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Baby purees elaborated with Andean crops. Influence of germination and oils in physico-chemical and sensory characteristics

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Abstract

Baby foods must be nutritious, semi-solid and of easy digestion. Quinoa and amaranth are a good source of macro and micronutrients. Germination can improve their nutritional properties; however, their technological and sensory characteristics are affected. The aim of this work was to develop purees formulated with non-germinated and germinated Andean grain flours (NGGF and GGF, respectively), and to evaluate their nutritional, technological and sensory characteristics. Formulations (9) with potato, pumpkin, and quinoa and amaranth flours (NGGF, GGF and mix of both) were analyzed. In each formulation soybean:sunflower, canola, and sunflower:chia oils were used. Chemical composition, water activity, pH, soluble solids, color, rheology and texture of purees, and *in vitro* protein digestibility of grain flours, were determined. Sensory characteristics of samples were studied using projective mapping. Nutritional content of purees did not differ, but the protein digestibility of grain flours improved with germination. Soluble solids and pH with GGF were higher and lower than purees with NGGF. GGF and canola oil caused deterioration in rheological and textural properties of the purees. The sensory evaluation differentiated the purees with NGGF,

GGF and mix of both; GGF worsened the sensory characteristics. Mixed flours and sunflower:chia oil were the best alternative to formulate baby purees.

Keywords

Quinoa; Amaranth; Technological properties; Rheological characteristics; Textural features

1. Introduction

Quinoa and amaranth are Andean grains with good nutritional profile. They have proteins and lipids of good biological quality, high content of dietary fiber, minerals, vitamins and bioactive compounds (Mir, Riar, & Singh, 2018). They are widely used for the preparation of foods such as pasta, breads, snacks, baby food (Alencar et al., 2017), among others. When these grains are germinated in an adequate environment the contribution and digestibility of nutrients can be improved (Khalil et al., 2007; Omary et al., 2012; Jan, Saxena, & Singh, 2016). Besides, the levels of antinutrients (saponins, tannins and phytates) can decrease during germination (Omary et al., 2012; Jan et al., 2016). However, during germination there is a weakening in the rheological performance of flours, due to the enzymatic breakdown of biopolymers. On the other hand, sensory characteristics can be improved or worsened depending on the type of crops and the germination conditions (Troszyήska et al., 2007; Nindo et al., 2007; Khalil et al., 2007; Jan et al., 2016; Sattar, Ali, & Hasnain, 2017; Aprodu et al., 2019).

Sprouts are pre-digested foods with easily absorbed nutrients. So, they are a good alternative for infant feeding. There are previous researches on the use of germinated grains in food formulation (Troszyήska, Szymkiewicz, & Wołejszo, 2007; Khalil et al., 2007; Jan et al., 2016; Marti et al., 2017; Agrahar-Murugka, Zaidi, & Dwivedi, 2018).

Breast milk is the best food until the first 6 months old; after, highly nutritious, digestible and safe complementary foods should be added. The energy and high digestibility protein intake in this age must be adequate to promote optimal growth and physical and mental development (Tiwari et al., 2016; Gan et al., 2018). Otherwise, the demand for ready-to-eat formulated baby foods has risen significantly with an increase in the number of working mothers (Ahmed and Ramaswamy, 2006 b).

Most of the weaning foods are semisolid with soft texture. The flow characteristics of infant foods must be thick enough to stay in the spoon, but not too thick as to make swallowing difficult (Alvarez & Canet, 2013; Sharma et al., 2017). These foods can be formulated with cereals, roots, tubers, vegetables and protein foods. Also, vegetable oils are added as a source of polyunsaturated fatty acid (PUFA) which in babies promote brain development, improves psychomotor performance and visual functions (Diallo et al., 2013). Besides, hydrocolloids are often used during preparation of puree to improve product stability and texture increasing viscosity, water retention, firmness and smoothness (Sharma et al., 2017).

Different researches about purees formulated with some foods show a gel behavior (Ahmed & Ramaswamy, 2006 a; Ahmed & Ramaswamy, 2006 b, Ahmed & Ramaswamy, 2007; Alvarez & Canet, 2013; Sharma et al., 2017). Nevertheless, there are no recent rheological and textural studies in puree for baby based on vegetable, fruit and cereal.

Furthermore, gluten-free mixtures are a good alternative for feeding children under 24 months old who suffer celiac disease or to avoid acquiring it (Cerezal Mezquita et al., 2011; Aronsson et al., 2015). So, Andean crops, like quinoa and amaranth, are an excellent gluten-free alternative for the formulation of infant foods in the complementary feeding stage due to its high biological value (good lipid and protein profiles) and, in addition, with functional properties (Nascimento et al., 2014).

Although the nutritional and technological characteristics are important parameters to formulate food products; the sensory evaluation also plays an important role. Sensory tests are performed to develop a new product, to improve it or identify its inherent sensory characteristics. Projective mapping is a rapid sensory descriptive methodology very useful in food product development and optimization. This technique allows panelists to express similarities and differences according to their own criteria. Besides, it allows grouping samples by placing them on a paper in a two-dimensional position (Pagès, 2005).

The aim of this work was to develop baby purees with improved nutritional characteristics and sensorially acceptable, incorporating as ingredients different oils and germinated and non-germinated quinoa and amaranth grain flours.

2. Materials and methods

2.1. Raw materials

2.1.1. Quinoa and amaranth grain flours

Quinoa (Cica variety) and amaranth (Mantegazzianus variety) grains were obtained from "Centro de Investigación y Desarrollo Tecnológico para la Agricultura Familiar" (CIPAF), Hornillos, Jujuy-Argentina. The grains were washed and the saponin of quinoa was removed by successive washes, with manual friction until bitter taste was eliminated, using tap water at room temperature (Ogungbenle, 2003). The washed grains were dried in a forced circulation oven (50ºC, until constant weight) and milled in a centrifugal mill (CHINCAN model FW 100, China) to obtain the non-germinated grain flours (NGGF).

2.1.2. Germinated quinoa and amaranth grain flours

Quinoa and amaranth were germinated according to Hager, Mäkinen & Arendt (2014) and Aphalo, Martínez & Añón (2015) respectively, with slight modifications. The washed grains were soaked in tap water (6 h, at room temperature). The wet grains were incubated by covering them with wet filter paper (22-24ºC, 80-90% RH, in darkness) 24 and 48 h for quinoa and amaranth, respectively. The germinated grains were dried in a forced circulation oven (50ºC, until constant weight) and then were milled in a centrifugal mill to obtain the germinated grain flours (GGF).

2.1.3. Potato and pumpkin

The Andean potato (Collareja variety) was obtained from CIPAF; the pumpkin was provided by regional producers. The vegetables were washed, and pumpkin was cut into small pieces. Then, the potatoes and pieces of pumpkin were cooked in boiling water (20 min), peeled and processed with a commercial food processor to prepare the purees.

2.1.4. Oils

Different oils were used to studied differences in physico-chemical, rheological, textural and sensory features due to their different fatty acid profiles. Soybean:sunflower (19:1), canola and sunflower:chia (2:1) oils were used for the formulations. Soybean:sunflower (19:1) is an oil marketed in that way in the region with high ω6 content. Canola is commercial oil with high ω3 and ω9 contents. On the other hand, sunflower:chia oil (2:1) was prepared by adding chia oil to commercial sunflower oil to increase the ω3 content in the purees.

2.1.5. Other ingredients

Citric acid, ascorbic acid, sugar and xanthan gum were obtained from local stores.

2.2. Purees formulation

The constant parameters of the experimental design were the amounts of potato, pumpkin, sugar, xanthan gum, citric and ascorbic acids, and water. The variables studied to evaluate the changes that occur in the chemical composition, physicochemical, rheological, textural and sensory properties of the formulated purees were flour type (NGGF, GGF and NGGF:GGF ratio 1:1) and oil type (soybean:sunflower, canola and sunflower:chia) used for the formulations of the purees. The amounts of grain flours and oil added in the purees were determined by preliminary sensory tests.

Nine purees (P) were formulated with Andean potato and pumpkin without skin (40 and 13 g, respectively), sugar (0.5 g), xanthan gum (0.1 g), citric acid (0.03 g), ascorbic acid (0.07 g), distil water (35 mL) and 0.5 mL of different oils: soybean:sunflower, canola and sunflower:chia ("A", "B" and "C", respectively). The following purees were obtained: purees with NGGF (PNGGF), purees with GGF (PGGF); and purees with NGGF and GGF (1:1), represented by "1", "2" and "3", respectively. So, the flours used were: a) 7.0 g of quinoa and 4.0 g of amaranth (PA1, PB1, PC1), b) 7.0 g and 4.0 g of germinated quinoa and amaranth (PA2, PB2, PC2) and c) combination 1:1 of non-germinated and germinated quinoa (3.5 g of each) and non-germinated and germinated amaranth (2.0 g of each) (PA3, PB3, PC3). The manufacturing process was as follow: potato, pumpkin, sugar and quinoa and amaranth flours were weighed. The xanthan gum was previously dissolved in hot water and then mixed with the other ingredients. The mixture was cooked for 20 min at boiling temperature (Shumoy & Raes, 2017); then citric and ascorbic acids, and oil were added. Finally, hot purees were packed in glass flasks with screwed metal caps and autoclaved (119ºC, 15 min).

2.3. Chemical composition

The chemical composition of purees was determined by official techniques (AOAC, 2018): Moisture (method 925.10), ash (method 923.03), lipid (method 963.15), total nitrogen (method 920.87). Nitrogen-protein conversion factors of 6.25 were used. Carbohydrate was determined by difference (Jan et al., 2016).

2.4. Protein digestibility

In vitro protein digestibility of grain flours was determined by AOAC 971.09 method modified (Miller, 2002). Defatted flours (1 g) were digested with 150 mL of pepsin solution in HCl 0.075 mol/L (0.002 mL/L) and incubated in shaking bath (45ºC, 16 h). The digested samples were vacuum-filtered and washed three times with water and acetone. In the residue, the nitrogen content was determined by Kjeldahl method (AOAC 920.87). The determination with free solution of pepsin was considered as blank.

2.5. Physical properties of the purees

2.5.1. Water activity

Water activity (aw) was determined in an instrument Aqua Lab Model 3 TE (Decagon Devices. Inc., USA) (± 0.003 of precision and ± 0.001 of resolution).

2.5.2. pH

The pH was determined by AOAC 945.27 method (2018). Solutions of each puree were prepared in distilled water (0.1 g/mL) and the pH was determined with a digital Ultra Basic pH Benchtop Meters (Denver Instrument, USA).

2.5.3. Soluble solids

Soluble solids were determined by AOAC 932.12 method (2018) in a refractometer Polish Optical Words model RL2 (Warszawa, Poland). Approximately 20 g of puree was filtered through cotton cloth and the percolated liquid was used for the determination of soluble solids. The results were expressed in Brix degrees (°Brix).

2.5.4. Color

Color was evaluated with Color Quest XE colorimeter (Hunter Lab, USA) and the following values were measured: L* (lightness, 100=white; 0=black), a* (-a=greenness; +a=redness), b* (-b=blueness; +b=yellowness), hue angle h*= arctan (b*/a*) and color saturation $C^* = [(a^{*2}) + (b^{*2}]^{1/2}$ (Francis, 1975; Maskan, 2001). The color was expressed with L*, h* and C*. The instrument was calibrated with standard white and black tiles.

2.6. Rheological measurements

The rheological characterization of purees was performed with MCR 301 rheometer (Anton Paar, Austria). Rheological data were collected using Rheo Plus software version 3.21 (Anton Paar). The following tests were performed: stress sweeps, frequency sweeps and flow curves.

The viscoelastic properties of the purees were determined using serrated parallel plates and sensor geometry of 50 mm of diameter with a gap of 1 mm. Before measurements were performed, samples remained 300 s between the plates for temperature equilibration at 25ºC.

2.6.1. Stress sweeps

Stress sweeps were run following a logarithmic stress increase from 0.1 to 100 Pa (σ) at a constant frequency and temperature (1 Hz and 25.0±0.5ºC, respectively).

2.6.2. Frequency sweeps

The mechanical spectrum of the samples was obtained using frequency sweeps from 0.1 to 10 Hz (f) at a constant stress within the linear viscoelastic range as well as at a constant temperature (0.1 Pa and 25.0±0.5ºC, respectively). The applied stress was selected to guarantee the existence of linear viscoelastic response according to the previously performed stress sweeps carried out in the same conditions.

The storage (G′) and the loss (G″) modulus values were recorded.

2.6.3. Flow Curves

Shear rate (γ) was increased logarithmically from 0.01 to 50 s^{-1}in 50 s, maintained 300 s, and followed by a linear decrease from 50 to 0.01 s^{-1}in 50 s. Each sample underwent a shearing cycle.

Flow curves were fit to the model of Herschel-Bulkley for their characterization. Flow behavior index (n) and consistency coefficient (K) were determined according the Herschel-Bulkley equation: $\sigma = \sigma_o + K\gamma^n$.

2.7. Mechanical properties

Texture profile analysis (TPA) was conducted using a TA-XT Plus Texture Analysis (Stable Micro Systems, UK). The baby food purees were analyzed for different textural characteristics (hardness, adhesiveness, gumminess and chewiness).

The samples (50 g) were subjected to compressive force by probe up to the distance of 5 mm, with a 6.35 mm P/0-25 stainless steel cylindrical probe. The conditions set in the texture analyzer were: pre-test speed 0.5 mm/s; post-test speed 1.0 mm/s; two penetration cycles, penetration depth of 16 mm; test time of 3 s; trigger force 49 N. Texture analysis was done at 25 °C.

2.8. Sensory evaluation

Sixteen individuals with considerable experience as sensory assessors using descriptive analysis of different food products were selected. Nevertheless, they did not receive any specific training in the products under study prior to the evaluation. Assessors evaluated the samples with the projective mapping technique. Rapid sensory techniques as projective mapping can be performed by assessors without specific training (Pagés, 2005; Albert et al., 2011).

Each assessor received all purees (approximately 10 g each) in plastic cups marked with a random three-digit code. They were asked to observe, smell and taste the samples and arrange them on a sheet of paper (A3, 60x40 cm) according to their differences and similarities, following their own criteria. The only rule they had to follow was “the more similar the samples, the closer they should be on the sheet”. The assessors were asked to write down comments to describe the samples or groups of samples according to their relevant sensory characteristics (Perrin et al., 2008).

2.9. Statistical analysis

2.9.1. Chemical composition, protein digestibility and physical properties

The experiments were done in triplicates. Chemical composition, protein digestibility and physical properties were analyzed by Kruskal Wallis non-parametric test with Dunn's multiple comparison. The median ± typical deviation was reported.

2.9.2. Projective mapping

The product positioning (X, Y coordinates) were measured in centimeters considering the bottom left corner of the paper sheet as the origin of the coordinates (0,0) (Pagès, 2005). The elicited words provided by assessors in the projective mapping were qualitatively analyzed by triangulation (consensus among three researchers after separate data processing). Frequency of mention of each attribute for each sample was determined by counting the number of assessors that used those words to describe it. The frequency of mention of repeated attributes and synonyms was combined and considered as a single variable when doing the data analysis. Only attributes mentioned by more than 10% of the assessors were considered.

Data table was analyzed by a multiple factorial analysis (MFA) using the table of coordinates (X and Y) as active variables; and the table of frequencies containing the descriptive terms was considered as a supplementary variable, thus not contributing to the conformation of the MFA factors (Pagès, 2005).

Hierarchical Cluster Analysis (HCA), using Euclidean distances and Ward's aggregation criterion, was carried out in order to identify groups of samples with similar characteristics.

All statistical analyses were performed with XL-Stat 2017 software (Addinsoft™, Paris, France).

3. Results and discussion

3.1. Chemical composition

Table 1 shows the chemical composition of the purees. The samples did not show significant differences in the moisture, ash, lipid, protein and carbohydrate contents.

The dietary reference intake (DRI) of proteins according to the Food and Nutrition Board (FNB, 2005) for babies from 7 to 12 months is 1.2 g/kg/day; so, a puree portion (100 g) would cover 21% of the DRI. Therefore, the purees formulated with germinated and non-germinated grain flours with different oils would be nutritionally suitable for babies.

These results agreed with other authors (Omary et al., 2012; Kanensi et al., 2011). However, other researches informed an apparent increase in ash and protein content due to the loss of dry matter (Khalil et al., 2007) or reduction of the lipid content (Devi, Kushwaha, & Kumar, 2015).

Protein and fat contents were similar than those reported by Alvarez y Canet (2013) for purees with rice and vegetables. On the other hand, the formulated purees had protein and fat contents similar and higher, respectively, than those reported by Ahmed and Ramaswamy (2006 b) for vegetable (pea, corn, and wax bean) baby purees.

3.2. Protein digestibility of grain flours

The protein digestibility of grain flours was significantly improved with germination from 61.3 ± 0.4 to 87.1 ± 0.4 and from 71.6 ± 4.3 to 85.3 ± 2.6 for quinoa and amaranth respectively, possibly due to hydrolysis of proteins in small molecules. This increase was also observed by Omary et al. (2012) and Khalil et al. (2007) in quinoa, amaranth, millet, corn and sorghum, chickpea, among others. So, the digestibility of the elaborated PGGF would improve, which is favorable for the infant consumers.

Gan et al. (2018) explained that the infant digestive system cannot fully hydrolyze proteins during the first two years of life. Therefore, protein digestion is critical for babies and the use of predigested foods, such as sprouted grain flours, could be a good alternative to formulate food products for these age groups.

3.3. Physical properties of purees

Table 2 shows the physical properties of purees. The water activities of all purees were higher than 0.90.

The PGGF presented a lower pH than those made with combined flours, followed by PNGGF. The release of fatty acids during germination could be responsible for the higher acidity of PGGF (Bewley, 2001). The pH values were within the range of baby vegetables purees reported by Alvarez & Canet (2013).

The soluble solid contents of the purees were between 10.5 and 14.7 ºBrix; which were higher than the ones informed by Ahmed and Ramaswamy (2007) and Santos et al. (2017). The PGGF showed soluble solid contents higher than the PNGGF. The starch hydrolysis during germination could be the cause of the increase in °Brix because of the release of soluble sugars. The starch and protein hydrolysis could cause rheological changes (lower consistence and viscosity).

The total or partial substitution of non-germinated grain flours by germinated grain flours produced changes in lightness (L*), hue angle (h*) and color saturation (C*) of the purees. No tendency was observed in the change of L* and h* with the replacement of non-germinated grain flours with germinated grain flours. The lipid oxidation is influenced by the fatty acid profile; therefore, it was different in the purees elaborated with the different oils. Lipid oxidation and its interaction with amino acids to form brown color polymer could occur during cooking (Agustini, 2017). On the other hand, PGGF had more color saturation than PNGGF. This possibly occurred due to the greater degree of Maillard and caramelization reactions during thermal treatments due to the higher reducing sugar and free amino acid content in the grain flours after germination.

3.4. Rheological measurements

Figure 1 and 2 show the variation of G', G" and G"/G' of the purees PA1, PA2, PA3 as response to dynamic stress and frequency sweep. Storage modulus (G') was higher than loss modulus (G") over the entire range of stress (0.1-100 Pa log) and frequency (0.1-10 Hz log) for all samples. These results indicated that all purees had a weak gel structure with a predominance of elastic over viscous behavior. As values of G"/G' gives a relative measure of lost energy versus stored energy in the cyclic deformation, the formulated purees were characterized as weak gels because G"/G'<1.0 (Ahmed & Ramaswamy, 2006 a; Ahmed & Ramaswamy, 2006 b; Alvarez & Canet, 2013; Cornejo et al., 2019). So, these products were more elastic than viscous, which would be a favorable feature to stimulate the swallowing of the babies (Sharma et al., 2017).

Stress sweep showed G' values between 4140-5580 Pa and G" at 740-927 Pa in formulated PNGGF, while for PGGF the G' values were 2880-3440 Pa and 550-734 Pa for G". The reduction of the G' and G" modules with the use of GGF in the puree could be related to the decrease in the starch content and the hydrolysis of high molecular weight proteins during germination, which produced a weaker food matrix and a more fluid behavior (Cornejo et al., 2019). The purees with mixed flours showed a similar behavior to the purees with GGF.

The frequency sweep showed the same tendency as with the stress sweep between purees formulated with NGGF, GGF and a combination of both flours for different oils. The results obtained are similar to those reported by Wu et al. (2013) for purees elaborated with flours of different cultivars of non-germinated and germinated rice. Moreover, the results were similar to those informed by Sharma et al. (2017) for carrot purees with different hydrocolloids.

Figures 2a, 2b and 2c show the flow curves of purees. The flow curves had non-Newtonian fluid characteristics and pseudoplastic behavior, in which viscosity (η) was dependent on shear rate (gradual deformation by shear stress).The flow curves (Figure 2a, b and c) were modeled using the Herschel-Bulkley model with an acceptable fit (R^2 0.90-0.96), which coincides with that reported by Ahmed and Ramaswamy (2007). A pseudoplastic behavior ($n<1$) was observed with flow behavior index (n) from 0.57 to 0.73 for PNGGF and between 0.88 and 0.98 for PGGF and mixed of flours (Table 2). Therefore, the PGGF showed a behavior less pseudoplastic than PNGGF. The lower content of high molecular weight polymeric structures of PGGF could be the reason for this behavior. The flow curves of PGGF and purees with the combination of flours had lower values of shear stress for the same shear rate in relation to the PNGGF. These downwards displacements of the curves indicated greater fluidity due to the enzymatic hydrolysis of starch and proteins. The flow index values of the formulated purees were similar to those shown by Nindo et al. (2007) for different fruit purees; furthermore, they also observed that the flow index increased with the total solid content.

The maximum viscosity values obtained from the shear stress sweep (apparent viscosity η_a) of PNGGF were higher than PGGF and mixed flours, because during germination the starch and proteins were hydrolyzed (Table 2). The apparent viscosity values of PNGGF were like those reported by Sharma et al. (2017).

The consistency coefficient (K) of PNGGF was superior due to the higher content of proteins and starch, and the lower content of soluble solids, than in PGGF. The consistency values obtained for PGGF were comparable to those reported for meat-based purees by Ahmed and Ramaswamy (2007). The results agreed with Nindo et al. (2007) who reported a decreased in K with the increase in soluble solids.

The measurement of increasing and decreasing shear rates for different formulated purees showed hysteresis loops (Figure 2a, b and c); therefore, all the purees had a thixotropic behavior. This type of food is characterized by a decrease in viscosity with increasing the shear rate with time (Alvarez & Canet, 2013; Amiryousefi & Razavi, 2013). The thixotropic behavior prevents the slimy mouthfeel of foods; therefore, the characterization of time-dependent rheological properties of food systems is important to establish relationships between structure and flow, and to correlate physical parameters with sensory evaluation (Alvarez & Canet, 2013; Yang et al., 2017; Sharma et al., 2017).

The PNGGF showed higher hysteresis than those formulated with combined flours or with GGF because enzymatic hydrolysis reduces the starch content and the molecular weight of proteins. Starch needs more time to reach an equilibrium viscosity when there is a change in the shear rate. On the other hand, the PGGF contained more sugar due to the hydrolysis of the starch, which caused greater deformation of food matrix for the same shear stress; however, the structures were more stable and, therefore, had less thixotropy. Lack of thixotropy in formulated purees could promote a viscous sensation in mouth (Yang et al., 2017). Therefore, the purees with GGF were characterized by low swallowing difficulty, because the low shear stress determined, favorable situation for infants. Enzymatic hydrolysis reduced the starch content and the molecular weight of proteins, with a consequently decreasing in shear stress.

The same behavior was observed among the purees with different flours with the same oil. On the other hand, the values of shear stress for the same shear rates, and apparent viscosity values (Table 2) were lower for the purees made with canola oil (Figure 2b) followed by those of soybean:sunflower and sunflower:chia oils (Figure 2a and 2c, respectively). Starch-fatty acid complexes formed during puree elaboration could have influence on their viscosity. The high concentration of oleic acid in the canola oil would not allow the formation of these complexes, since the oleic acid is not easily included in the amylose helices (Zheng et al., 2018).

3.5. Texture profile analysis

Table 3 shows the parameters resulting from force-time curves. PGGF had significantly less hardness and adhesiveness than PNGGF; possibly, the hydrolysis of the starch and protein caused less polysaccharide chain network within the food matrix (Sharma et. al., 2017).

The gumminess and chewiness did not show significant differences among purees formulated with GGF, NGGF or mixed flours with the same oil.

On the other hand, all textural properties of PNGGF with sunflower:chia oil were higher than those formulated with soybean:sunflower and canola oils. This behavior occurred possibly due to the interaction between macromolecules of NGGF with the oil, so a higher amount of work was necessary to make a food sample ready to swallow. The purees elaborated with germinated and mixed grain flours did not show significant variation on textural properties according to the type of oil used due to the macromolecule’s hydrolysis.

3.6. Sensory analysis of formulated purees

The descriptive terms were those mentioned by the assessors. There were 51 different descriptive terms with appearance frequency greater than 10% (Figure 3a). The first two dimensions of MFA accounted for 57% of the variance (Figure 3a and b). HCA highlighted four groups of samples according to their inherent sensory characteristics (Figure 3b). Purees made only from NGGF (GI) were described with: low odor, heterogeneous texture, firm, slightly sweet and mild flavor, and cereal/pumpkin/fruity flavor. Purees made from GGF (GII) had unpleasant flavor, bitter flavor, intense flavor and odor, slightly acid, vegetable odor, corn flavor and with aftertaste.

The complete or partial (50%) replacement of NGGF with GGF affected the sensory attributes of the purees in a negative way. Sensory alteration depends mainly on the types of sprouts (Troszyήska et al., 2007) and the germination conditions (Khalil et al., 2007).

Khalil et al. (2007) explained that the overall sensory scores of chickpeas increased with the first (24 h) sprouting interval and then decreased. On the other hand, Sattar et al. (2017) observed that the replacement of more than 25% of the rice flour by germinated legumes to prepare pudding caused a decrease in acceptability.

The purees formulated with a mixture of NGGF and GGF (1:1) were located with intermediate characteristics among those made with NGGF and GGF (Figure 3, groups GIIIa and GIIIb). However, they differed according to the different types of oil. The puree with mixed flours made with canola oil (sample 6) was more tasty and it had higher density and adhesiveness determined by assessors than those formulated with soybean:sunflower and sunflower:chia oils (Figure 3, samples 3 and 9 respectively). The sensory characteristics of the purees formulated with GGF could be improved with different proportions of substitution or by incorporating additives that mask the flavor of the products.

In addition, the use of mixed flours with NGGF and GGF improved the digestibility of the products (Khalil et al., 2007; Omary et al., 2012; Jan et al., 2016) with an intermediate effect on the sensory characteristics of the product.

The sensory differences in color, consistency, texture and stickiness among samples on group GI and GII presented correlation with instrumental measurements (color, rheological behavior and texture characteristics). This result agreed with those informed by Sharma et al. (2017).

4. Conclusion

The use of different oils and non-germinated or germinated quinoa and amaranth flours in the formulated purees for babies produced variability in their physical, rheological and textural properties. These changes were detected by sensory assessors.

Purees had chemical composition, and physico-chemical, rheological and textural features suitable for babies' consumption and like to other researches. Besides, elaborated purees had soft texture and viscoelastic characteristics that favor the swallowing of these age groups.

On the other hand, germination improved protein digestibility. However, purees made with germinated grain flours did not have a good sensory description by assessors; nevertheless, the purees made with the combination of non-germinated and germinated grain flours, with different oils, were positively described in the sensory evaluation.

Therefore, a purée elaborated with the mixed flours and sunflower:chia oil could be the most suitable for babies.

Rheological studies could be deepened to define an optimal combination of the different proportions of non-germinated and germinated grain flours. Besides, the effect of the addition of other ingredients (such as dry milk or essences) to improve the sensory properties of the formulated baby purees could be studied in order to obtain an "ideal product".

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References

Agrahar-Murugka, D., Zaidi, A., & Dwivedi, S. (2018). Development of gluten free eggless cake using gluten free composite flours made from sprouted and malted ingredients and its physical, nutritional, textural, rheological and sensory properties evaluation. *Journal of Food Science and Technology*, 55(7), 2621-2630.

Agustini, S. (2017). Color development in complex model system on various time and temperature. *Journal of the Dinamika Penelitian Industrial*, 28(1), 1-9.

Ahmed, J., & Ramaswamy H.S. (2006 a). Viscoelastic properties of sweet potato puree infant food. *Journal of Food Engineering*, 74, 376-382.

Ahmed, J., & Ramaswamy H.S. (2006 b). Viscoelastic and thermal characteristics of vegetable puree-based baby foods. *Journal of Food Process Engineering*, 29, 219-233.

Ahmed, J., & Ramaswamy, H.S. (2007). Dynamic rheology and thermal transitions in meat-based strained baby foods. *Journal of Food Engineering*, 78, 1274-1284.

Albert, A., Varela, P., Salvador, A., Hough, G., & Fiszman, S. (2011). Overcoming the issues in the sensory description of hot served food with a complex texture. Application of QDA, flash profiling and projective mapping using panels with different degrees of training. *Food Quality and Preference*, 22, 463-473.

Alencar, N.M.M., Carvalho de Morais, E., Joy Steel, C., & Bolini, H.M.A. (2017). Sensory characterization of gluten-free bread with addition of quinoa, amaranth flour and sweeteners as an alternative for coeliac patients. *International Journal of Food Science and Technology,* 52(4), 872-879.

Alvarez, M.D., & Canet, W. (2013). Time-independent and time-dependent rheological characterization of vegetable-based infant purees. *Journal of Food Engineering,* 114(4), 449-464.

Amiryousefi, M.R., & Razavi, S.M.A. (2013). Viscous flow behavior, microstructure and physicochemical characteristics of a sweet paste functional dessert (*samanu*) made from germinated wheat. *Journal of Food Process Engineering*, 36, 385-396.

AOAC, Association of Official Analytical Chemists. Methods of Analysis (AOAC). http://www.aoac.org/, [2018].

Aphalo, P., Martínez, N., & Añón, M.C. (2015). Amaranth Sprouts: A Potential Health Promoting and Nutritive Natural Food. *International Journal of Food Properties*, 18, 2688-2698.

Aprodu, I., Vasilean, I., Muntenită, C., & Patrascu, L. (2019). Impact of broad beans addition on rheological and thermal properties of wheat flour-based sourdoughs. *Food Chemistry*, 293, 520-528.

Aronsson, C.A., Lee, H., Liu, E., Uusitalo, U., Hummel, S., Yang, J., … Agardh D. (2015). Age at Gluten Introduction and Risk of Celiac Disease. *Pediatrics*, 135(2), 239-245.

Bewley, J.D. (2001). Seed Germination and Reserve Mobilization. Encyclopedia of Life Sciences. John Wiley & Sons, Ltd. Ontario, Canada.

Cerezal Mezquita, P., Urtuvia Gatica, V., Ramírez Quintanilla, V., Romero Palacios, N., & Arcos Zavala, R. (2011). Product development based on cereal and legume flours for celiac children between 6 and 24 months; I: Formulation and acceptability. *Nutricion Hospitalaria*, 26(1), 152-160.

Cornejo, F., Novillo, G., Villacrés, E., & Rosell, C.M. (2019). Evaluation of the physicochemical and nutritional changes in two amaranth species (*Amaranthus quitensis* and *Amaranthus caudatus*) after germination. *Food Research International*, 121, 933-939.

Devi, C., Kushwaha, A., & Kumar, A. (2015). Sprouting characteristics and associated changes in nutritional composition of cowpea (*Vigna unguiculata*). *Journal of Food Science and Technology,* 52(10), 6821-6827.

Diallo, M., Cissé M., Dessor F., Soulimani R., Sock O., & Desobry S. (2013). Formulation of Infant Food Based on Local Cereals: Stability and Effects on Cognitive Development. *Journal Nutrition and Food Science,* 3:4.

Food and Nutrition Board (FNB). (2005). Dietary Reference Intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids (Macronutrients). *Institute of Medicine of the National Academies*. The National Academies Press. Washington D.C., 1331.

Francis, F.J. (1975). The origin of tan-1 a/b. *Journal of Food Science*, 40, 412.

Gan, J., Bornhorst, G.M., Henrick, B.M., & German, J.B. (2018). Protein digestion of baby foods: study approaches and implications for infant health. *Molecular Nutrition & Food Research*, 62(1) (doi:10.1002/mnfr.201700231).

Hager, A.S., Mäkinen, O.E., & Arendt, E.K. (2014). Amylolytic activities and starch reserve mobilization during the germination of quinoa. *European Food Research and Technology*, 239(4), 621-627.

Jan, R., Saxena, D.D., & Singh, S. (2016). Physico-chemical, textural, sensory and antioxidant characteristics of gluten-Free cookies made from raw and germinated Chenopodium (*Chenopodium album*) flours. *LWT-Food Science and Technology,* 71, 281-287.

Kanensi, O.J., Ochola, S., Gikonyo, N.K., & Makokha, A. (2011). Optimization of the period of steeping and germination for Amaranth Grain. *Journal of Agriculture and Food Technology,* 1(6), 101-105.

Khalil, A.W., Zeb, A., Mahmood, F., Tariq, S., Khattak, A.B., & Shah, H. (2007). Comparison of sprout quality characteristics of desi and kabuli type chickpea cultivars (*Cicer arietinum L.*). *LWT - Food Science and Technology,* 40, 937-945.

Marti, A., Cardone, G., Nicolodi, A., Quaglia, L., & Pagani, M.A. (2017). Sprouted wheat as an alternative to conventional flour improvers in bread-making. *LWT-Food Science and Technology* (doi: 10.1016/j.lwt.2017.02.028).

Maskan, M. (2001). Kinetics of colour change of kiwifruits during hot air and microwave drying. *Journal of Food Engineering*, 48(2), 169-175.

Miller E.L. (2002). Determination of Nitrogen Solubility in Dilute Pepsin Hydrochloric Acid Solution of Fishmeal: Interlaboratory Study. *Journal of AOAC International*, 85(6), 1374-1381.

Mir, N.A., Riar, C.S., & Singh, S. (2018). Nutritional constituents of pseudo cereals and their potential use in food systems: A review. *Trends in Food Science & Technology*, 75, 170-180.

Nascimento, A.C., Mota, C., Coelho, I., Gueifão, S., Santos, M., Matos, A.S., … Castanheira, I. (2014). Characterisation of nutrient profile of quinoa (*Chenopodium quinoa*), amaranth (*Amaranthus caudatus*), and purple corn (*Zea mays L.*) consumed in the North of Argentina: Proximate, minerals and trace elements. *Food Chemistry*, 148, 420-426.

Nindo, C.I., Tang, J., Powers, J.R., & Takhar, P.S. (2007). Rheological properties of blueberry puree for processing applications. *LWT-Food Science and Technology,* 40, 292-299.

Ogungbenle, H.N. (2003). Nutritional evaluation and functional properties of quinoa (Chenopodium quinoa) flour. *International Journal of Food Sciences and Nutrition,* 54, 153-158.

Omary, M.B., Fong, C., Rothschild, J., & Finney, P. (2012). Effects of Germination on the Nutritional Profile of Gluten-Free Cereals and Pseudocereals: A Review. *Cereal Chemistry,* 89(1), 1-14.

Pagès, J. (2005). Collection and analysis of perceived product inter-distances using multiple factor analysis: Application to the study of 10 white wines from the Loire Valley. *Food Quality and Preference,* 16(7), 642-649.

Perrin, L., Symoneaux, R., Maître, I., Asselin, C., Jourjon, F., & Pagès, J. (2008). Comparison of three sensory methods for use with the Napping® procedure: Case of ten wines from Loire valley. *Food Quality and Preference,* 19(1), 1-11.

Santos, L.C.O., Simão, V., Santos Opuski de Almeida, J., Moura de Sena Aquino, A.C., Carase, E., & Amante, E.R. (2017). Study of Heat Treatment in Processing of Pumpkin Puree (*Cucurbita moschata*). *Journal of Agricultural Science,* 9(10), 234-243.

Sattar, D., Ali, T.M., & Hasnain, A. (2017). Effect of Non-germinated and Germinated Legumes on Antioxidant, Functional, and sensory Characteristics of Rice Puddings. *Cereal Chemistry,* 94(3), 417-423.

Sharma, M., Kristo, E., Corredig, M., & Duizer, L. (2017). Effect of hydrocolloid type on texture of pureed carrots: Rheological and sensory measures. *Food Hydrocolloids,* 63, 478-487.

Shumoy, H., & Raes, K. (2017). Tef: The Rising Ancient Cereal: What do we know about its Nutritional and Health Benefits?. *Plant Foods for Human Nutrition,* 72, 335-344.

Tiwari, S., Bharadva, K., Yadav, B., Malik, S., Gangal, P., Banapurmath, C., … Agrawal, Rk. (2016). Infant and Young Child Feeding Guidelines. *Indian Pediatrics,* 53, 703-713.

Troszyήska, A., Szymkiewicz, A., & Wołejszo, A. (2007). The effects of germination on the sensory quality and immunoreactive properties of pea (*Pisum Sativum l.*) and soybean (*Glycine max*). *Journal of Food Quality,* 30, 1083-1100.

Wu, F., Chen, H., Yang, N., Wang, J., Duan, X., Jin, Z., & Xu, X. (2013). Effect of germination time on physicochemical properties of brown rice flour and starch from different rice cultivars. *Journal of Cereal Science*, 58, 263-271.

Yang, H., Li, X., Gao, J., Tong, P., Yang, A., & Chen, H. (2017). Germination-assisted enzymatic hydrolysis can improve the quality of soybean protein. *Journal of Food Science* (Doi: 10.1111/1750-3841.13782).

Zheng, M., Chao, C., Yu, J., Copeland, L., Wang, S., & Wang, S. (2018). Effects of chain length and degree of unsaturation of fatty acids on structure and *in vitro* digestibility of starch-protein-fatty acid complexes. *Journal of Agriculture and Food Chemistry*, 66(8), 1872-1880.

Figure Captions

Figure 1. Curves of the rheological tests of the studied purees PA1, PA2, PA3

(a) G’ and G’’ modules of the dynamic stress sweeps; (●) G'(PA1), (■) G"(PA1), (▲) G'(PA2), (▼) G"(PA2), (♦) G'(PA3), (○) G"(PA3).

(b) Tangent (G"/G') of the dynamic stress sweeps; (●) G"/G'(PA1), (■) G"/G'(PA2), (▲) G"/G'(PA3).

(c) G’ and G’’ modules of the dynamic frequency sweeps; (●) G'(PA1), (■) G"(PA1), (▲) G'(PA2), (▼) G"(PA2), (♦) G'(PA3), (○) G"(PA3).

(d) Tangent (G"/G') of the dynamic frequency sweeps; (●) G"/G'(PA1), (■) G"/G'(PA2), (▲) G"/G'(PA3).

PA1: purees with non-germinated grain flours with soybean:sunflower oil; PA2: purees with germinated grain flours with soybean:sunflower oil; PA3: purees with mixed grain flours (1:1) with soybean:sunflower oil.

Figure 2. Flow curves of different studied purees

(a) Purees with soybean:sunflower oil (●) G''/G'(PA1), (■) G''/G'(PA2), (▲) G''/G'(PA3).

(b) Purees with canola oil (●) G''/G'(PB1), (■) G''/G'(PB2), (▲) G''/G'(PB3).

(c) Purees with sunflower:chia oil (●) G''/G'(PC1), (■) G''/G'(PC2), (▲) G''/G'(PC3).

PA1, PB1, PC1: purees with non-germinated grain flours; PA2, PB2, PC2: purees with germinated grain flours; PA3, PB3, PC3: purees with mixed grain flours (1:1).

Figure 3. Samples configuration with Multiple Factor Analysis (MFA)

a) Attribute Plot. **b)** Sample Plot.

Ellipses on the Sample Plot show the grouping obtained from Hierarchical Cluster Analysis (HCA).

1, 4, 7: purees with non-germinated grain flours; 2, 5, 8: purees with germinated grain flours; 3, 6, 9: purees with mixed grain flours (1:1); 1, 2, 3: purees with soybean:sunflower oil; 4, 5, 6: purees with canola oil; 7, 8, 9: purees with sunflower:chia oil.

Table Captions

Table 1. Chemical composition of the different studied purees

Table 2. Physical properties of the different studied purees

Table 3. Texture Profile Analysis of the different studied purees

Table 1. Chemical composition of the purees

Sample	Moisture	Ash	Proteins	Lipids	Carbohydrates
PA1	83.0±0.8^{a}	0.69±0.06^{a}	2.14±0.06^{a}	0.77±0.07^{a}	13.4
PA2	82.0±0.1^{a}	0.78±0.08^{a}	2.61±0.06^{a}	0.70±0.03^{a}	13.9
PA3	81.6±0.4^{a}	0.79±0.03^{a}	2.52±0.09^{a}	0.83±0.18^{a}	14.2
PB1	82.5±0.7^{a}	0.64±0.03^{a}	2.31±0.02^{a}	0.92±0.19^{a}	13.7
PB2	82.4±0.1^{a}	0.78±0.19^{a}	2.41±0.05^{a}	0.89±0.11^{a}	13.5
PB3	82.0±0.3^{a}	0.68±0.04^{a}	2.44±0.04^{a}	0.69±0.19^{a}	14.2
PC1	82.2±0.5^{a}	0.65±0.06^{a}	2.23±0.06^{a}	0.90±0.16^{a}	14.0
PC2	81.2±0.5^{a}	0.77±0.12^{a}	2.44±0.07^{a}	0.74±0.12^{a}	14.8
PC3	82.9±0.2^{a}	0.69±0.10^{a}	2.18±0.04^{a}	0.80±0.06^{a}	13.4

Values are median ± typical deviation (g/100g wb) from triplicate analysis.

Different superscript letters in the same column indicate significant differences ($p<0.05$).

PA1, PB1, PC1: purees with non-germinated grain flours; PA2, PB2, PC2: purees with germinated grain flours; PA3, PB3, PC3: purees with mixed grain flours (1:1); PA1, PA2, PA3: purees with soybean:sunflower oil; PB1, PB2, PB3: purees with canola oil; PC1, PC2, PC3: purees with sunflower:chia oil.

Table 2. Physical properties of the purees

Sample	aw (25 °C)	pH	ºBrix	Color			n	K (Pa.s)	η_a (Pa.s)
				L*	h*	C*			
PA1	0.992 ± 0.002^{b}	5.83 ± 0.02^{bc}	11.1 ± 0.6^{ab}	67.1 ± 0.4^{ab}	1.354 ± 0.005^{a}	51.2 ± 0.7^{a}	0.63 ± 0.07^{ab}	290 ± 3^{d}	7.0 ± 0.5^{b}
PA2	0.991 ± 0.002^{ab}	5.34 ± 0.03^{a}	13.9 ± 0.8^{cd}	64.7 ± 0.7^{a}	1.331 ± 0.003^{a}	59.7 ± 1.4^{bc}	1.00 ± 0.04^{d}	105 ± 1^{ab}	3.0 ± 0.3^{a}
PA3	0.991 ± 0.002^{ab}	5.67 ± 0.02^{abc}	12.1 ± 0.6^{bc}	68.6 ± 0.4^{abc}	1.362 ± 0.006^{ab}	58.1 ± 0.9^{abc}	0.98 ± 0.01^{d}	103 ± 2^{ab}	2.6 ± 0.4^{a}
PB1	0.990 ± 0.001^{a}	5.85 ± 0.03^{bc}	12.5 ± 0.9^{bc}	69.9 ± 1.5^{abcd}	1.386 ± 0.010^{abc}	55.3 ± 0.3^{ab}	0.73 ± 0.03^{abc}	179 ± 2^{cd}	4.6 ± 0.2^{ab}
PB2	0.991 ± 0.001^{ab}	5.55 ± 0.03^{a}	14.7 ± 0.3^{d}	72.2 ± 0.3^{d}	1.403 ± 0.004^{bc}	64.9 ± 0.3^{c}	0.98 ± 0.02^{d}	96 ± 1^{a}	3.2 ± 0.1^{a}
PB3	0.991 ± 0.001^{ab}	5.68 ± 0.04^{abc}	13.1 ± 0.4^{bcd}	71.5 ± 0.3^{bcd}	1.406 ± 0.001^{c}	62.6 ± 0.2^{bc}	0.95 ± 0.03^{cd}	109 ± 1^{abc}	3.2 ± 0.2^{a}
PC1	0.990 ± 0.001^{a}	6.02 ± 0.03^{c}	10.5 ± 0.5^{a}	69.2 ± 0.8^{abcd}	1.369 ± 0.005^{abc}	52.5 ± 1.1^{a}	0.57 ± 0.01^{a}	412 ± 2^{e}	9.4 ± 0.4^{c}
PC2	0.992 ± 0.002^{b}	5.60 ± 0.03^{ab}	11.7 ± 0.4^{bc}	72.5 ± 1.1^{d}	1.411 ± 0.013^{c}	63.9 ± 0.8^{c}	0.88 ± 0.02^{bcd}	114 ± 1^{abcd}	3.6 ± 0.3^{ab}
PC3	0.990 ± 0.002^{a}	5.68 ± 0.03^{abc}	11.5 ± 0.5^{abc}	71.8 ± 0.7^{cd}	1.389 ± 0.007^{abc}	57.9 ± 0.4^{abc}	0.82 ± 0.02^{bcd}	159 ± 2^{bcd}	4.9 ± 0.3^{ab}

Values are median ± typical deviation from triplicate analysis. Different superscript letters in the same column indicate significant differences ($p<0.05$).

L*: lightness; h*: hue angle; C*: chroma; PA1, PB1, PC1: purees with non-germinated grain flours; PA2, PB2, PC2: purees with germinated grain flours; PA3, PB3, PC3: purees with mixed grain flours (1:1); PA1, PA2, PA3: purees with soybean:sunflower oil; PB1, PB2, PB3: purees with canola oil; PC1, PC2, PC3: purees with sunflower:chia oil; n:behavior index; K: consistency coefficient; η_a: apparent viscosity.

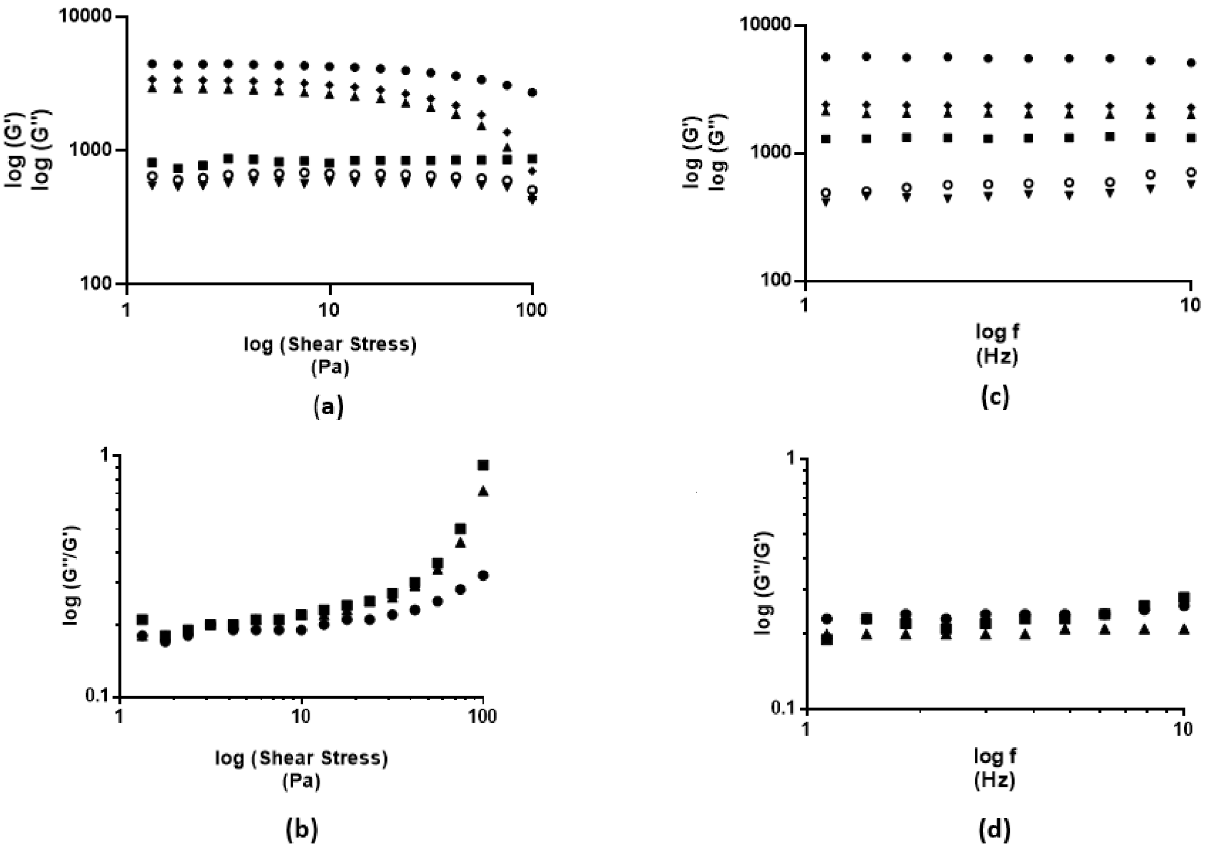
Table 3. Texture Profile Analysis of the purees

Sample	Hardness (N)	Adhesiveness (N)	Gumminess (N)	Chewiness (N)
PA1	132±7^{c}	787±12^{d}	94±7^{bc}	91±8^{bc}
PA2	113±5^{ab}	493±13^{a}	79±8^{abc}	78±6^{abc}
PA3	119±4^{b}	621±12^{bc}	83±5^{abc}	81±7^{abc}
PB1	112±4^{ab}	750±17^{cd}	83±5^{abc}	80±7^{abc}
PB2	96±4^{a}	588±17^{ab}	71±9^{a}	70±8^{a}
PB3	99±8^{a}	709±13^{bcd}	63±9^{a}	61±7^{a}
PC1	194±4^{d}	1194±15^{e}	123±6^{c}	116±7^{c}
PC2	98±5^{a}	546±13^{ab}	75±4^{ab}	74±6^{abc}
PC3	113±5^{ab}	738±11^{cd}	76±7^{ab}	72±6^{ab}

Values are median ± typical deviation from triplicate analysis.

Different superscript letters in the same column indicate significant differences ($p<0.05$).

PA1, PB1, PC1: purees with non-germinated grain flours; PA2, PB2, PC2: purees with germinated grain flours; PA3, PB3, PC3: purees with mixed grain flours (1:1); PA1, PA2, PA3: purees with soybean:sunflower oil; PB1, PB2, PB3: purees with canola oil; PC1, PC2, PC3: purees with sunflower:chia oil.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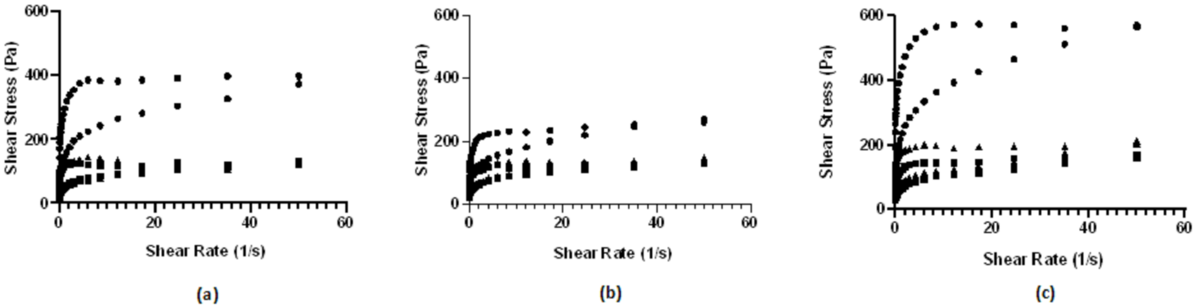
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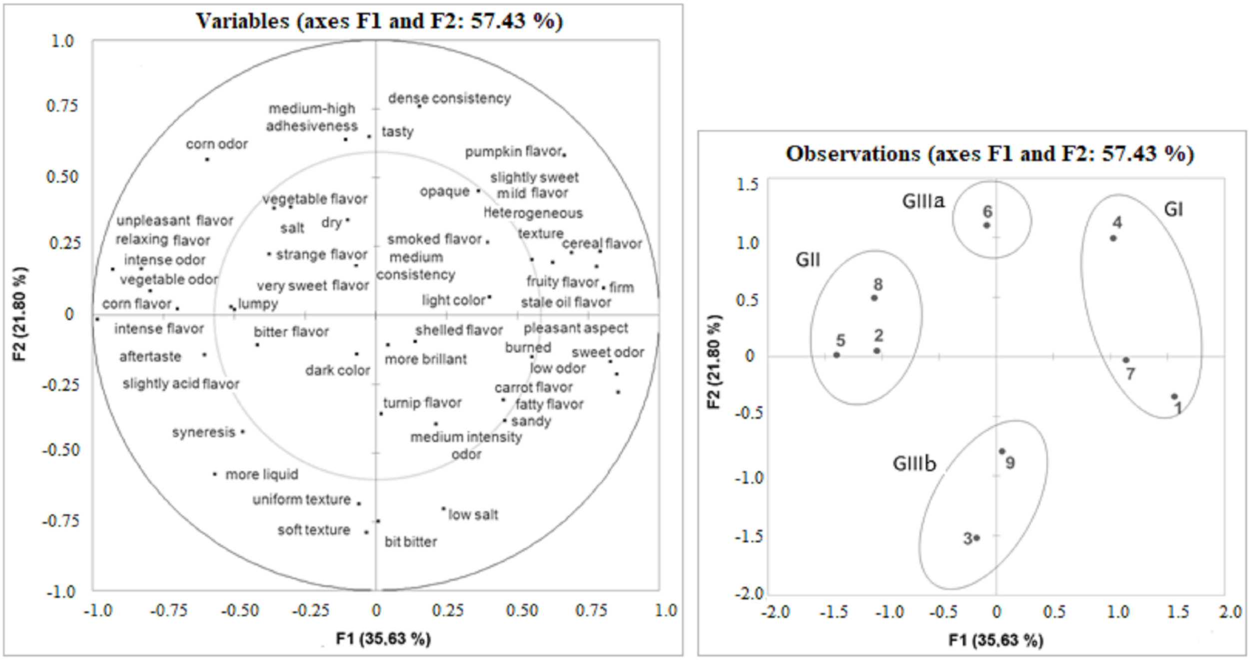
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F2 (21.80 %)
F1 (35,63 %)
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1.0
dense consistency
medium-high adhesiveness
tasty
corn odor
pumpkin flavor
slightly sweet
mild flavor
opaque
vegetable flavor
Heterogeneous texture
unpleasant flavor
salt
dry
relaxing flavor
smoked flavor
cereal flavor
intense odor
strange flavor
medium consistency
vegetable odor
fruity flavor
firm
very sweet flavor
corn flavor
lumpy
light color
stale oil flavor
intense flavor
bitter flavor
shelled flavor
pleasant aspect
burned
sweet odor
aftertaste
more brillant
dark color
low odor
slightly acid flavor
carrot flavor
fatty flavor
turnip flavor
sandy
syneresis
medium intensity odor
more liquid
uniform texture
low salt
soft texture
bit bitter
Observations (axes F1 and F2: 57.43 %)
F2 (21.80 %)
F1 (35,63 %)
1.5
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GIIIa
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GI
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GII
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1
GIIIb
9
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(a)

(b)

Highlights

1) Germination improved *in vitro* protein digestibility of the quinoa and amaranth grains

2) Germination decreased consistency, viscosity, hardness and acceptability of purees

3) Elaborated purees presented the pseudoplastic behavior characteristic of baby foods

4) Nongerminated:Germinated grain flours were the best nutritional and sensorial option