Methodology for design of suitable dishes for dysphagic people

Gorka Merino [a]; Inmaculada Gómez [b]; M Remedios Marín-Arroyo [a]; María José Beriain [a]; Francisco C Ibañez [a,*]

[a] Research Institute for Innovation & Sustainable Development in Food Chain, Universidad Pública de Navarra, Pamplona, Spain

[b] Department of Biotechnology and Food Science, Universidad de Burgos, Burgos, Spain

Highlights

- A method to adapt conventional dishes for dysphagic people was developed.
- Acceptability of adapted dishes was evaluated by cerebral palsy dysphagic people.
- Sensory analysis was fundamental in the selection of texturizing agents.
- Instrumental and sensory texture analyses were useful to study the thermostability.
- Mixtures of xanthan-based additives led to suitable and stable dishes.

Abstract

A methodology to adapt dishes for cerebral palsy (CP) dysphagic people was developed. Five conventional dishes were cooked, blended and texturized with mixtures of thickeners and gelling agents based on xanthan gum. The most appropriate texturizing agents were selected, the textural thermostability of the dishes was studied, and the shelf-life was evaluated by back extrusion, sensory and microbiology analysis. Information about the acceptability of the adapted dishes by CP dysphagic people was obtained through the control of the consumed fraction and the liking or disliking reaction after eating the dishes. The adapted dishes considered suitable for swallowing process showed maximum force between 6.2(0.1) N and 18.9(3.3) N, minimum force between -3.9(0.3) N and -9.2(1.3) N, and F_{min}/F_{max} ratio between 0.4(0.0) and 0.7(0.0). Regarding sensory characteristics, the adapted dishes showed low stickiness, residue and firmness, and high suitable texture score. The methodology was appropriate for developing suitable dishes, sensorially accepted by dysphagic people, thermostable for 7 days refrigerated storage and ready-to-eat.

Industrial relevance

This study presents the technological basis for the standardized design of suitable ready-to-eat dishes for dysphagic people. The methodology developed is of great interest to the industry of ready-to-eat dishes.

Key words: dysphagia; cerebral palsy; texture-modified; textural thermostability; sensory analysis; shelf-life

[*] Corresponding author at: Campus Arrosadia sn, Research Institute for Innovation & Sustainable Development in Food Chain, (IS-FOOD), Universidad Pública de Navarra. 31006 Pamplona, Spain

E-mail address: pi@unavarra.es (F.C. Ibañez)

1. Introduction

Dysphagia is the chronic disturbance in the swallowing process and has origin in pathological conditions. Untreated dysphagia can severely compromise the normal feeding and hydration. People who suffer dysphagia have a higher risk of malnutrition and dehydration (Manduchi et al., 2019). In general population, the prevalence of oropharyngeal dysphagia varies (depending on the participant selection, screening or assessment tools) between 2.3 % and 16.0 %, and it rises with age, up to 26.7 % for people older than 76 years (Baijens et al., 2016). More than 30 % of the hospitalized elderly patients with dysphagia have malnutrition, which implies a lower functional capacity (Carrión et al., 2015) and an increase in the mortality risk (Lindroos et al., 2014). In the case of people with cerebral palsy (CP), the symptoms of dysphagia are more severe than among patients with other neurological illness (Parkinson's disease or amyotrophic lateral sclerosis). CP dysphagic adults experience a body mass index (BMI) decrease as compared to healthy people. The longer the meal time, the greater the loss of BMI, which is associated to a more severe level of dysphagia (Yi et al., 2019). In the case of CP dysphagic children, between 46 % (Scarpato et al., 2017) and 90 % (Penagini et al., 2015) show malnutrition.

A strategy to alleviate the adverse effects on people with dysphagia is feeding with texture-modified foods (TMF). This modification eases the intake of nutrients in accordance with the requirements of the dysphagic people, improving their nutritional status. TMF for dysphagia are obtained basically by three different strategies. The first one is to provide a diet based on purée obtained by mechanical blend. The second one is to thicken liquids chemically (addition of texturizing polymers). Both strategies present disadvantages, such as the deficiency of certain nutrients like proteins (O'Keeffe, 2018). The third strategy, the most complex and least studied one, consists to adapt the texture of complex dishes (Costa et al., 2019; Houjaij et al., 2009). Standardization and protocol are necessary in order to facilitate the elaboration of the adapted dishes in hospitals or nursing homes. In spite of guidelines and classifications for TMF (Cichero et al., 2017), there are no easy and effective standardized culinary processes for the adaptation of the texture of complex dishes or solid foods. A few methods to adapt the texture have been developed: Houjaij et al. (2009) suggested a freezing and texturizing combination and Nakatsu et al. (2012) proposed a combination of recoating and macerating with enzymes. Both are complex methods to adapt the food texture. This lack of standardization may lead to variations in nutrient contents, consistency, appearance, and acceptability (Keller et al., 2012).

Setting-up the suitable texture characteristics are necessary to design and develop new foodstuffs or dishes (culinary preparation with two or more ingredients) for dysphagic people. For this purpose, several methods have been proposed: methods based on instrumental techniques, notably uniaxial extrusion test (Ibañez et al., 2019), descriptive sensory analyses performed by healthy people (Hall & Wendin, 2008; Vickers et al., 2015) or integrated methods combining instrumental and sensory analysis (Brenner et al., 2014; Houjaij et al., 2009; Vickers et al., 2015; Wendin et al., 2010). Foegeding et al. (2011) pointed out the convenience of the integration of the physical and physiological elements. Thus, the integrated method to analyze the texture of suitable foodstuffs combines instrumental and sensory analysis (Foegeding et al., 2011; Houjaij et al., 2009). This strategy was used by different authors (Brenner et al., 2014; Wendin et al., 2010) to study the effectiveness of the combined instrumental and sensory tests to analyze the TMF. To sum up, as previously reported, the foodstuffs for dysphagic people have to be physiologically suitable. Likewise, it is critical to design TMF that, stored at chilled conditions, prevent health risks, since the dysphagic people are more susceptible to illnesses due to their compromised immune systems. In addition, the TMF should have a high sensory quality to be appealing and to increase the acceptability by dysphagic people. In this context, the main aim of the present work was to design a methodology to develop suitable dishes for CP dysphagic people. The specific objectives of this study were: (*i*) to investigate the aptitude of dishes for texturing, and propound a method to select the most appropriate texturizing agents to obtain suitable dishes for dysphagic people; (*ii*) to assess the textural thermostability of the suitable dishes and their sensory acceptability by CP dysphagic people; (*iii*) to determine the shelf-life of the suitable dishes using microbiological, instrumental and sensory texture analyses.

2. Material and methods

2.1. Raw material

Five dishes were selected by speech therapists of ASPACE Navarra Foundation (Spanish Cerebral Palsy Foundation, Cizur Menor, Navarre, Spain) for the difficulty to be texturized. The five dishes were selected from the habitual menu of ASPACE, chickpea stew (CS), lentils with rice (LR), chicken stew (ChS), halibut with green sauce (H) and pasta bolognese (PB), because they showed stickiness and residue properties.

The dishes were elaborated by the catering company Irigoyen Comedor Saludable S.L. (Pamplona, Spain), with ingredients from local market, in ASPACE Navarra Foundation facilities. All ingredients and the cooking methods are detailed in Table S1 (Supplementary materials).

Mixtures of thickeners and gelling agents are considered texturizers (Whaley et al., 2019). They were supplied by Tecnoalimentación HELA SL (Berriainz, Navarre, Spain). All mixtures contained xanthan gum (XG) in combination with other food additives such as guar gum (GG), agar-agar (AA) or maltodextrin (ML), all of them, legally authorized (European Commission, 2013). The information about the mixtures and their usage is collected in Table 1. GG and AA were selected for their thickening and gelling effect, respectively. XG was chosen because it confers a thermostable texture to the heated foods (Rahmati et al., 2018) and it enhances the effect of the hydrocolloids in the food texture (Hayakawa et al., 2014). Based on preliminary trials, ML was added in combination with other texturizing agents to reduce residue formation and to increase viscosity. Olive oil was incorporated to the texturizing agents when it was necessary to obtain a lubricating effect. The final composition of the tested mixtures depended on the physicochemical characteristics and the recipe of each dish.

2.2. Dishes elaboration

All the adapted dishes were prepared according to the procedure described below. Once the dish was cooked as specified by its cooking method (Table S1, Supplementary materials), it was blended using a kitchen robot (Blixer® 6V.V, Robot Coupe® SNC, Vincennes, France) at 314.2 rad/s. The following blending times were applied: chickpea stew 3.5 min; lentils with rice, 8 min; and chicken, halibut and pasta bolognese, 12 min. The blended dish (control dish, C; C1-C5) was poured in a kitchen robot Thermomix® TM5 (Vorwerk España M.S.L., S.C., Madrid, Spain). Texturizing agents were added, it was stirred at medium speed 4.5/10 (over 115.2 rad/s) and the temperature was increased up to 100 ºC. Dishes were poured in a polypropylene container. To achieve desired food texture modification, the temperature was reduced from 100 ºC to 17.5 ± 2.5 ºC for 45 min using a blast chiller Edenox (EFFICOLD S.A., Córdoba, Spain). For instrumental and microbiological analysis, dishes were transported to the Universidad Pública de Navarra laboratory in isothermal containers. After that, the dishes were stored at 5 ºC in a refrigerator (Liehberr, Ind Met S.A., Pamplona, Spain) until further analysis.

2.3. Design of the study

Study was developed in three stages (Fig. 1) and Table 1 shows the mixtures of texturizing agents used in each stage.

At stage 1, the suitability of the five control dishes (cooked and blended) to be textured was investigated using a line-spread test. Then, a total of fifteen mixtures of texturizing agents were evaluated by instrumental (back extrusion test) and sensory texture analyses (by trained panel) in order to select the most appropriate mixture for each dish. At this stage, the range of suitable texture score for CP dysphagic people was established.

At stage 2, the textural thermostability of the suitable and refrigerated (5 ± 2 ºC) dishes, which were selected at stage 1, was characterized at 0 and 3 days using instrumental (back extrusion test) and sensory textural analyses (by trained panel). The dishes were reheated at 45 ± 5 ºC (700 W for 1 min) using a microwave before analysis. At this stage, the acceptability of the adapted dishes by CP dysphagic people was assessed on day 0.

At stage 3, a shelf-life determination was performed for the selected five adapted and refrigerated (5 ± 2 ºC) dishes at 0, 3 and 7 days. The cooled dishes were reheated at 45 ± 5 ºC before analysis. Parameters of microbiological, instrumental (back extrusion test) and sensory textural (by trained panel) analyses were evaluated.

2.4. Instrumental analysis

The instrumental analyses were performed for heated samples to the expected temperature of consumption (45 ± 5 ºC) using a microwave of 700 W from Lacor WHITE (Lacor Menaje Profesional S.L., Guipuzkoa, Spain) for a minute.

2.4.1. Back extrusion test (BET)

The back extrusion test (BET) was performed in a texturometer TA.XT2i Plus Texture Analyzer (Stable Micro System Ltd., Surrey, UK) according to the method described by Ibañez et al. (2019). The uniaxial extrusion force was measured at 5 mm/s. BET data including the maximum (F_{max}) and minimum (F_{min}) forces to extrude at 30 mm, N; and F_{min}/F_{max} ratio (as absolute value) were collected via Exponent Lite v.6.1. software (Stable Micro Systems Ltd., Surrey, UK). Each analysis was run in triplicate.

2.4.2. Line-spread test

A modification of the line-spread test for thickened liquids (Y.-H. Kim et al., 2018) was used to evaluate the flow distance of blended dishes. A range of flow distance was measured to assess the adequate consistency of blending dishes in order to add the texturizing agents. The test was carried out using a horizontal template marked with concentric circles separated 0.5 cm between their radiuses. A metal cylinder, with a diameter of 6.5 cm and a height of 4.5 cm, was placed in its center (the cylinder diameter was the same one than the first circle of the template). The cylinder was filled with sample of the blended dish. When temperature of the sample dropped to 50 ± 5 ºC (temperature that the dishes reach after blending process), the cylinder was lifted in order to minimize time of analysis. After 20 s, the flow distance (cm) was measured. Five repetitions of the analysis were performed for each dish.

2.5. Sensory analysis

The sensory analyses were performed at the ASPACE Navarra Foundation. The dishes for sensory analysis were evaluated at the expected temperature of consumption (45 ± 5 ºC).

2.5.1. Sensory analysis by trained panel

Texture of adapted dishes was evaluated by a trained panel composed of five speech therapists from the ASPACE Navarra Foundation, experienced in CP dysphagia. Fifteen training sessions of 60 min were necessary. The attributes like firmness, cohesiveness, fluidity, stickiness, residues and suitable texture score were chosen, and their definition and evaluation method were established by consensus during the training sessions (Table S2 in Supplementary materials). The perceived intensity was evaluated by a continue scale with 5-points and verbal anchors at the ends (very low, 1; very high, 5). The way of swallowing process of the CP dysphagic people was kept in mind during analysis. This sensory analysis was used to establish the suitability and characteristics of the adapted dishes for CP dysphagic people. In individual sessions, sensory analysis for each dish was performed at service temperature (45 ± 5 ºC).

2.5.2. Acceptability of adapted dishes for CP dysphagic people

The acceptability of the adapted dishes was obtained through the control of the consumed fraction and the liking or disliking reaction after eating the dishes. Participants were CP dysphagic people from the ASPACE Navarra Foundation centres in Pamplona and Cizur (Navarre, Spain). A total of 59 CP dysphagic people (59.3 % men), with ages ranging from 5 to 71 years (32.9 years on average) were enrolled. The inclusion criterion was the absence of the food allergies. Their characteristics are collected in the Table S3 (Supplementary materials). People' relatives were informed about their participation. Assessments of the five control dishes and the five adapted dishes selected at stage 1 were performed at the same day of the elaboration (day 0).

The consumed fraction was calculated by weight difference between the served portion and the amount remaining in the plate at the final intake. The serving portion size varied between 165 g (chicken stew and halibut with green sauce) and 200 g (chickpea stew, lentils with rice, and pasta bolognese). Secondly, the speech therapists in charge of assisting the people affected by dysphagia during the meal, collected information about the level of liking of the dishes, asking the CP dysphagic people directly or interpreting their reactions to the intake. For this purpose, they used cards with three-point graphic scales materials (Fig. S1 in the Supplementary materials). This method was selected because the graphic scales are registered in the International Organization for Standardization (ISO) as a method normally used for speech impaired people (ISO, 2006). In addition to the facial expressions, a comment section was added for speech therapists. These comments served to justify the score in the pictograms when participants would like to explain it. After acceptability data collection, each card pictogram was assigned a score for statistical evaluation (Stone et al., 2012): 1, "I like extremely" (happy face or thumb up hand); 2, "I neither like nor dislike" (neutral face or boy and girl); 3, "I dislike extremely" (angry face or thumb down hand).

2.6. Microbiological analysis

Microbiological analysis was performed for the refrigerated (5 ± 2 ºC) five selected adapted dishes (with the texturizing agents selected at stage 1) for 0, 3 and 7 days. Mesophilic aerobes at 30 ºC and coagulase-positive staphylococci (ISO, 1999) count were effectuated.

Salmonella spp, *Listeria monocytogenes* and *Enterobacteriaceae* count were performed with certificated methods (ISO, 2013). Microbiological limits established by legislation (European Commission, 2007) were used to guarantee the microbiological safety of the adapted dishes. Five repetitions of each dish were analyzed.

2.7. Statistical analysis

Data were assessed by descriptive and inference analysis according to procedures described by Devore (2016). Analysis of variance (ANOVA) was applied to parameters. Least Significant Difference (LSD) Fisher test ($P \leq 0.05$) was used to determine significant differences between multiple means. Paired *t*-Student test ($P \leq 0.05$) was carried-out to compare two means. A discriminant analysis (test of equality of means of Lambda Wilks groups; $P \leq 0.05$) was performed with the sensory data (firmness, cohesiveness, fluidity, adhesiveness, and residues), the suitable texture score and instrumental data (F_{max}, $F_{mín}$ and $F_{mín}/F_{max}$) to know the characteristics of adapted dishes. All statistical procedures were carried out using the SPSS 23.0 (IBM Corp., New York, USA).

3. Results and discussion

3.1. Stage 1: Selection of the texturizing agents

3.1.1. Consistency of the blended dishes for texturing

The consistency of the blended dishes was measured to obtain a range of spread distance, which describes the adequate consistency of the blended dishes for subsequent texturing process by adding texturizing agents. The line-spread test was applied because this method provides reproducible results to evaluate the consistency of fluid products (Y.-H. Kim et al., 2018). The spread distance of each blended dish is shown in Fig. S2 (Supplementary materials). The spread range was between 7.0 cm and 9.9 cm. The range was obtained with the blended dishes elaborated as detailed in section 2.2. The minimum distance corresponded to the ChS and the maximum one to the LR. Therefore, in the present study a range to evaluate the aptitude of control treatments (dishes cooked and blended) to be texturized were achieved. For this reason, if the flow of the dish exceeds the maximum limit of the range it will be too fluid and if it does not reach the minimum limit of the range it will be too thick to be texturized. In light of the data and considering the line-spread test as an effective method to measure the consistence and the expansion of fluid foods (S.-G. Kim et al., 2014b), it would be necessary to carry out more studies with different dishes in order to confirm that the obtained range in the present study is the adequate one.

3.1.2. Evaluation of texturizing agents

At stage 1, the effect of different texturizing agents (M1-M15) on the textural characteristics of control dishes was investigated. Fifteen mixtures of texturizing agents were tested in order to select the most suitable mixtures, using the BET and sensory analysis. The texturizing agents used in this stage and most suitable texturizing agents for each dish can be seen in Table 1.

Cooking losses of each dish during cooking process should be considered in order to obtain the necessary quantity of samples. After the blending, texturing and packaging processes the losses were 10-15 % in current study (data not shown). Likewise, the blending and texturing processes change the original appearance of the cooked dishes and acquiring a uniform and homogeneous texture (Fig. S3 in the Supplementary materials).

Changes in force-time curves by BET are shown in Fig. S4a (Supplementary materials). Anglioni & Collar (2009) reported that F_{max} and F_{min} are associated with firmness and cohesiveness of the sample, respectively. Cohesiveness is the force necessary to overcome the force of internal attraction between food molecules. However, in the present study F_{min} was called "adhesiveness", since it coincides with the cessation of contact between the probe and the sample, that is, with the force to separate the probe from the sample. The force values at 30 mm (N) for dishes elaborated at stage 1 are reported in Table 2. The control dishes had F_{max} values between 1.6 (0.0) N (LR-C2) and 5.4 (1.8) N (CS-C1). The control sample of chicken (ChS-C3) could not be analyzed due to logistic reasons. The F_{max} values increased in dishes after texturizing process, ranging from 8.4 (0.6) N (H-M15) to 14.1 (0.6) N (CS-M1). The higher F_{max}, the lower F_{min}. This can be explained because, the more force it takes to deform or break the sample, the more negative force is needed to separate the sample from the probe. That is, when exercising a higher F_{max}, the adhesive forces between probe and food will be greater. The control dishes had F_{min} values between -1.0 (0.0) N (LR-C2) and -2.9 (0.1) N (PB-C5). The F_{min} values of the adapted dishes ranged between -3.8 (0.4) N (H-M1) and -8.4 (0.9) N (ChS-M11). Regarding the F_{min}/F_{max} ratio, there were no significant differences ($P > 0.05$) between control dishes and adapted dishes, ranging between 0.5 and 0.8. F_{min}/F_{max} ratio explains the relation between stickiness and firmness. F_{min}/F_{max} ratios lower than 0.5 are obtained with high F_{max} values, which correspond with very rigid textures caused by a low amount of water (crumbly texture) or an excess of texturizing agents. F_{min}/F_{max} ratios higher than 0.9 are obtained with high F_{min} values (very low values), that is, with sticky textures that are produced by a low number of texturizing agents. Thus, dishes that have either of these two characteristics are not suitable for CP dysphagic people.

The results of sensory analysis at stage 1 are shown in Fig. 2. All samples from adapted dishes showed firmness values higher than those obtained from their controls. This may be due to the addition of texturizing agents such as XG, GG and AA, which increase the viscosity and firmness of the dishes to which they are added (Wüstenberg, 2014). The cohesiveness values of adapted dishes were higher than those of their controls due to the addition of XG and GG, which increase the cohesiveness of the foodstuffs (Brenner et al., 2014; Encina-Zelada et al., 2019). There were no significant differences ($P > 0.05$) among control dishes and adapted dishes for the fluidity and stickiness and the values obtained were high and low, respectively. The residue values were low-medium (1.5-3.0/5.0). The treatments PB-M12 and LR-M6 had lower residue values than those from its controls. This could be due to the increase of the cohesiveness, as result of the addition of the XG as previously explained. In the case of the dishes ChS-M12, H-M14 and H-M15, there was a tendency to lower residue values ($P > 0.05$) than their controls. In fish dish (H), the reduction in residue value was obtained by adding ML and XG. Several authors reported that the combination of ML and XG decreased the perception of residue (Bolivar-Prados et al., 2019; Ong et al., 2018). In the case of chicken, which was cooked with more carbohydrates content (potato), the ML and XG addition resulted in excessive firmness values. These values resulted in unsuitable dishes for dysphagia. Moreover, olive oil was used to decrease the intensity of residue of the treatment LR-C2. The olive oil provides higher creaminess and facilitates the intake of food with high carbohydrate content (Canet et al., 2015).

At stage 1, the texturizing agents were selected based only on the results of the suitable texture score. The higher suitable texture score values were for treatments CS-M1 (3.3), PB-M1 (4.0), LR-M6 (4.0), ChS-M12 (4.0), and H-M15 (3.9). All adapted dishes had higher suitable texture score values than those from control dishes, except for CS. These different results for CS could be explained because the texturizing agents were studied for *Maragato* variety and a different chickpea variety was used for the first elaboration of the CS treatments (C1 and M1-M4). When it was changed in subsequent stages (to *Maragato* variety), it was found that the adapted dishes were more suitable than control dishes. These adapted dishes selected were significantly firmer than their respective control. Regarding sensorial results, the adapted dishes showed low-medium firmness values, medium cohesiveness values, high fluidity values, and low stickiness and residue values. These results agree with previous studies that reported that foodstuffs intended for dysphagic people should have low firmness and stickiness and high fluidity during swallowing process (Hall & Wendin, 2008; Houjaij et al., 2009; Nakatsu et al., 2012)

3.2. Stage 2: Thermostability and acceptability evaluation

The textural thermostability after reheating was assessed during instrumental and sensory textural analyses (by trained panel). In addition, information about the consumed fraction and sensory of each treatment, with and without texturizing agents, were obtained.

3.2.1. Textural thermostability

The textural thermostability of the control dishes and the adapted dishes selected at stage 1 were evaluated for 3 days of refrigerated storage.

Table 3 shows the results obtained for the BET. The control dishes had F_{max} and F_{min} values similar to those obtained at stage 1. The treatments CS-M1 reached the highest F_{max} with 18.7 (1.7) N and ChS-M12 the lowest value with 6.8 (0.1) N. Regarding F_{min}, the lower negative values were obtained by CS-M1 with -11.5 (1.3) N and by ChS-M12 with (-4.3 (0.1) N. All values of ratio F_{min}/F_{max} ranged between 0.5 (0.0) of LR-M6 and 0.7 (0.0) of H-M15 and PB-M1. The values were similar to those of stage 1 and prove a good standardization of the process of elaboration of the adapted dishes. Time affected significantly (*P* < 0.05) the F_{max}, F_{min} and F_{min}/F_{max} (LR-C2), F_{min}/F_{max} (H-C4 and PB-C5), and F_{max} and F_{min} (ChS-M12, PB-M1, and LR-M6).

Fig. 2 shows the results of sensory analysis for the control dishes and adapted dishes at days 0 and 3. The adapted dishes had low firmness values and medium-high cohesiveness values. Both attributes values of adapted dishes were higher than those from their control dishes. The fluidity values were high and similar in control dishes and adapted dishes. The adapted dishes had stickiness and residue values lower than those from control dishes (*P* < 0.05). Time significantly affected (*P* < 0.05) the fluidity (ChS-C3), stickiness (ChS-M12), firmness (H-M15), and residue (H-C4 and LR-C2). Moreover, time did not affect (*P* > 0.05) the parameters of cohesiveness and suitable texture score of the adapted dishes for 3 days of refrigerated storage. The changes in some attributes did not adversely affect the suitability for swallowing of the adapted dishes. In addition to this, the suitable texture score values of the adapted dishes were higher (*P* < 0.05) than those from their control dishes. The suitable texture score values ranged from 4.1 to 4.6 and there were no significant differences for the 3 days of refrigerated storage (*P* > 0.05). Therefore, the adapted dishes selected at stage 1 were suitable for CP dysphagic people and stable for refrigerated storage.

Xanthan gum has been used to stabilize the texture of simple models such as water (Alves et al., 2017), binary models such as emulsions or starch gels (Krystyjan et al., 2013; Pocan et al., 2019), or simple food products such as hot soup (S.-G. Kim et al., 2014a), but not in complex foodstuffs. In the present study, the characteristic of suitable texture score for 3 days remained on dishes reheated at serving temperature (45 ºC) thanks to xanthan gum. These results confirm its ability to confer thermostability to the food matrix in which it is added (Liu & Xu, 2019). It should be noted that hydrocolloids have very low melting points and their viscosity is altered by the temperature of the oral cavity (Hayakawa et al., 2014).

3.2.2. Acceptability of adapted dishes for CP dysphagic people

The fraction consumed and the level of pleasure when consuming the control dishes and the adapted dishes were measured during consumption of the dishes as part of the daily meal.

The results of the consumed fraction are shown in Table 4. For the evaluation, only people whose consumed fraction was upward 60 % were considered. The LR-C2 was the dish with more people above the 60 % of consumed fraction (37) and H-M15 was the dish with less people (21). In the case of the H-m15, the reason why some people consumed less than 60 % was that they do not like fish and the texturization process increases its flavor (data collected in comment section, data not shown).

The CP dysphagic people's level of liking was collected by graphic scales. As other authors anticipated with people with intellectual disability (Maïano et al., 2009), the graphic scales help to transmit the CP people opinions about the dishes. The treatment LR-M6, with the smallest fraction consumed, was the worst rated ($P < 0.05$) for CP dysphagic people due to an excessive firmness and a slight stickiness perceived by people, who expressed it during the sensory analysis (data collected during meal, data not shown). These results agree with those established by other authors (Hall & Wendin, 2008), who declared that a sticky and very firm dish is not suitable for an appropriate swallowing process for dysphagic people.

The obtained results were positive, since although the trained panel detected differences between the control dishes and the adapted dishes, the CP dysphagic people accepted both types of dishes (control *vs*. adapted dishes) in a similar way. Taking into account that the CP dysphagic people are reluctant to accept changes in their dietary habits (ASPACE, 2018), the adapted dishes designed in the present study could be incorporated into their menu since no significant differences were found in the sensory perception of the adapted dishes selected at stage 1 compared to their control dishes.

3.3. Stage 3: Shelf-life

Microbiological analysis, BET and sensory analysis of the adapted dishes selected at stage 1, based on results of suitable texture score, were performed for 0, 3, and 7 days of refrigerated storage.

A count of 240 CFU/g total aerobic microorganisms was detected in LR-M6 at 7 days. This value is below the limit of the European standard (10^6 CFU/g). Moreover, the microbiological results (data not shown) did not show significant differences for the time ($P > 0.05$). Thus, the process of elaboration of the adapted dishes was microbiologically safe for at least 7 days of refrigerated storage.

Table 5 shows the results obtained for the BET of the adapted dishes selected at stage 1 and refrigerated for 0, 3 and 7 days. The highest F_{max} value was for CS-M1 at day 3 (18.9 N), and the lowest F_{min} value was for CS-M1 at day 0 (-9.2 N). Ibañez et al. (2019) classified foods for CP dysphagic people into three consistencies, soft, medium and hard, which corresponded with F_{max} values of 4.1 N, 7.8 N and 23.5 N, respectively. In the present study, the lowest F_{max} value was 6.2 N (LR-M6) and the highest F_{max} value was 18.9 N (CS-M1). Thus, the dishes of current study would be into the "medium" and "hard" consistency groups of the classification previously explained. There were no statistical differences ($P > 0.05$) by storage time, except for the treatment ChS-M12 in the parameters F_{max} and F_{min}, and the treatment H-M15 in the F_{min}/F_{max} ratio. These results show the textural thermostability established in 3 days in the adapted dishes at stage 2.

Fig. 4 shows the sensorial results by the trained panel of the adapted dishes, selected at the stage 1, for 0, 3, and 7 days of refrigerated storage. The firmness, stickiness and residue values were low, whereas cohesiveness and fluidity values were high. In addition to this, suitable texture score results were high. The lowest suitable texture score value was for PB-M1 at day 7 (4.4) and the highest one was for LR-M6 at day 0 (4.9). Similarity of the values obtained for the sensory attributes evaluated in the five adapted dishes can also be seen, which corroborates their similar texture characteristics. The correct standardization of the elaboration of the adapted dishes of the current study can be checked with the Fig. 4 since there were no differences ($P > 0.05$) by time for all adapted dishes.

The results of the shelf-life of the adapted dishes selected at stage 1 would confirm the commercial viability of these dishes for, at least, 7 days of refrigerated storage.

3.4. Multivariate analysis

Discriminant analysis was employed in an attempt to classify the adapted dishes of the present study. Two functions were generated by the analysis. Discriminant function F1 explained 85.9 % of the variance and it was characterized by positive F_{min} and stickiness values (0.9 and 0.2) and negative F_{max} and fluidity values (-0.8 and -0.3). As expected, F_{min} and stickiness were at the same axis since both are related. Discriminant function 2 explained 14.1 % of the variance and was related to positive suitable texture score and cohesiveness values (0.9 and 0.3) and negative firmness and residue values (-0.4 y -0.3). Applying the first two functions to the variables analyzed in the control dishes and the adapted dishes, the scatterplot in Fig. 5 was depicted. The dishes selected as suitable (green marks) were on the left and top part. This indicates that they had higher values for F_{max}, fluidity, cohesiveness and suitable texture score, and lower values for F_{min}, stickiness, firmness and residue compared to control dishes. Therefore, firmness, cohesiveness, fluidity, stickiness, residue and suitable texture score were the sensory attributes and F_{max} and F_{min} were the instrumental parameters that might be considered critical attributes to characterize the texture of dishes intended for dysphagic people.

Certain attributes to characterize foods intended for dysphagic people have been identified as important in the scientific literature. These parameters are the cohesiveness (Sukkar et al., 2018), low firmness and stickiness, and high fluidity (Houjaij et al., 2009). In the present study, these parameters are collected by the centroids of the suitable adapted dishes for swallowing process for dysphagic people. Their position corresponds with medium-high values of F_{min}, F_{max}, fluidity, cohesiveness, suitable texture score, and low values of stickiness and residue. These results are consistent with those obtained in the previous sections. It should be noted that the BET is an effective instrumental technique to analyze TMF (Ibañez et al., 2019) and should be used together with other sensory and instrumental techniques (Houjaij et al., 2009).

In the present study, a correspondence between the instrumental parameters of the texture and its sensory descriptors was observed. These correlations between the results of the sensory analysis and those of the instrumental tests were reported in previous studies about the textural modification of foodstuffs (Brenner et al., 2017; Conti-Silva et al., 2018; Sharma et al., 2017). The instrumental and sensorial firmness had the same behavior, and their values were higher in the adapted dishes than in their control dishes. However, there is not always a close relationship between instrumental and sensory measures. Thus, statistically significant differences obtained in instrumental tests do not imply sensory differences and vice versa.

This can be explained due to the complexity of the food and the changes that occur in them during swallowing process (Joyner (Melito), 2018).

4. Conclusion

The methodology developed was effective in achieving a suitable texture score for CP dysphagic people in conventional dishes. The use of mixtures of xanthan-based additives provided suitable and stable dishes for dysphagic people for 7 days in refrigeration and after reheating up to 45 ºC. For this purpose, the choice of the texturizing agents most suitable for each dish was necessary. This selection was successfully carried out through sensory evaluations with speech therapists experienced in swallowing process. The adapted dishes,were classified as more suitable than their blended counterparts. Regarding sensorial acceptability, CP dysphagic people tested the adapted dishes, thus confirming that all the adapted dishes had similar levels of liking compared to the blended counterparts. Finally, the adapted dishes obtained a shelf-life of 7 days, which makes them suitable for consumption at the domestic level or in the elderly or day care institutions.

This study proposes a methodology for preparing conventional dishes with a texture adapted to CP dysphagic people. These dishes would improve the nutritional status and quality of life of dysphagic people. Further research of the adapted dishes would be necessary to verify their safety, by clinical evaluations, as well as the possible modification of sensory parameters, such as odor or flavor.

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Declaration of competing interests

The authors declare that there are no conflicts of interest.

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Table 1.

Mixtures of texturizing agents used in each stage to modify the texture of five dishes for cerebral palsy dysphagic people.

		Texturizing agents						
Dish	**Treatment**	**Xanthan gum**	**Agar-agar**	**Guar gum**	**Locust bean gum**	**Maltodextrin**	**Olive oil**	**Stage**
Chickpea stew (CS)	C1							1, 2
	M1	X	X					1, 2, 3
	M2	X	X	X				1
	M3	X	X		X			1
	M4	X	X	X	X			1
Lentils with rice (LR)	C2							1, 2
	M5	X	X	X			X	1
	M6	X	X	X			X	1, 2, 3
	M7	X	X	X			X	1
	M8	X	X	X			X	1
Chicken stew (ChS)	C3							1, 2
	M9	X	X					1
	M10	X	X				X	1
	M11	X	X			X	X	1
	M12	X	X	X				1, 2, 3
	M13	X	X	X		X	X	1
Halibut (H)	C4							1, 2
	M1	X	X					1
	M12	X	X	X				1
	M14	X	X			X		1
	M15	X	X	X		X		1, 2, 3
Pasta bolognese (PB)	C5							1, 2
	M1	X	X					1, 2, 3
	M12	X	X	X				1

X: labels the texturizing agents that were used in the respective mixture.

Treatments: C, a dish cooked and blended (C1-C5); M, a dish cooked, blended and texturized with texturizing agents (M1-M15)

Stage 1: selection of texturizing agents; Stage 2: thermostability; Stage 3: self-life

Table 2.

Mean values (n=3) and standard deviations for maximum (F_{max}) and minimum (F_{min}) extrusion force (N) and F_{min}/F_{max} ratio for the dishes, for cerebral palsy dysphagic people, elaborated at stage 1 (selection of the most appropriate texturizing agents).

Dish	Treatment	F_{max}	F_{min}	F_{min}/F_{max}
Chickpea stew (CS)	C1	5.4 (1.8)^{b}	-2.7 (0.7)^{b}	0.5 (0.0)^{a}
	M1	14.1 (0.6)^{a}	-7.4(0.2)^{a}	0.5(0.0)^{a}
Lentils with rice (LR)	C2	1.6(0.0)^{b}	-1.0(0.0)^{b}	0.6(0.0)^{a}
	M5	8.5(0.2)^{a}	-6.6(0.2)^{a}	0.8(0.0)^{a}
	M6	8.8(0.7)^{a}	-5.3(0.5)^{a}	0.6(0.0)^{a}
	M7	8.5(0.7)^{a}	-6.9(0.6)^{a}	0.8(0.0)^{a}
	M8	5.6(0.2)^{b}	-4.0(0.5)^{a}	0.7(0.1)^{a}
Chicken stew (ChS)	C3	-	-	-
	M9	9.1(0.1)^{a}	-4.5(0.0)^{a}	0.5(0.0)^{a}
	M10	10.4(0.3)^{a}	-6.2(0.2)^{a}	0.6(0.0)^{a}
	M11	14.7(0.8)^{a}	-8.4(0.9)^{a}	0.6(0.0)^{a}
	M12	13.4(0.0)^{a}	-7.0(0.0)^{a}	0.5(0.0)^{a}
	M13	19.8(0.0)^{a}	-6.6(0.0)^{a}	0.5(0.0)^{a}
Halibut with green sauce (H)	C4	2.2(0.0)^{d}	-1.5(0.1)^{a}	0.7(0.0)^{a}
	M1	5.0(0.4)^{b}	-3.8(0.4)^{a}	0.8(0.0)^{a}
	M12	7.1(0.1)^{a}	-4.4(0.2)^{a}	0.6(0.0)^{a}
	M14	6.2(0.2)^{a}	-4.9(0.1)^{a}	0.8(0.0)^{a}
	M15	8.4(0.6)^{a}	-6.1(0.5)^{a}	0.7(0.0)^{a}
Pasta bolognese (PB)	C5	4.1(0.1)^{a}	-2.9(0.1)^{b}	0.7(0.0)^{a}
	M1	8.6(0.4)^{b}	-6.0(0.5)^{a}	0.7(0.0)^{a}
	M12	10.2(0.4)^{a}	-6.7(0.5)^{a}	0.7(0.1)^{a}

Different superscripts in the same column for each dish differ significantly ($P \leq 0.05$) by the Fisher's LSD test.

Treatments: C, a dish cooked and blended (C1-C5); M, a dish cooked, blended and texturized with texturizing agents (M1-M15).

ChS-C3, CS-M2, CS-M3 and CS-M4: data unavailable (logistic reasons).

Table 3.

Mean values (*n*=3) and standard deviations for maximum (F_{max}) and minimum (F_{min}) extrusion force (N) and F_{min}/F_{max} ratio for the dishes, for cerebral palsy dysphagic people, elaborated at stage 2 (textural thermostability and acceptability evaluation).

		F_{max}		F_{min}		F_{min}/F_{max}	
Dish	**Treatment**	**Day 0**	**Day 3**	**Day 0**	**Day 3**	**Day 0**	**Day 3**
Chickpea stew (CS)	C1	6.0(0.5)^{a}	6.4(0.2)^{a}	-3.3(0.4)^{a}	-3.8(0.1)^{a}	0.6(0.0)^{a}	0.6(0.0)^{a}
	M1	18.0(1.0)^{a}	18.7(1.7)^{a}	-11.0(1.4)^{a}	-11.5(1.3)^{a}	0.6(0.0)^{a}	0.6(0.0)^{a}
Lentils with rice (LR)	C2	1.6(0.0)^{b}	3.5(0.1)^{a}	-1.0(0.0)^{a}	-2.6(0.0)^{b}	0.6(0.0)^{b}	0.7(0.0)^{a}
	M6	8.8(0.7)^{b}	15.7(0.3)^{a}	-5.3(0.5)^{a}	-8.0(0.2)^{b}	0.6(0.0)^{a}	0.5(0.0)^{b}
Chicken stew (ChS)	C3	2.7(0.1)^{a}	2.6(0.1)^{a}	-1.7(0.1)^{a}	-1.6(0.1)^{a}	0.6(0.0)^{a}	0.6(0.0)^{a}
	M12	6.8(0.1)^{b}	9.8(1.2)^{a}	-4.3(0.1)^{a}	-6.3(1.2)^{b}	0.6(0.0)^{a}	0.6(0.1)^{a}
Halibut with green sauce (H)	C5	3.6(0.1)^{a}	3.7(0.2)^{a}	-2.1(0.1)^{a}	-1.9(0.1)^{a}	0.6(0.0)^{a}	0.5(0.0)^{b}
	M15	10.3(0.2)^{a}	10.1(0.4)^{a}	-7.0(0.3)^{a}	-7.0(0.5)^{a}	0.7(0.0)^{a}	0.7(0.0)^{a}
Pasta bolognese (PB)	C5	1.7(0.0)^{a}	1.7(0.1)^{a}	-1.2(0.1)^{a}	-1.1(0.1)^{a}	0.7(0.0)^{a}	0.6(0.0)^{b}
	M1	7.0(0.2)^{b}	8.3(0.2)^{a}	-5.1(0.2)^{a}	-5.9(0.4)^{b}	0.7(0.0)^{a}	0.7(0.0)^{a}

Different superscripts in the same row for each treatment differ significantly ($P \leq 0.05$) by the paired *t*-Student test.

Treatments: C, a dish cooked and blended (C1-C5); M, a dish cooked, blended and texturized with the texturizing agents (M1-M15) selected at stage 1.

Table 4.

Consumed fraction (%) by cerebral palsy dysphagic people and level of liking of the control dishes and adapted dishes selected at stage 1.

Dish	Treatment	Nº Male/ Nº Female	Average consumed fraction (%)	Nº people consumption >60 % (%)	Liking score*
Chickpea stew (CS)	C1	25/20	77.3(28.7)^{a}	33(73.3)	1.5(0.7)^{b}
	M1	21/18	77.2(31.8)^{a}	31(79.5)	1.5(0.8)^{b}
Lentils with rice (LR)	C2	25/16	84.5(19.7)^{a}	37(90.2)	1.2(0.5)^{b}
	M6	28/16	66.9(32.6)^{b}	35(79.5)	2.1(0.9)^{a}
Chicken stew (ChS)	C3	22/18	78.6(18.9)^{a}	31(77.5)	1.3(0.5)^{b}
	M12	24/14	88.0(16.8)^{a}	30(78.9)	1.3(0.5)^{b}
Halibut with green sauce (H)	C4	18/13	79.0(22.7)^{a}	26(83.9)	1.3(0.6)^{b}
	M15	17/14	73.4(28.5)^{a}	21(67.7)	1.5(0.7)^{b}
Pasta bolognese (PB)	C5	14/13	83.6(22.8)^{a}	24(88.9)	1.1(0.4)^{b}
	M1	17/12	84.9(20.6)^{a}	24(82.8)	1.2(0.5)^{b}

Different superscripts in the same column for each dish differ significantly ($P \leq 0.05$) by the paired *t*-Student test.

Treatments: C, dish cooked and blended (C1-C5); M, a dish cooked, blended and texturized with the texturizing agents (M1-M15) selected at stage 1.

Data of average consumed fraction and liking score are expressed as mean values (standard deviations)

* Pictorial scales of three points: 1, “I like extremely” (happy face or thumb up hand); 2, “I neither like nor dislike” (neutral face or boy and girl); 3, “I dislike extremely” (angry face or thumb down hand).

Table 5.

Mean values (*n*=3) and standard deviations for maximum (F_{max}) and minimum (F_{min}) extrusion force (N) and F_{min}/F_{max} ratio for the adapted dishes (selected at stage 1), for cerebral palsy dysphagic people, elaborated at stage 3 (shelf-life).

		F_{max}			F_{min}			F_{min}/F_{max}		
Dish	**Treatment**	**Day 0**	**Day 3**	**Day 7**	**Day 0**	**Day 3**	**Day 7**	**Day 0**	**Day 3**	**Day 7**
Chickpea stew (CS)	M1	17.9(4.7)^{a}	18.9(3.3)^{a}	17.6(1.7)^{a}	-9.2(0.9)^{a}	-9.0(1.1)^{a}	-8.0(0.7)^{a}	0.5(0.1)^{a}	0.5(0.1)^{a}	0.5(0.0)^{a}
Lentils with rice (LR)	M6	6.5(0.6)^{a}	6.2(0.1)^{a}	7.2(1.1)^{a}	-3.9(0.3)^{a}	-4.0(0.4)^{a}	-4.8(0.5)^{a}	0.6(0.0)^{a}	0.7(0.1)^{a}	0.7(0.0)^{a}
Chicken stew (ChS)	M12	14.9(2.6)^{ab}	11.2(1.6)^{b}	17.6(1.1)^{a}	-7.6(0.1)^{a}	-6.4(0.6)^{b}	-8.3(0.5)^{a}	0.5(0.1)^{a}	0.6(0.1)^{a}	0.5(0.0)^{a}
Halibut with green sauce (H)	M15	14.9(1.4)^{a}	13.8(0.4)^{a}	14.5(0.3)^{a}	-5.8(0.5)^{a}	-6.4(0.2)^{a}	-6.0(0.4)^{a}	0.4(0.0)^{b}	0.5(0.0)^{a}	0.4(0.0)^{b}
Pasta bolognese (PB)	M1	13.8(2.1)^{a}	13.7(2.8)^{a}	17.8(5.0)^{a}	-7.8(0.7)^{a}	-8.1(1.0)^{a}	-8.1(0.9)^{a}	06.(0.0)^{a}	0.6(0.0)^{a}	0.5(0.1)^{a}

Different superscripts in the same row for each dish differ significantly ($P \leq 0.05$) by the Fisher's test.

Treatments: M, a dish cooked, blended and texturized with the texturizing agents (M1-M15) selected at stage 1.

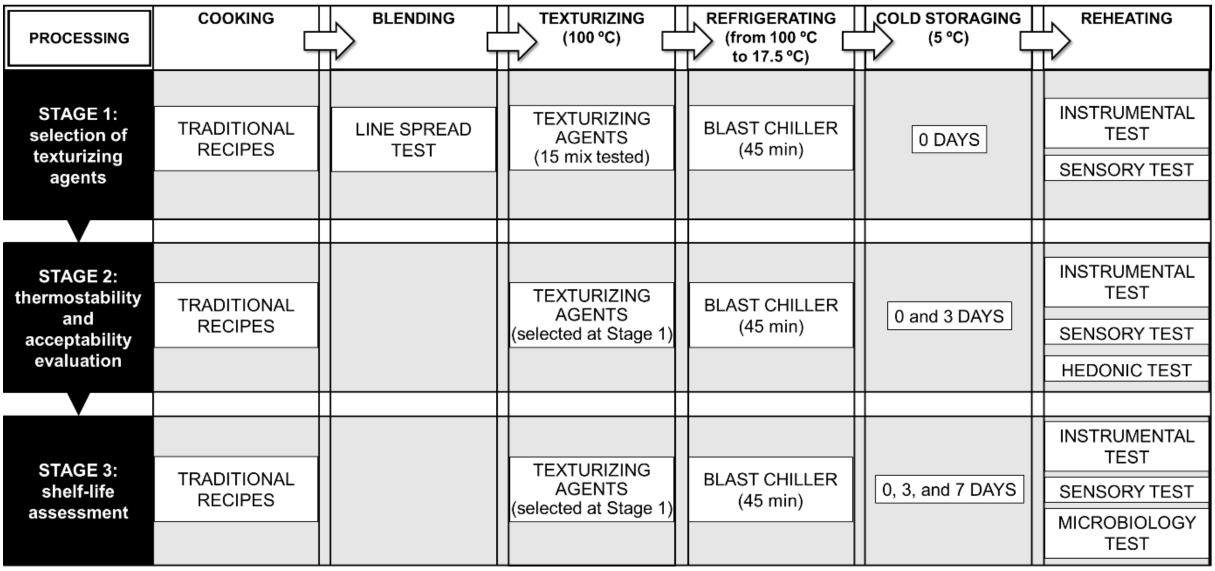

Fig. 1. Stages, process and analysis performed to develop suitable dishes for cerebral palsy dysphagic people.

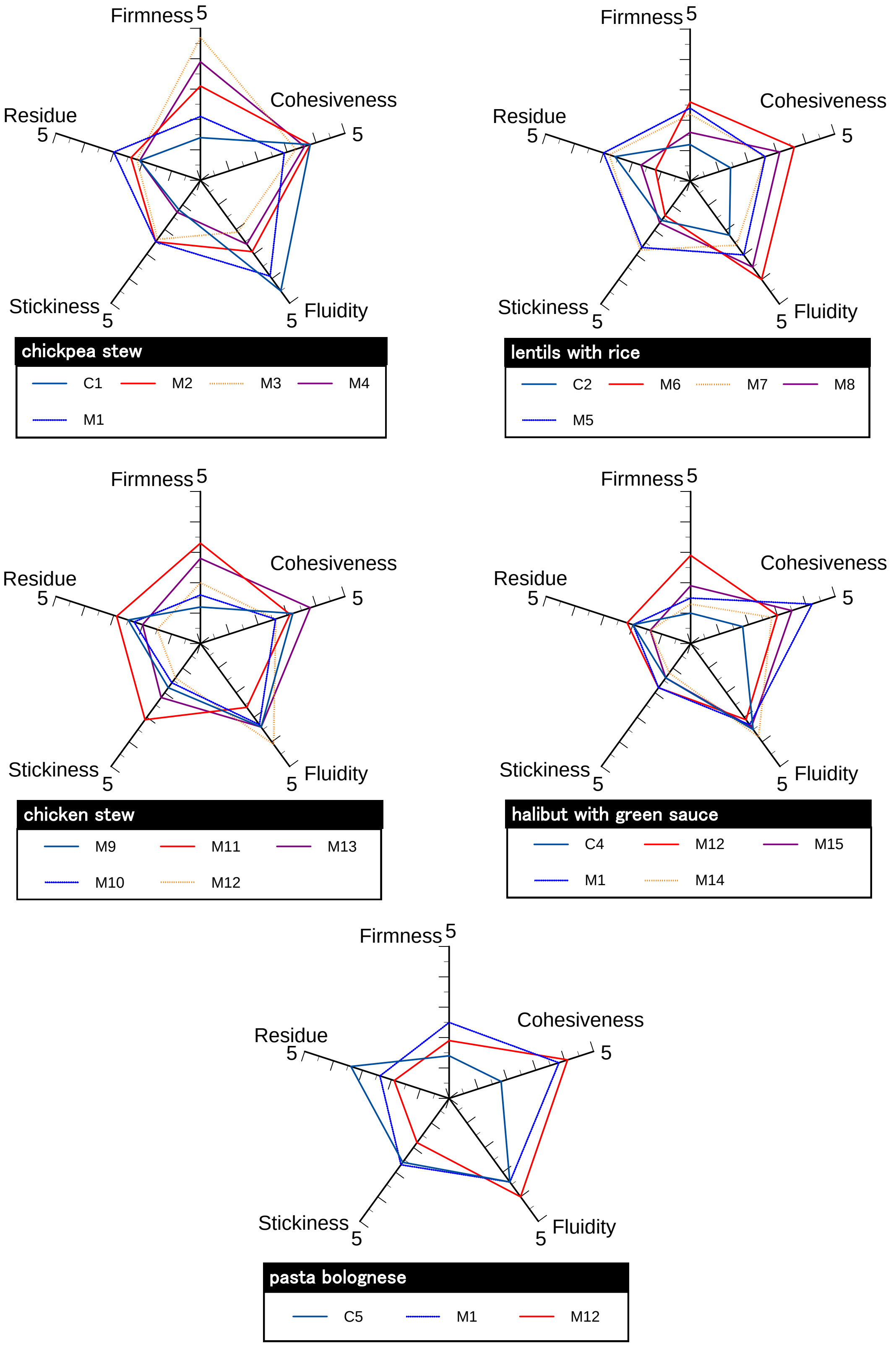

Fig. 2. Sensory profile of the dishes elaborated at stage 1 (selection of the most appropriate texturizing agents) at day 0. Chicken stew-control: data unavailable (logistic reasons). Treatments: C, a dish cooked and blended (C1-C5); M, a dish cooked, blended and texturized with texturizing agents (M1-M15).

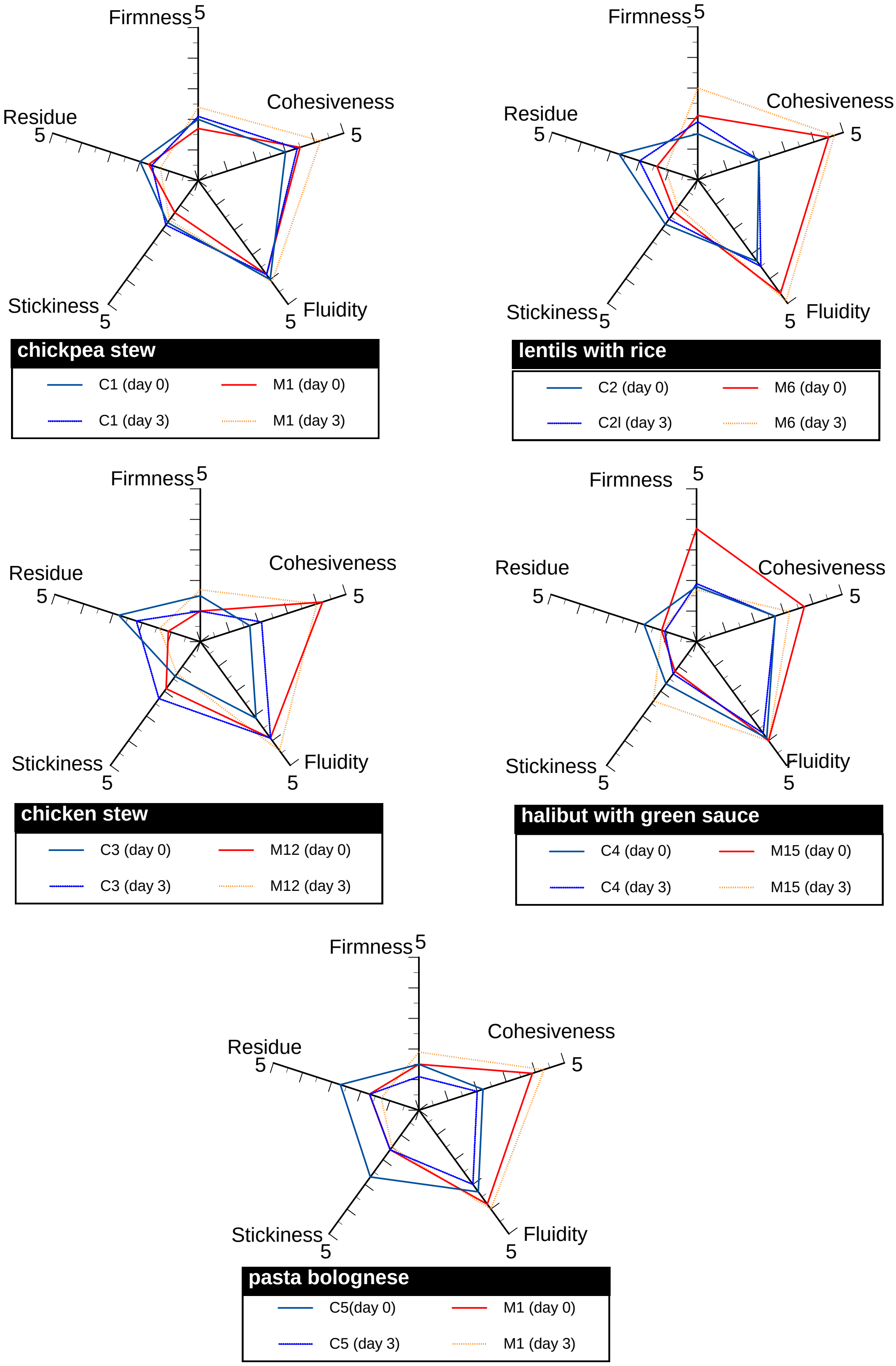

Fig. 3. Sensory profiles of the dishes elaborated at stage 2 (textural thermostability and acceptability evaluation) at days 0 and 3. Treatments: C, dish cooked and blended (C1-C5); M, dish cooked, blended and texturized with texturizing agents (M1-M15).

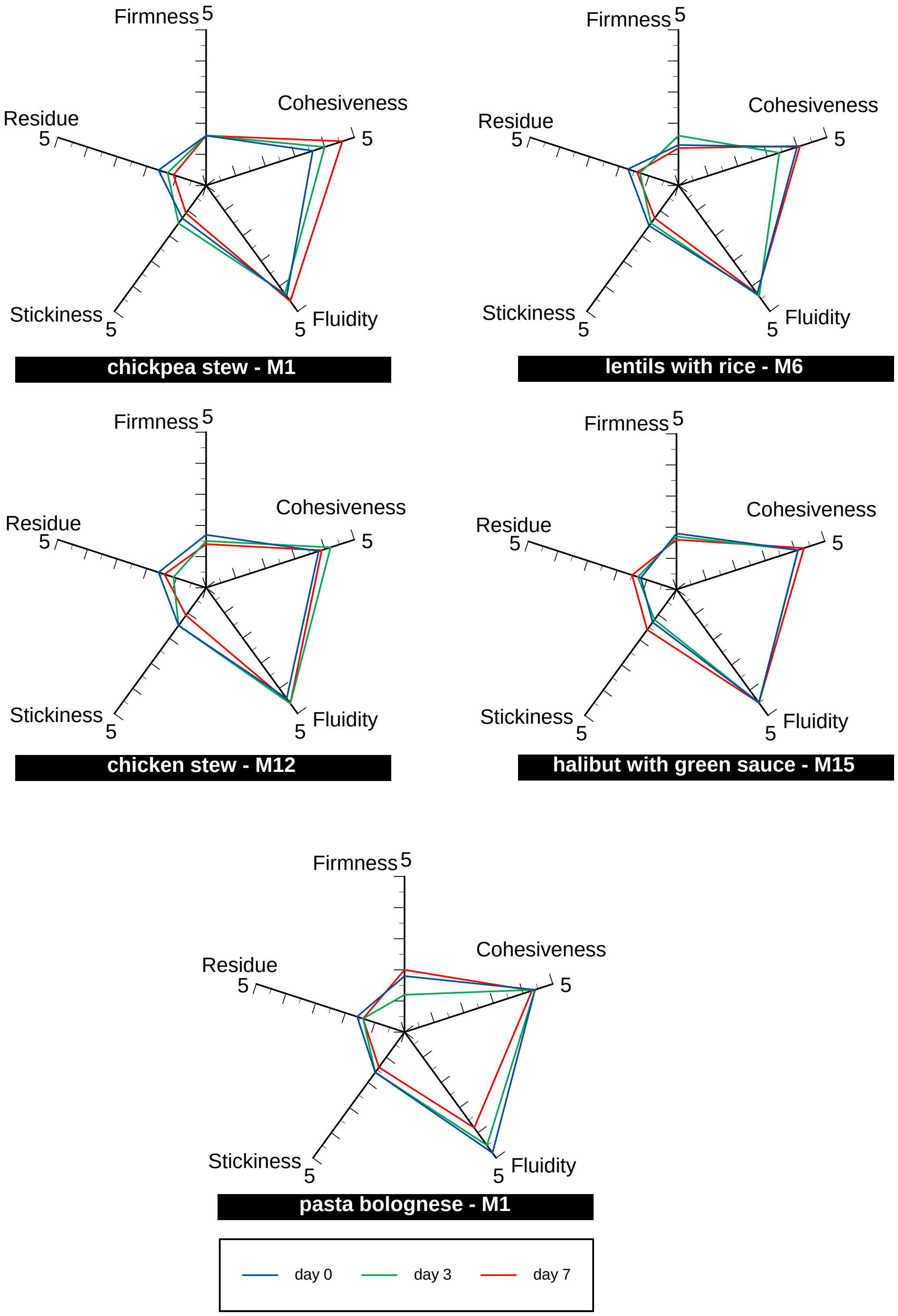

Fig. 4. Sensory profiles of the adapted dishes elaborated at stage 3 (shelf-life) at days 0, 3 and 7. Dishes cooked, blended and texturized with the texturizing agents (M1-M15) selected at stage 1.

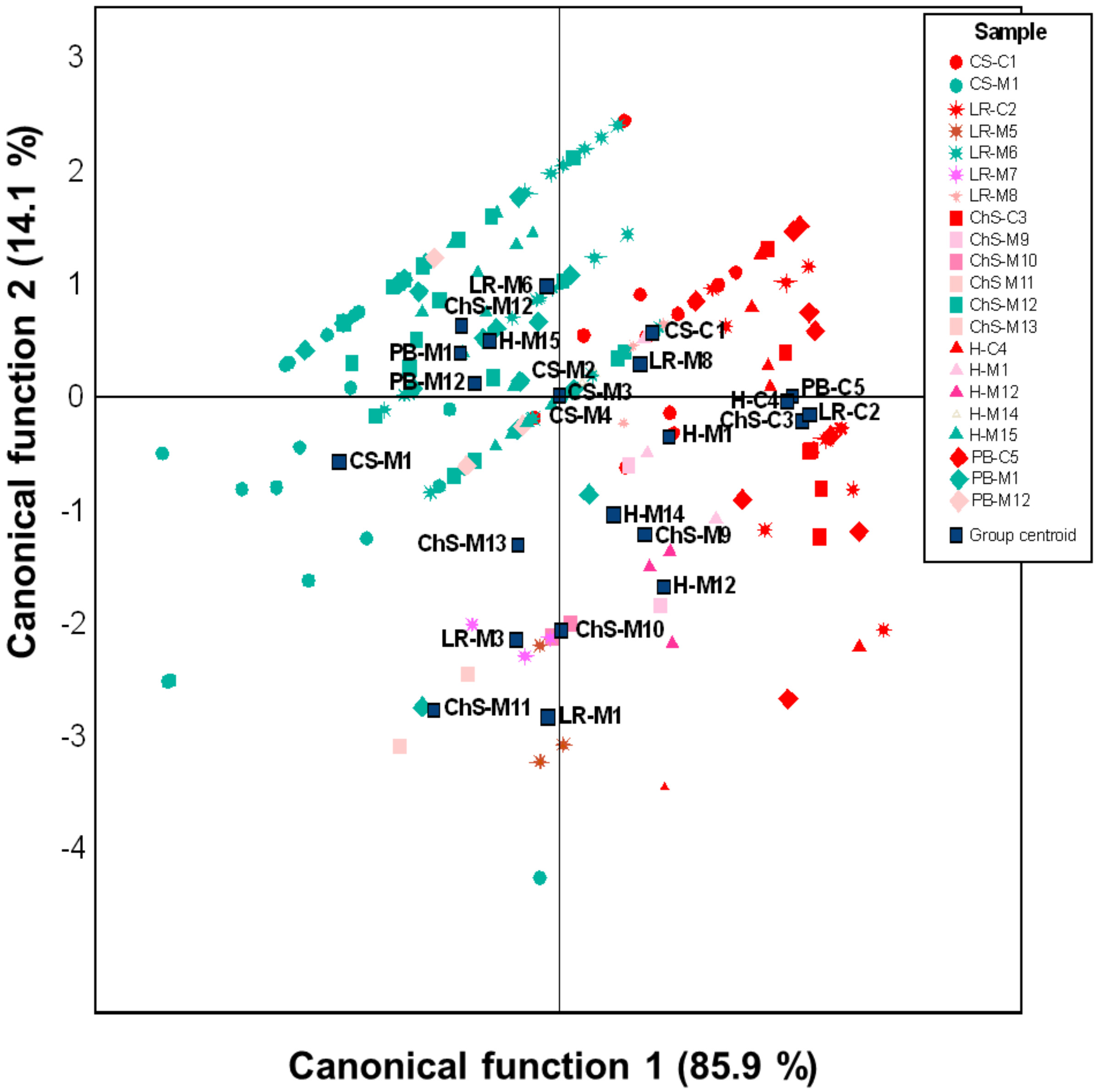

Fig. 5. Plot of the canonical discriminant functions for the instrumental parameters (maximum and minimum extrusion force), and sensory analysis (firmness, cohesiveness, fluidity, stickiness, residue and suitable texture score) evaluated in the dishes for cerebral palsy dysphagic people elaborated at stages 1, 2 and 3.

Dishes: CS, chickpea stew; LR, lentils with rice; ChS, chicken stew; H, halibut with green sauce; PB, pasta bolognese. Treatments: C, a dish cooked and blended (C1-C5); M, a dish cooked, blended and texturized with texturizing agents (M1-M15).

Supplementary materials

Table S1.

Traditional dishes, ingredients, cooking method for each dish and their nutritional value (fat, protein and carbohydrates).

Dish	Ingredients	Cooking method	Fat (%)	Protein (%)	Carbohydrates (%)
Chickpea stew (CS)	Water (75.1 %), chickpea *Maragato* (16.9 %), onion (2.4 %), green pepper (2.4 %), red pepper (2.4 %), olive oil (0.7 %), salt (0.1 %)	Stew with water and vegetables	2.2	6.6	13.6
Lentils with rice (LR)	Lentils (62.7 %): water (68.6 %), lentils *Pardina* (23.0 %), onion (3.4 %), green pepper (1.7 %), red pepper (1.7 %), olive oil (1.4 %), garlic (0.2 %) Rice (20.9 %): water (63.0 %), round grain white rice (34.3 %), olive oil (2.7 %) Water for blending (16.4 %)	Boiled	1.4	3.6	10.2
Chicken Stew (ChS)	Boneless and gutted chicken (56.5 %), water (30.8 %), onion (7.1 %), red pepper (3.6 %), olive oil (1.2 %), garlic (0.5 %), parsley (0.2 %), salt (0.1 %)	Stew with water and vegetables	9.7	11.4	1.1
Halibut with green sauce (H)	Halibut *Hippoglossus hippoglossus* (74.4 %), onion (7.4 %), olive oil (2.5 %), maize flour (0.4 %), water (14.9 %), salt (0.2 %) parsley (0.2 %)	Baked	4.7	20.2	1.0
Pasta bolognese (PB)	Water (46.7 %), tomato (28.2 %), refined flour dough (16.4 %), minced veal (4.5 %), onion (2.7 %), olive oil (1.4 %), oregano (0.1 %)	Boiled	1.2	1.3	6.4

Table S2.

Attributes, description and methods used in the sensory evaluation of dishes for cerebral palsy dysphagic people (continuous scale with 5 anchor words; from 1 “very low” to 5 “very high”).

Attribute	Description	Analysis method
Firmness	Force needed to crush or deform food with the tongue against the palate.	1º To support the tongue tip against the incisors 2º Raise it and support it against the palate preventing the food from dispersing; push the bolus towards the back of the oral cavity, towards the pharynx, to unleash the swallowing reflex.
Cohesiveness	The ability of food to remain in a single block or mass even after crushing it into the oral cavity and moving it towards the pharynx.	When pushing the food towards the back of the oral cavity, assess whether it remains intact as a bolus or whether it fragments.
Fluidity	The ability of food to move easily from the oral cavity to the pharynx without expanding through the pharynx.	To assess the effort required to move the bolus to the back of the mouth with the natural movement of the tongue. Not to chew or move the tongue sideways.
Stickiness	The ability of food to adhere to different areas of the mouth (lips, teeth, tongue, etc.) after swallowing process.	To assess whether, by raising the tongue and crushing the bolus against the palate, it leaves scraps that sticks the tongue to the palate.
Residue	The ability of food to deposit scraps in the mouth (lips, teeth, tongue, etc.) after swallowing process.	To evaluate the remains dispersed through the mouth after swallowing. Cohesiveness and residue are attributes with an inverse association.
Suitable texture score	Score assigned to the food taking into account all evaluated attributes.	The highest score will be associated with moderate intensities of firmness, fluidity and cohesiveness and very low intensities of stickiness and residue. The lowest score will be associated with low intensities of firmness, fluidity and cohesiveness and high intensities of stickiness and residue.

Table S3.

Characteristics of the cerebral palsy people enrolled for acceptability evaluation. Percentual values in parentheses.

Age (years)	Men n = 35 (59.3)	Women n = 24 (40.7)	Total n = 59 (100.0)
5-15 range	6 (17.1)	6 (25.0)	12 (20.3)
16-30 range	13 (37.1)	6 (25.0)	19 (32.2)
31-50 range	12 (34.3)	7 (29.2)	19 (32.2)
51-71 range	4 (11.4)	5 (20.4)	9 (15.3)
Minimum	9	5	5
Maximum	68	71	71
Average	31.8	34.7	32.9

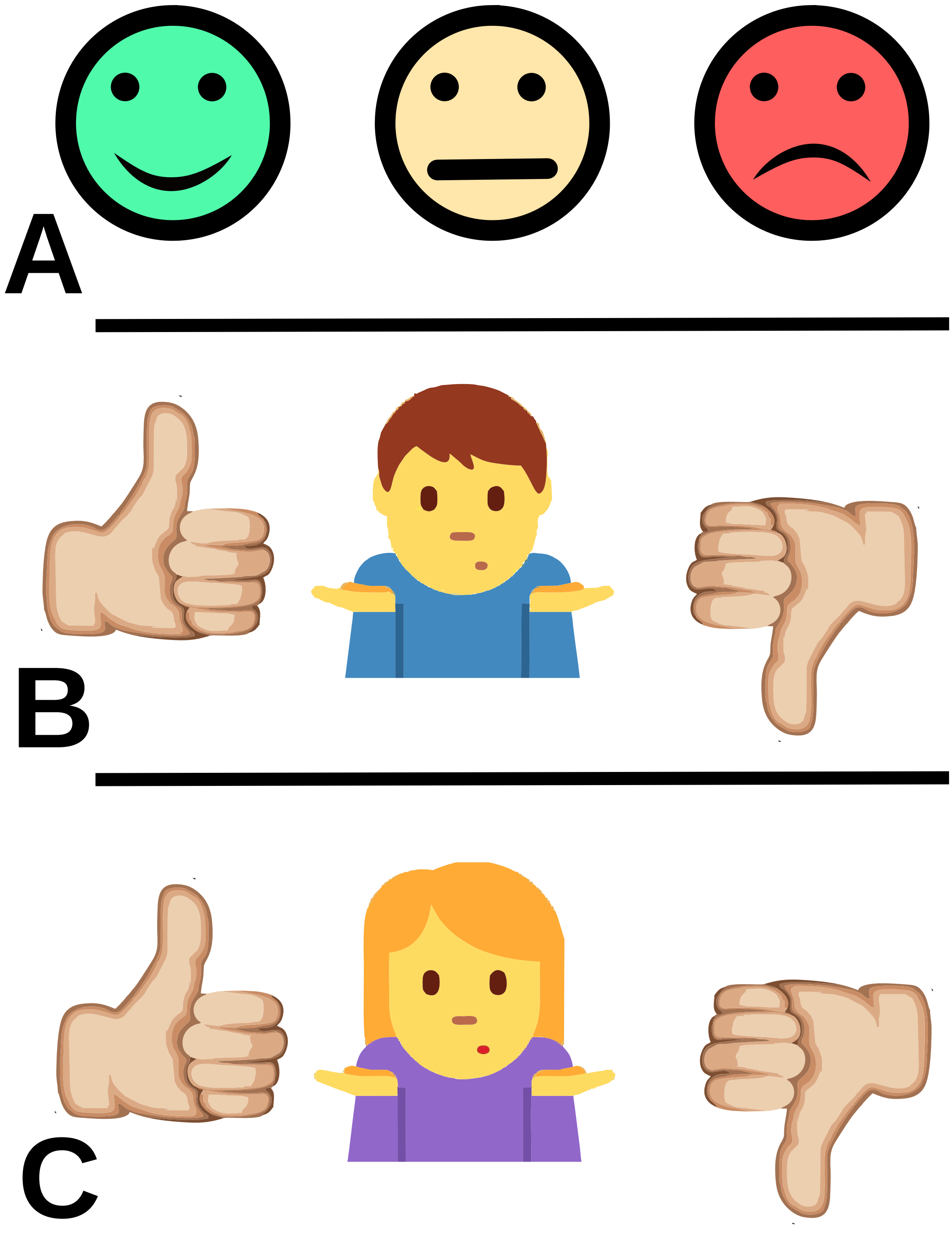

Fig. S1. Pictorial scorecards used in the acceptability test of the control and adapted dishes for cerebral palsy dysphagic people. (A) Principal scorecard; (B and C) Complementary scorecards.

Scale: 1, "I like extremely" (happy face or thumb up hand); 2, "I neither like nor dislike" (neutral face or boy and girl); 3, "I dislike extremely" (angry face or thumb down hand).

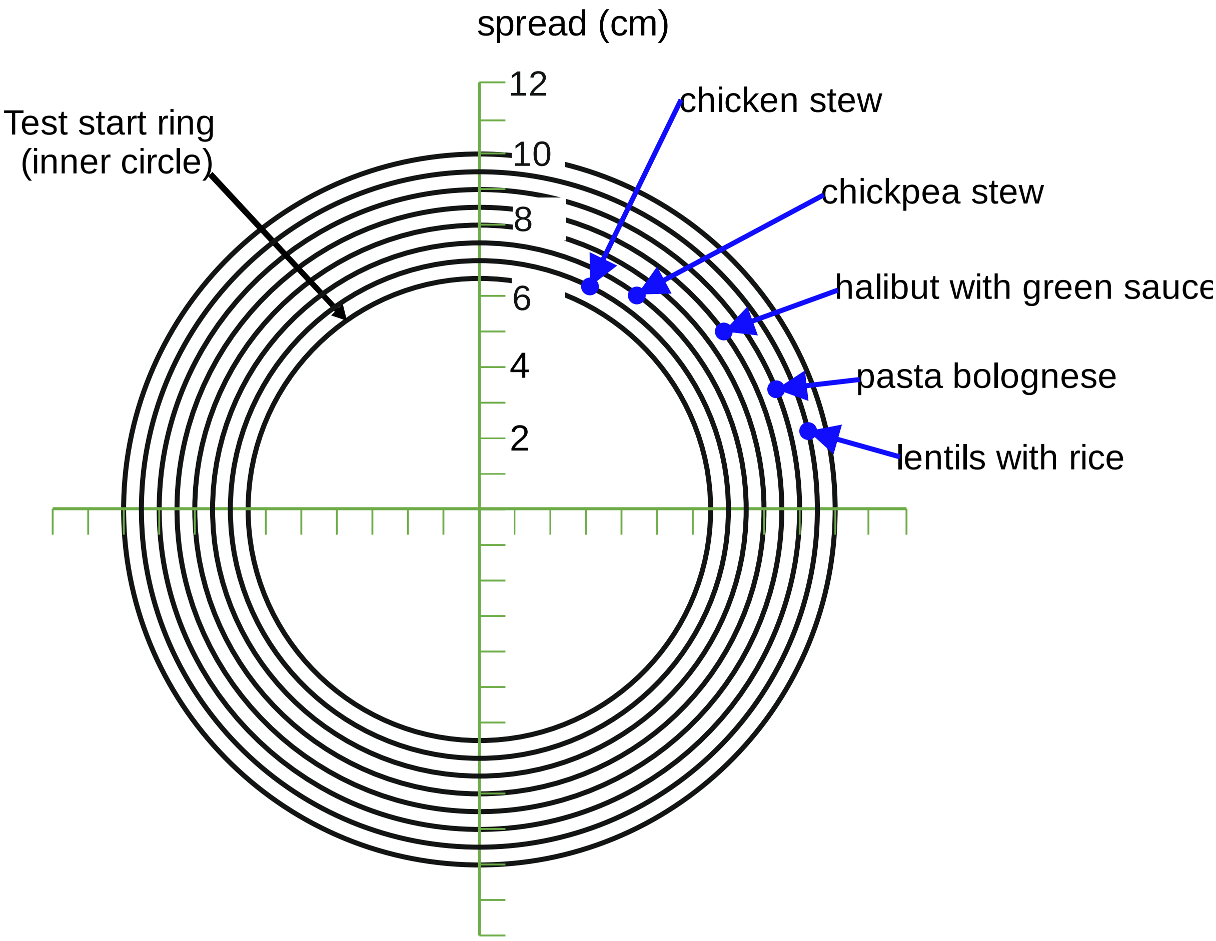

Fig. S2. Maximum values of the line-spread test applied to the control dish (dish cooked and blended)**.**

Fig. S3. Changes in the appearance of the pasta bolognese dish elaborated using the methodology proposed to develop suitable dishes for cerebral palsy dysphagic people: dish after cooking (a), blending (b), and texturizing (c).

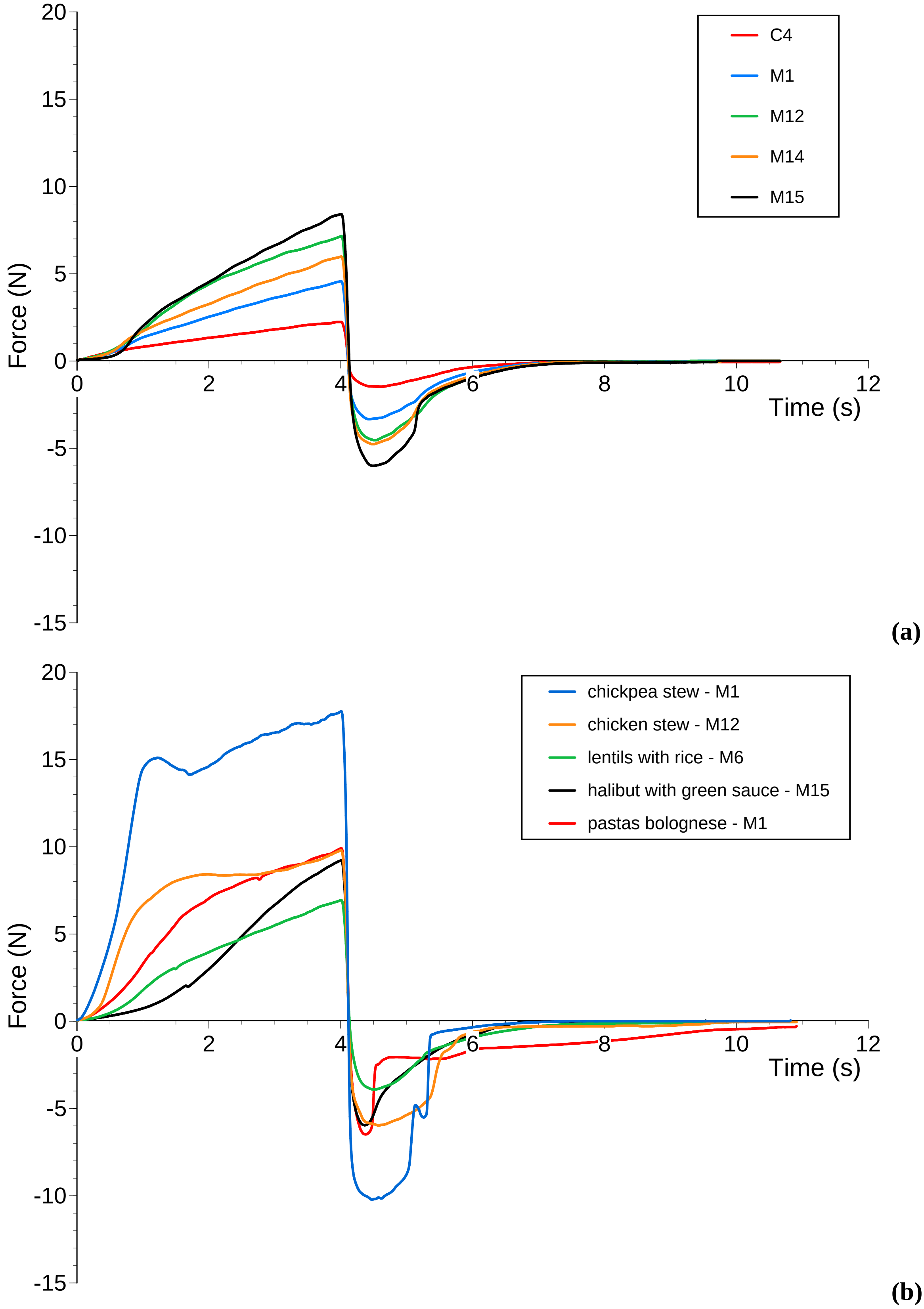

Fig. S4. Force-time curves obtained with the back extrusion test at constant speed (5 mm/s). (a): changes in halibut dish (C4) according to the texturizing agents added (M1, M12, M14, and M15); (b): differences in the five adapted dishes elaborated with the texturizing agents (M1-M15) selected as suitable at stage 1.