or phrases from which consumers select those they consider appropriate for describing the sample they have tasted. These terms included in the CATA questions were previously generated in a session with fifteen assessors by using the Repertory Grid method. They were first given some samples and then they were asked to choose and write down the most appropriate attributes which describe the characteristics of the samples. At the end of the session, a consensus on the list of sensory attributes was reached (Stone & Sidel, 2004). The main advantage of this type of questionnaire is that it allows multiple options to be selected instead of limiting respondents to only one answer or forcing consumers to focus their attention on specific attributes to be evaluated (Smyth et al.,

2006). Besides the list of words or phrases, the CATA questionnaire can include terms related to both sensory and non-sensory characteristics (Varela & Ares, 2012). In this study, five sensory terms (lumpy, gummy, creamy, thick, strange taste) and 2 non-sensory terms (“unappetising” and “satiating”) has been used. A non-parametric Cochran's test was used to study the significant differences in the frequencies of the seven attributes used to describe the purees. The frequencies of six of the seven attributes studied presented significant differences ($p < 0.05$) that indicates that these terms could be used to describe perceived differences in the four purees studied. Only the term “unappetising” did not present significant differences ($p > 0.05$).

Then, a Correspondence Analysis (CA) was performed with the frequency of mention of the six attributes that exhibited significant differences. The first two dimensions of the CA graph explained 96.54% of the total variability of the data set. The first and second dimensions represent 66.56% and 29.98% of the total variability, respectively. As can be observed in Figure 4 the term “gummy” and “satiating” was associated with the puree with HPMC, the term “strange taste” and “lumpy” with the puree with guar gum, while the puree with λ -carrageenan was linked to the terms “satiating” and “thick”. Sharma et al. (2017) also found carrot puree with carrageenan as the densest compared with purees with xanthan gum, gellan gum, CMC and starch. As was to be expected, the puree with starch was associated with the term “creamy”. Bearing the second dimension in mind, it may be seen how the purees elaborated using carrageenan and starch are grouped on the negative side of the axis, whereas those made with HPMC and guar gum are grouped on the positive side, related to the negative aspects.

In order to understand which sensory attributes were associated with acceptability, the frequency of mention obtained when using the CATA questions was studied in combination with the consumer acceptability data by means of a Multifactorial Analysis

(MFA) (Figure 5). The first two dimensions of the MFA represented 93.98% of the total variability of the experimental data. The first and second dimensions explain 58.73% and 35.15% of the total variability, respectively. The puree with starch was the one that the consumers liked the most ($p<0.05$) and was perceived as the creamiest sample, although the puree with carrageenan sample also approaches acceptability values that are linked to the attributes of consistency and satiating. The samples with the lowest acceptability ratings ($p<0.05$), however, were the purees with HPMC and guar gum due to the fact that they are associated with lumpy, gummy and with strange taste attributes.

Conclusions

The reformulation of a zucchini puree with λ -carrageenan hydrocolloid is a good option for the purposes of obtaining healthy food, without any significant modification to the sensory acceptability properties when compared to a sample of traditional puree with starch. Although purees with carrageenan, HPMC and guar gum presented similar expected satiety, in terms of structural resistance to *in vitro* digestion, the viscoelastic properties of puree with carrageenan were the least affected. And in addition, this puree showed similar acceptability scores to the traditional puree with starch. Therefore, carrageenan could be considered a good alternative thickener with which would be possible to increase the expected satiety properties of vegetable purees and even to thicken purees for patients with dysphagia.

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Table 1. Viscoelastic rheological parameters (1 Hz) of the fresh zucchini purees and after *in vitro* digestion.

Hydrocolloid added	Treatment	G' (Pa)	G'' (Pa)	Tan δ
Carrageenan	Fresh	110.27a (26.21)	56.14a (10.71)	0.512a (0.024)
	Saliva	141.25a (2.62)	70.32a (2.90)	0.498a (0.011)
	Saliva dilution	111.85a (13.08)	60.00a (1.43)	0.539a (0.047)
	Stomach	13.08b (1.05)	8.81b (0.50)	0.667b (0.016)
HPMC	Fresh	48.84a (2.90)	68.05a (82.62)	1.395a (0.029)
	Saliva	41.94a (6.63)	60.08a (7.61)	1.437a (0.046)
	Saliva dilution	35.06a (0.95)	52.56a (0.92)	1.501a (0.07)
	Stomach	2.26b (0.01)	8.15b (0.26)	3.606b (0.140)
Guar gum	Fresh	129.3a (15.41)	81.77a (5.76)	0.634a (0.031)
	Saliva	69.3a (0.74)	50.84a (0.34)	0.734a (0.003)
	Saliva dilution	84.61a (28.84)	58.77a (14.92)	0.706a (0.064)
	Stomach	10.53b (0.95)	14.95b (1.03)	1.422b (0.03)
Starch*	Fresh	193.9 (5.80)	30.43 (0.45)	0.157 (0.002)

Saliva dilution: only water was added instead of enzymes.

*Starch: rheological properties after saliva and stomach *in vitro* digestion was not

measured because a liquid slurry was obtained due to the effect of amylase after saliva addition.

Values between brackets are standard deviations.

^{abc}Means in the same column and for each puree without a common letter differ (P <

0.05) according to Tukey's test.

528 Figure 1. Evolution of viscosity over time after *in vitro* digestion (A: mouth digestion;
530 B: stomach digestion).

532 Figure 2. Mechanical spectra of the fresh purees (A) and purees after *in vitro* digestion
 534 (B: carrageenan; C: guar gum; D: HPMC).

536 Figure 3. Acceptability and expected satiety of the purees.

Figure 4. Representation of the terms and puree samples of the Correspondence Analysis performed on data from the CATA question.

Figure 5. Multiple factor analysis using acceptability scores and CATA data for consumers of purees.