

Skim yoghurt with microbial transglutaminase: evaluation of consumer acceptance

Belén García-Gómez, Ángeles Romero-Rodríguez, Lourdes Vázquez-Odériz, Nieves Muñoz-Ferreiro & Manuel Vázquez

To cite this article: Belén García-Gómez, Ángeles Romero-Rodríguez, Lourdes Vázquez-Odériz, Nieves Muñoz-Ferreiro & Manuel Vázquez (2019) Skim yoghurt with microbial transglutaminase: evaluation of consumer acceptance, *CyTA - Journal of Food*, 17:1, 280-287, DOI: [10.1080/19476337.2019.1577304](https://doi.org/10.1080/19476337.2019.1577304)

To link to this article: <https://doi.org/10.1080/19476337.2019.1577304>



© 2019 The Author(s). Published with license by Taylor & Francis Group, LLC.



Published online: 05 Jun 2019.



Submit your article to this journal [↗](#)



Article views: 817



View related articles [↗](#)




View Crossmark data [↗](#)



Citing articles: 3 View citing articles [↗](#)

Skim yoghurt with microbial transglutaminase: evaluation of consumer acceptance

Belén García-Gómez^a, Ángeles Romero-Rodríguez^a, Lourdes Vázquez-Odériz^a, Nieves Muñoz-Ferreiro^b and Manuel Vázquez ^a

^aDepartment of Analytical Chemistry, Faculty of Veterinary Science, University of Santiago de Compostela, Lugo, Spain; ^bModesty Research Group, Department of Statistics, Mathematical Analysis and Optimization, University of Santiago de Compostela, Lugo, Spain

ABSTRACT

The decrease in the fat content of yoghurt causes sensory modifications. Microbial transglutaminase (TG) has been proposed as an alternative for reducing the problems caused by the fat reduction. This work deals with the evaluation of the sensory profile, acceptance and preferences of skim yoghurt produced with TG at pilot scale. A group of 124 consumers of yoghurts were randomly selected. A lower firmness has been observed in yoghurt without TG (NoTG). TG Yoghurt has shown a lower whey odor and less acid taste than NoTG yoghurt. Free whey was not observed in the TG yoghurt. Despite of those differences, consumers only observed minor textural differences. In terms of overall acceptance and preference, no statistically significant differences were observed. The use of TG avoids the addition of milk protein or other texture additives into the yoghurt, decreasing production cost with the same overall acceptance and preference by consumers.

Yogur desnatado con transglutaminasa microbiana: evaluación de la aceptación del consumidor

RESUMEN

La disminución del contenido graso del yogur provoca modificaciones sensoriales. La transglutaminasa microbiana (TG) se ha propuesto como una alternativa para reducir los problemas causados por la reducción de grasa. Este trabajo trata sobre la evaluación del perfil sensorial, la aceptación y la preferencia del yogur desnatado producido con TG en una planta piloto. Un grupo de 124 consumidores de yogures fueron seleccionados al azar. Una menor firmeza se observó en el yogur sin TG (NoTG). EL yogur con TG mostró menor olor a suero, menor sabor ácido que el yogur NoTG. No se observó suero en el yogur con TG. A pesar de esas diferencias, los consumidores solo observaron pequeñas diferencias de textura. En términos de aceptación global y preferencia, no se observaron diferencias estadísticamente significativas. El uso de TG evita la adición de proteínas de la leche u otros aditivos para mejorar la textura del yogur, lo que reduce los costes de producción manteniéndose la aceptación y preferencia por parte de los consumidores.

ARTICLE HISTORY

Received 7 January 2019
Accepted 28 January 2019

KEYWORDS

Sensory evaluation; acceptance; preference; transglutaminase; yoghurt

PALABRAS CLAVE

Evaluación sensorial; aceptación; preferencia; transglutaminasa; yogur

1. Introduction

Microbial transglutaminase (TG) is an enzyme that form bonds between protein molecules (inter- and intramolecular cross-links between γ -carboxylamide groups of glutamine residues and ϵ -amino groups of lysine residues). TG isolated from *Streptomyces mobaraensis* has been available at commercial scale several years ago. TG is widely used in food industry due to its capacity to improve functional properties of proteins like firmness, elasticity, viscosity, heat stability and water-holding capacity. Several studies have shown that the casein is an excellent substrate for TG (Dube, Schäfer, Neidhart, & Carle, 2007; Kuraishi, Yamazaki, & Susa, 2001; Motoki & Seguro, 1998; Routray & Mishra, 2011).

The lactose fermentation produces lactic acid, which decreases pH and denatures milk protein to form a coagulated gel. It gives its texture and its characteristic tang to the yoghurts. By-products are also produced during this process being responsible of specific aroma and flavor of yoghurt (Tamine & Robinson, 1999). Yoghurts can be classified

into two types: (a) set-style yoghurt is made in the sale packaging with a continuous gel structure in the final product and (b) stirred yoghurt where the gel is disrupted by stirring before being packaged.

Yoghurt is a popular product worldwide. It has gained widespread consumer acceptance as a healthy food (Adolfsson, Meydani, & Russell, 2004; Fisberg & Machado, 2015; Glanville, Brown, Shamir, Szajewska, & Eales, 2015; McKinley, 2005). Today consumers continually search for new and unique food products while trying to maintain healthy eating habits (Karagül-Yüceer, Coggins, Wilson, & White, 1999; Zhi et al., 2017). Around 16 kg of fermented milks are consumed per capita annually in Europe (https://ec.europa.eu/agriculture/milk/origin-labelling/com-2015-205_es.pdf). Skim set-type yoghurt is the most consumed despite the great variety of yoghurts offered by the market in order to satisfy all palates and meal occasions (textures, flavors or fat content).

Several nutritional guides recommend low-fat or skim dairy products (Aranceta et al., 2016). Food manufacturers want to produce items that consumers will buy. They must understand

consumers' preferences and needs if they want to survive in an intense market's competition. However, a consumer's food choice is a complex phenomenon affected by many factors (Kresic, Herceg, Lelas, & Jambrak, 2010; Pohjanheimo & Sandell, 2009). Acceptance of yoghurt depends on many factors. The most important is sensory quality (Ares, Giménez, Barreiro, & Gámbaro, 2010; Gardini, Lanciotti, Guerzoni, & Torriani, 1999; Isleten & Karagul-Yuceer, 2006; Johansen, Næs, Øyaas, & Hersleth, 2010). The main sensory quality characteristics of yoghurt include texture, taste, aroma and flavor (Akalin, Unal, Dinkci, & Hayaloglu, 2012; Jaworska & Hoffmann, 2008; Pereira, Singh, Munro, & Luckman, 2003; Sodini, Remeuf, Haddad, & Corrieu, 2004).

Analytical sensory evaluation and consumer testing allow identifying the key sensory attributes that affect consumer preferences for food products providing powerful information for product development. The sensory properties of products are generally evaluated using descriptive methods, such as conventional profiling (Zhao, Feng, Ren, & Mao, 2018). In parallel, determining hedonic responses to products involves asking consumers to identify their preferences (Dabija, Codinã, & Gâtlan, 2018). To establish relationships between sensory data and consumer preferences is the main interest of these studies to reduce the gap that may exist between product development and consumer expectations. Consequently, it reduces the number of failed new products.

As a result, improving the identification of drivers of liking appears to be a necessary part of the development of new yoghurts (Guinard & Mazzucchelli, 1996; Masson, Saint-Eve, Delarue, & Blumenthal, 2016). To satisfy increasing consumer demand for low-fat yoghurt, manufactures increasingly propose yoghurts with low-fat content. However, the consumers' demand for skim yoghurt also included a similar sensory quality as fat yoghurts (Sahan, Yasar, & Hayaloglu, 2008).

Fat is well known to have an impact on food texture, aroma and taste. In order to improve texture and physical properties, fat is replaced by milk proteins or gums but changes in the sensory properties are difficult or impossible to avoid. Thus it seems that more research is needed to maintain the fat yoghurt sensory characteristics on reduced-fat or skim yoghurts (Routray & Mishra, 2011). Skim milk powder is traditionally used for decreasing syneresis and improving gel texture in yoghurt production (Akalin et al., 2012). However, fortification ingredients on low or skim yoghurts can negatively affect sensory quality and consequently decreases in acceptance (Isleten & Karagul-Yuceer, 2006; Matumoto-Pintro, Rabiey, Robitaille, & Britten, 2011; Ünal & Akalin, 2013). Therefore, it is necessary to find alternatives.

Enzymatic cross-linking may be an alternative method to the addition of protein or gums in the production of skim yoghurt. Problems such as low strength and syneresis in skim yoghurt can be solved by a TG treatment (Faergemand, Otte, & Qvist, 1998; Kuraishi et al., 2001; Motoki & Seguro, 1998). Consequently, TG treatment can be possibly a useful method in production of skim and low-solid content yoghurts without using additives and texturally similar to yoghurt with regular-fat and so-called SNF (all the solids in milk except fat) content (Yüksel & Erdem, 2010).

TG treatment in the yoghurt production can be performed by two methods: acting TG prior to the fermentation step (Lorenzen, Neve, Mautner, & Schlimme, 2002) or simultaneous addition of TG and the starter culture (Yüksel & Erdem, 2010). Simultaneous addition does not require additional processing

step like enzyme inactivation. TG is gradually inactivated by acidification of the media. The physicochemical and sensory characteristics of both have been analyzed by our group (García-Gómez, Romero-Rodríguez, Vázquez-Odériz, Muñoz-Ferreiro, & Vázquez, 2018, 2019). However, no studies on acceptance and preference of TG yoghurt by consumer were found. Therefore, the aim of this work was to study the acceptance and preference of a set-style skim yoghurt manufactured with a microbial TG produced in our laboratory.

2. Materials and methods

Skim milk was measured before use, obtaining the following composition: fat, 0.04%; protein, 3.30%; and total dry matter, 9.35%. Microbial TG was produced in our laboratory following the manufacture process described in our Spanish patent (Vázquez & Guerra-Rodríguez, 2012). The activity measured before use was 757 U/g. A colorimetric procedure was used to determine TG activity before use. Briefly, N- α -CBZ-gln-gly (Sigma-Aldrich Corp, St. Louis, MO, USA) was used as substrate. A calibration curve was made using L-glutamic acid γ -monohydroxamate (Sigma-Aldrich Corp, St. Louis, MO, USA). One unit of TG is defined as the formation of 1 μ mol L-glutamic acid γ -monohydroxamate in 1 min at 37°C (Grossowicz, Wainfan, Borek, & Waelsch, 1950).

2.1. Preparation of yoghurt/samples

The manufacturing of yoghurts was performed in a pilot plant (Aula de productos lácteos, USC, Lugo, Spain). A set-style skim yoghurt with milk powder was used as control (NoTG yoghurt). The skim milk (120 L) was split into two batches, one of 60 L for TG yoghurts and the other of 60 L for the control yoghurts (NoTG yoghurts). For the control batch, the milk was standardized for achieving an increase in dry matter without increase in fat prior to the heat treatment. It was blended with skim milk powder to achieve the following values: 0.05% fat; 3.80% protein; and 10.45% total dry matter. For TG batch, it was used a dose of 0.76 U/g of milk protein. The dose was calculated after conducting preliminary studies (García-Gómez et al., 2018, 2019). Culture starter of 0.2 g/L of milk was used. Inoculation of microbial TG was simultaneous with the starter culture.

The milk used of the two batches was pasteurized at 95°C for 5 min and homogenized (200 + 50) bar. Then they were cooled to incubation temperature at 43°C. Freeze-dried lactic culture (LyoCulture Dairy, BDF Natural Ingredients, Girona, Spain) at 0.2 g/L of milk was inoculated and blended into the milk. The mixture was poured into 125 g plastic cups and incubated at 43°C. Each batch was formed by 358 yoghurts. The coagulation of milk was monitored by pH change during the incubation period until a pH of 4.6 was attained. TG was gradually inactivated with the decrease of pH. TG activity was not detected at the end of the fermentation. Then, yoghurts were moved to a cool room and stored at 4°C. Samples were evaluated by the consumers and the trained panel after 5 days.

2.2. Descriptive sensory analysis

The samples were evaluated by a trained panel performed by 17 assessors with previous experience establishing yoghurt's sensory profiles. The assessments were carried out at a sensory laboratory

room. The samples were randomly presented to the judges coded with three-digit in 125 g plastic cups. Sensory tests were performed 4 days after the yoghurt production. The serving temperature of the samples was 8°C. Tap water and crackers were available. Descriptors were quantified using 10-cm unstructured intensity scale line anchored by appropriate references for each of the tested attributes. Definition and evaluation procedure for each attribute are shown in Table 1.

2.3. Consumer panel analysis

Simultaneously to the trained panel analysis, the hedonic test was conducted in Lugo (NW Spain). A group of 124 consumers of yoghurts were randomly selected and invited to take part in the test. Regarding gender, 64.5% were women and 35.5% were men. In terms of age, 37.9% were between 18 and 39 years old, 39.5% were between 40 and 59 years old and 22.6% were over 60 years old.

The two samples were randomly presented to the consumers (such as each sample was scored individually) at 8°C, served in 125 g covered plastic cups and coded with three-digit numbers using a balanced complete block design. Participants were instructed to drink water between samples to clean the palate.

Participants were asked about purchasing habits and frequency and motivation for yoghurt consumption. In the acceptance test, appearance, odor, aroma, texture and overall acceptability have been assessed using a 9-point hedonic scale: 1 – dislike extremely, 2 – dislike very much, 3 – dislike, 4 – dislike slightly, 5 – neither like nor dislike, 6 – like slightly, 7 – like, 8 – like very much and 9 – like extremely (Majchrzak, Lahm, & Dürschmid, 2010). Respondents were also asked about preference, if they would consume any of the products or if they would totally discard some of them, as well as the reasons for choosing or discarding the samples.

2.4. Statistical analysis

The *t*-Student test was applied to examine the differences between trained judges' scores for TG and NoTG yoghurts. Previously to compare the difference between quantitative variables means, the distribution of data was studied by the Shapiro–Wilk test. A normal distribution was assumed when the *p*-value was significant (*p*-value < 0.05). For those that did not comply with the assumption of normality, the Wilcoxon test with Bonferroni correction was applied.

The Pearson chi-squared test of independence was applied in order to analyze the relation between the consumer profile and the frequency or the type of yoghurt consumed. Wilcoxon test for comparing the hedonic score of the two yoghurts was proposed in terms of hedonic attributes acceptance. Then, Spearman test was performed to study the correlations between the acceptance of hedonic attributes and the overall acceptance for both yoghurts.

Respondents were grouped through cluster analysis applying the conglomeration of ward and a biplot with the groups and the hedonic attributes correlated with overall acceptance were drawn. Finally, multiple correspondence analysis (MCA) was performed in order to visualize the associations between the groups of consumers depending on acceptance, the preference and the motivation for the yoghurt consumption. Statistical calculations were performed using Statistics 20 software for Windows (IBM, Armonk, NY, USA) and R (R Core Team, 2018).

3. Results and discussion

3.1. Descriptive sensory analysis

The yoghurts were evaluated by a trained panel. The sensory profiles obtained were different for each kind of yoghurt as can be seen in Figure 1. The trained panel perceived more syneresis in NoTG yoghurt than in TG yoghurt. Significant differences (*t*-Student test) were observed for several attributes. Creaminess (*p*-value = 0.0005), whey odor (*p*-value = 0.0011), density (*p*-value = 0.0147) and acid taste (*p*-value = 0.0138) were perceived higher in NoTG yoghurt by the trained panel. Meanwhile firmness (*p*-value = 0.0051) was perceived higher in NoTG yoghurt. Concerning the acidity, other studies did not find noticeable differences in acidity between camel's milk yoghurt treated with TG and a control without TG (Abou-Soliman, Sakr, & Awad, 2017). Other authors also found that TG yoghurt was slightly less acid taste and more firmness than no treated yoghurt. Although contrary to our results, they considered it with less odor whey and slightly more creaminess (Faergemand et al., 1998).

3.2. Consumer profile

Most of the respondents share the responsibility for purchasing (64.6%), a 30.6% were solely responsible for purchasing food at home and only 4.8% never made it. Overall, 93.5%

Table 1. Definition and evaluation procedure for the sensory attributes considered in this work.

Tabla 1. Definición y procedimiento de evaluación para los atributos sensoriales considerados en este trabajo.

Descriptor	Definition	Scale and references	
Whey odor	Odor perceived when holding the yoghurt close to the nose caused by the whey produced in the yoghurt process	0 = Diluted yoghurt whey (1:4)	10 = Yoghurt whey
Firmness	Force required to lift the product with a coffee spoon	0 = Custard	10 = Vanilla flan
Density	Perception of compactness and body after introducing the sample in the mouth and compressed it between the tongue and the palate	0 = Curd	10 = Petit Suisse
Creaminess	Perception of thickness and smoothness pressing the sample between the tongue and the palate	0 = Curd	10 = Mayonnaise
Acid taste	Basic taste similar to that produced by dilute aqueous solutions of citric acid	0 = 0.13 g/L citric acid solutions	10 = 0.60 g/L citric acid solutions
Bitter taste	Basic taste similar to that produced by dilute aqueous solutions of caffeine	0 = 0.03 g/L caffeine solutions	10 = 0.17 g/L caffeine solutions
Astringency	Shrinking or drying effect on the mouth surface produced by dilute aqueous solutions of tannic acid	0 = Not detected	10 = 0.1 g/L tannic acid solutions
Persistency	Time of persistence of the olfactory/gustatory sensation perceived after the bolus has been swallowed or ejected	0 = <20 s	10 ≤ 60 s

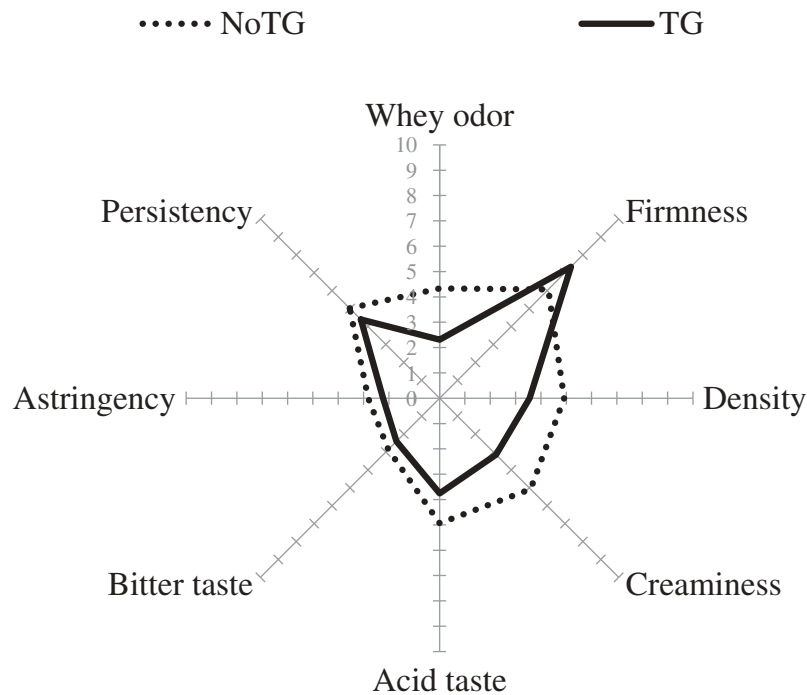


Figure 1. Sensory profiles obtained by the trained panel for the yoghurt manufactured with microbial transglutaminase (TG) and the control yoghurt manufactured with powdered skim milk (NoTG). Statistical significance: **p*-value < 0.05, ***p*-value < 0.01 and ****p*-value < 0.001.

Figura 1. Perfiles sensoriales obtenidos por el panel entrenado para el yogur elaborado con transglutaminasa microbiana (TG) y el yogur control (NoTG) elaborado con leche en polvo desnatada. Significación estadística: **p*-value < 0,05, ***p*-value < 0,01 and ****p*-value < 0,001.

like to try novel foods. Yoghurt consumption was high since 49.2% of the respondents consumed yoghurt daily and 25.8% do it 3–5 times per week. This agrees with other studies where 42% of the panelists consumed yoghurt once a day, 47% consumed yoghurt once a week and 11% consumed yoghurt once a month (Hekmat & Reid, 2006).

In our study, significant differences were detected by the chi-square test of independence on consumer frequency related with age (*p*-value = 0.01). Daily consumers were observed in the elderly and weekly in the younger consumers. This does not agree with a previous study where yoghurt consumption was higher for younger respondents (Valli & Traill, 2005). Yoghurt most frequently consumed was low and regular-fat set type and only 1.6% of the respondents were consumers of stirred yoghurt. Yoghurt type consumed was not related with gender and age, except in low-fat yoghurt with fruit pieces since were consumed mainly by women (*p*-value = 0.024). This agrees with previous studies where low-fat was an important factor for women (Valli & Traill, 2005). Respondents were asked about the motivation for yoghurt consumption. The main reason cited was the aroma (80.6%), the 54.8% of the respondents pointed the texture, for the 35.5% health was the motivation and others were the price, calories and without additives with 24.2%, 21.8% and 0.8%, respectively.

3.3. Consumer acceptance

There was a high share of respondents scoring both yoghurts with “like” (Table 2). Thus, in terms of consumers’ scores, both TG and NoTG yoghurts were scored similar. Wilcoxon test showed only statistically significant differences among yoghurts in terms of texture ($Z = -3.273$, *p*-value = 0.001) because the consumers gave higher scores to the NoTG yoghurt. Some authors have found that yoghurt treated with

Table 2. Percentage of acceptance scores obtained for the yoghurts produced with microbial transglutaminase (TG) and control yoghurt (NoTG) performed with powdered skim milk.

Tabla 2. Porcentaje de puntuaciones de aceptación obtenidos para los yogures producidos con transglutaminasa microbiana (TG) y para el yogur control (NoTG) elaborado con leche desnatada en polvo.

		Acceptance values								
		1	2	3	4	5	6	7	8	9
Appearance	TG	0.0	0.8	0.0	5.6	16.2	16.2	43.5	13.7	4.0
	NoTG	0.8	0.8	2.4	10.5	14.5	20.2	36.3	12.9	1.6
Odor	TG	0.0	0.0	0.0	2.4	25.0	13.7	45.2	10.5	3.2
	NoTG	0.8	0.0	1.6	3.2	25.1	14.5	35.5	16.9	2.4
Texture	TG	0.0	4.8	4.8	12.1	16.2	19.4	27.4	12.1	3.2
	NoTG	1.6	0.0	1.6	9.7	4.1	19.4	40.3	18.5	4.8
Aroma	TG	0.0	0.0	8.1	12.9	16.9	20.2	29.8	8.9	3.2
	NoTG	0.8	0.0	4.8	11.3	13.7	22.6	31.5	12.9	2.4
Overall acceptance	TG	0.0	0.0	5.6	8.9	20.2	21.8	29.0	12.1	2.4
	NoTG	0.0	0.8	1.6	6.5	12.9	25.8	37.1	14.5	0.8

was better scored than control without TG according to texture and aroma. It was although found in yoghurt control with any other additive or component used (Aprodu, Gurau, Ionescu, & Banu, 2011). The regular fat yoghurt obtained using 75 U/L and adding TG simultaneously with the starter culture was better scored than the control yoghurt in appearance and texture. No differences were detected in aroma (Mahmood & Sebo, 2012). In contraposition, negative effects in TG addition in the aroma and odor evaluation were found. It was probably due to the adverse effect caused by TG addition on yoghurt acidity and acetaldehyde production. This is the main compound responsible for the aroma (Ozer, Avni Kirmaci, Oztekin, Hayaloglu, & Atamer, 2007).

The aroma and the texture are the hedonic attributes that are more related with overall acceptance for both yoghurts. When the Spearman test between the scores for acceptance was performed, it was observed that a correlation for the

aroma and overall acceptability of TG and NoTG yoghurts was $r = 0.874$ and $r = 0.796$, respectively. It was also detected that a correlation for texture and global acceptance was $r = 0.774$ and $r = 0.641$, respectively, for TG and NoTG and p -value < 0.0001 .

Several researchers found that yoghurt's texture and aroma attributes were highly appreciated by consumers and were a key factor for discrimination between different yoghurt types (Bayarri, Carbonell, Barrios, & Costell, 2011; Bruzzone, Ares, & Giménez, 2013; Cheng, 2010; Coggins, Schilling, Kumari, & Gerrard, 2008; Gallina Toschi et al., 2012).

Aroma, texture and overall acceptability were used to perform the cluster analysis. Three clusters of respondents were identified as shown in Figure 2. A biplot is shown for illustrated data acceptance in each cluster (Figure 3). Cluster 1 comprised 50.81% of respondents who pointed TG yoghurt with high scores. Second cluster (28.23% of respondents) comprised those respondents who showed a high acceptance toward NoTG yoghurt. Cluster 3, which comprised 20.97% of respondents, groups those respondents with a low acceptance for both yoghurts. A relationship among gender, age or the affinity

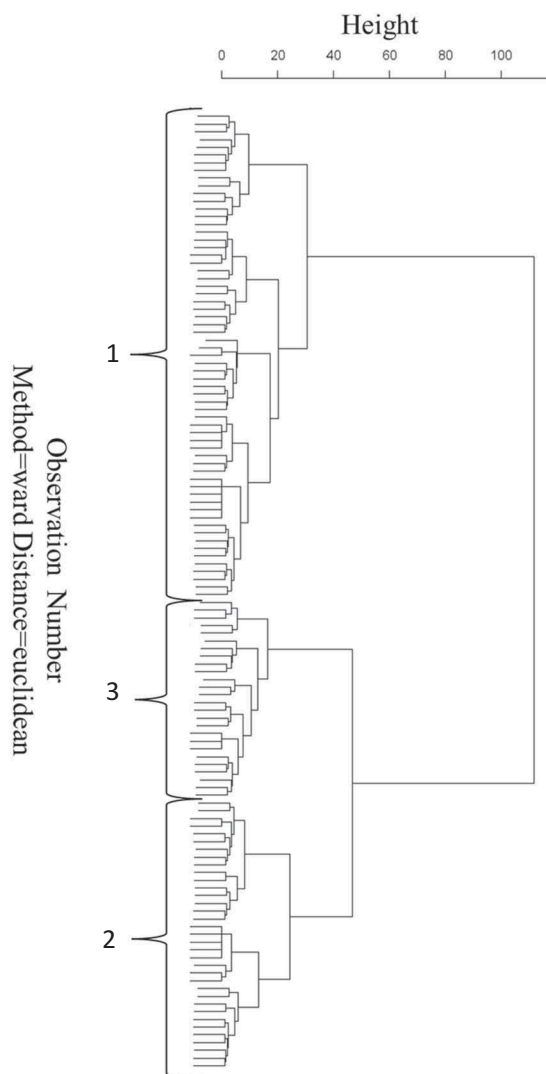


Figure 2. Cluster dendrogram of aroma, texture and overall acceptance. Cluster 1 = high acceptance for TG yoghurt; Cluster 2 = high acceptance for NoTG yoghurt; Cluster 3 = low acceptance for both yoghurts.

Figura 2. Cluster dendrograma del aroma, textura y aceptación global. Cluster 1 = aceptación alta para el yogur con TG; Cluster 2 = aceptación alta para el yogur NoTG; Cluster 3 = aceptación baja para ambos yogures.

to taste novel food was not established in the consumers of each cluster. The Pearson chi-squared test of independence was not significant.

3.4. Consumer preference

The main motivation toward set-type skim yoghurt produced with powdered skim milk (NoTG yoghurt) or TG yoghurt was the taste. More than 70% of the respondents would consume one of the two proposed yoghurts. The main reasons are that they liked taste (80%), texture (33%) and for health (12%). Health is an important driver for skim yoghurt consumers (Valli & Traill, 2005). NoTG yoghurt was chosen as preferred by 55.6% of the respondents. However, the difference was not statistically significant (p -value = 0.2087). An 86.8% of those consumers who preferred TG yoghurt would consume it due to its aroma and 13.2% preferred it because they like its texture. In those who have chosen NoTG as a preferred yoghurt, 75.5% would consume it because of the aroma and 49.0% due to its texture. Despite of preferring yoghurts (TG or NoTG), only 9.7% and 12.1% of consumers have discarded the consuming of TG and NoTG yoghurts, respectively.

MCA factor map was performed with the aim of relating acceptance, preference and yoghurt consume motivation. Results are shown in Figure 4. The first group is the consumers with high scores in aroma, texture and overall acceptance toward TG yoghurt. Consequently, they preferred TG yoghurt. Regarding the consume motivation, health was pointed as important. The sensory properties (aroma and texture) were not pointed as important. The second group are those that shown more acceptance toward NoTG yoghurt and predictably preferred it. The last group was comprised of consumers that shown a low acceptance for both yoghurts. They did not opt for either of the two yoghurts. They pointed as motivation of consume the aroma and texture.

3.5. Relation between trained panel and consumers

The small significant differences in acid taste found by the trained panel are valued positively by consumers even though differences in acceptability are not statistically significant. Differences in odor were detected by trained panel but they were not detected by the consumers since both yoghurts were similar pointed in appearance. Creaminess perception (thickness and smoothness) was correlated to consumer acceptance in a wide range of dairy products, including yoghurts (de Wijk, Terpstra, Janssen, & Prinz, 2006; Guinard & Mazzucchelli, 1996; Janhøj, Bom Frøst, & Ipsen, 2008; Janhøj, Petersen, Frøst, & Ipsen, 2006). Oppositely, it was suggested that sensory texture properties related with the creaminess are not significantly correlated with consumer acceptability of natural yoghurts (Jaworska & Hoffmann, 2008).

For US consumers, the relatively high extent of sourness along with the intensity of acetaldehyde (the key volatile compound of yoghurt) has resulted in low consumer acceptance but cannot be used for predicting consumer preferences for unflavored yoghurt (Barnes, Harper, Bodyfelt, & McDaniel, 1991). Other findings identified that many plain yoghurts were simply too sour for many consumers (Harper, Barnes, Bodyfelt, & McDaniel, 1991).

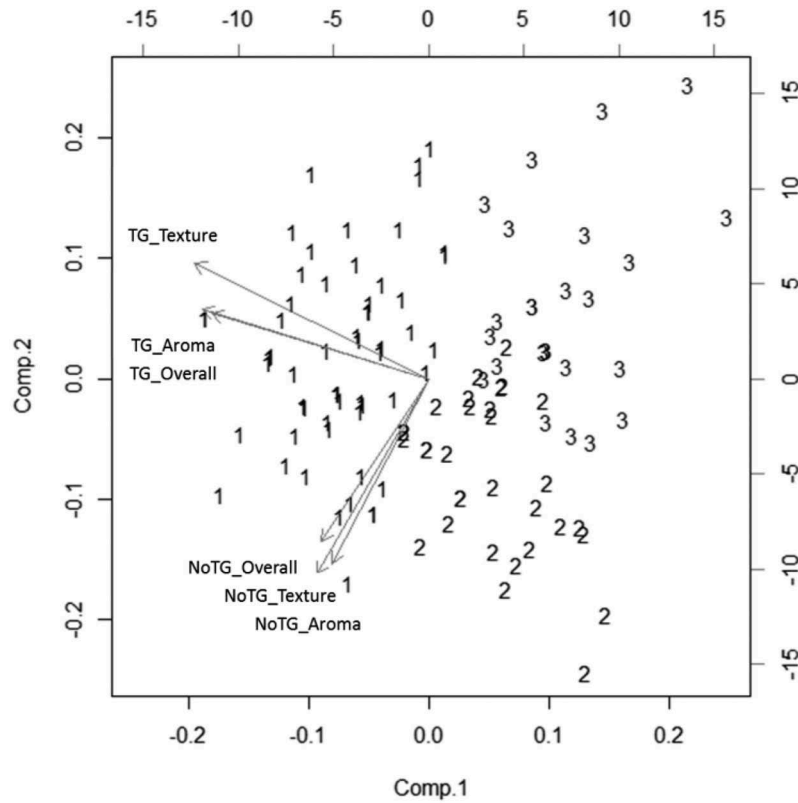


Figure 3. Biplot drawing of the texture, aroma and overall acceptance with the groups obtained of the cluster analysis. Cluster 1 = high acceptance for TG yoghurt; Cluster 2 = high acceptance for NoTG yoghurt; Cluster 3 = low acceptance for both yoghurts.

Figura 3. Representación biplot de la textura, al aroma y de la aceptación global con los gupos obtenidos del análisis cluster. Cluster 1 = aceptación alta para el yogur con TG; Cluster 2 = aceptación alta para el yogur NoTG; Cluster 3 = aceptación baja para ambos yogures.

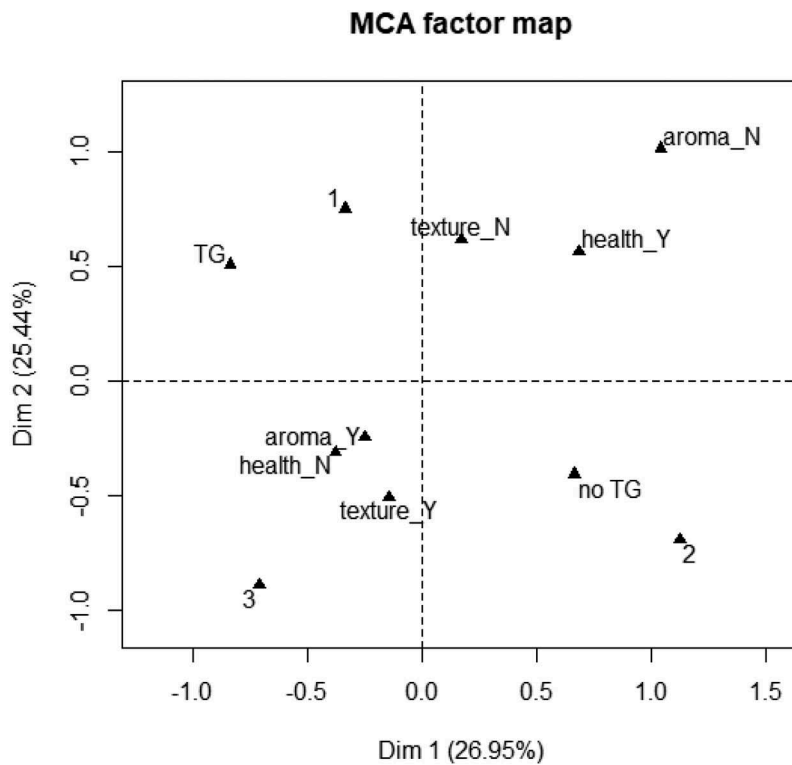


Figure 4. Multiple correspondence analysis (MCA) factor map (1 is cluster 1, 2 is cluster 2, 3 is cluster 3, TG represents those consumers who have preferred TG yoghurt, NoTG represents those consumers who have preferred NoTG yoghurt; aroma_Y when aroma has been a consume motivation, aroma_N when aroma has not been a consume motivation, texture_Y when texture has been a consume motivation, texture_N when texture has not been a consume motivation, health_Y when health has been a consume motivation, health_N when health has not been a consume motivation).

Figura 4. Mapa de factores del análisis de correspondencias múltiples (ACM) (1 es el cluster 1, 2 es el cluster 2, 3 es el cluster 3, TG consumidores que prefieren el yogur TG, NoTG consumidores que prefieren el NoTG yogurt; aroma_Y cuando el aroma es el motivo de consumo, aroma_N cuando el aroma no es el motivo de consumo, texture_Y cuando la textura es el motivo de consumo, texture_N cuando la textura no es el motivo de consumo, health_Y cuando la salud es el motivo de consumo, health_N cuando la salud no es el motivo de consumo).

Sensory characteristic of yoghurt has a large effect on consumer acceptability (Delikanli & Ozcan, 2014; Grygorczyk, Lesschaeve, Corredig, & Duizer, 2013; Pereira et al., 2003). Although not all sensory texture properties and aroma attributes were correlated with yoghurt consumer acceptability (Jaworska & Hoffmann, 2008), absence of free whey was determinant for overall acceptance of yoghurts (Lee & Lucey, 2010). Statistically significant differences were observed among yoghurt samples only in terms of texture because the consumers gave higher scores to the yoghurt produced with powdered skim milk (NoTG). The consumers valued better high density and creaminess and less firmness of NoTG yoghurt.

4. Conclusions

Sensory profiles performed by the trained panel were different for both yoghurts. TG yoghurt was firmer than NoTG yoghurt. This fact has decreased the creaminess perception. TG yoghurt exhibits lower odor whey and acid taste. Despite these differences, consumers only perceived textural differences. TG yoghurt presented lower textural acceptance than NoTG yoghurt. Consumers prefer yoghurt with a creamier, dense texture and low firmness. However, in terms of overall acceptance and preference, no significant differences were observed. Therefore, the use of TG avoids the addition of milk protein or other texture additives, decreasing production cost and the same overall acceptance and preference by consumers.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was supported by MICINN (Spain) [Project No. RTC2014-1835-2] and Consellería de Cultura, Educación e Ordenación Universitaria, Xunta de Galicia (ES) [Project No. ED431B 2016/009].

ORCID

Manuel Vázquez  <http://orcid.org/0000-0002-0392-1724>

References

- Abou-Soliman, N. H. I., Sakr, S. S., & Awad, S. (2017). Physico-chemical, microstructural and rheological properties of camel-milk yogurt as enhanced by microbial transglutaminase. *Journal of Food Science and Technology*, 54(6), 1616–1627.
- Adolfsson, O., Meydani, S. N., & Russell, R. M. (2004). Yogurt and gut function 1, 2. *American Journal Clinical Nutrition*, 80, 245–256.
- Akalin, A. S., Unal, G., Dinkci, N., & Hayaloglu, A. A. (2012). Microstructural, textural, and sensory characteristics of probiotic yogurts fortified with sodium calcium caseinate or whey protein concentrate. *Journal of Dairy Science*, 95(7), 3617–3628.
- Aprodu, I., Gurau, G., Ionescu, A., & Banu, I. (2011). The effect of transglutaminase on the rheological properties of yogurt. *Scientific Study and Research: Chemistry and Chemical Engineering, Biotechnology, Food Industry*, 12(2), 185–196.
- Aranceta, J., Arija, M. V., Maiz, E., Martínez de Victoria, E., Ortega, R. M., Pérez, C., ... Serra, L. (2016). Guías alimentarias para la población española (SENC, 2016). La nueva pirámide de la alimentación saludable. *Nutrición Hospitalaria*, 33(8), 1–48.
- Ares, G., Giménez, A., Barreiro, C., & Gámbaro, A. (2010). Use of an open-ended question to identify drivers of liking of milk desserts. Comparison with preference mapping techniques. *Food Quality and Preference*, 21(3), 286–294.
- Barnes, D. L., Harper, S. J., Bodyfelt, F. W., & McDaniel, M. R. (1991). Correlation of descriptive and consumer panel flavor ratings for commercial prestirred strawberry and lemon yogurts. *Journal of Dairy Science*, 74(7), 2089–2099.
- Bayarri, S., Carbonell, I., Barrios, E. X., & Costell, E. (2011). Impact of sensory differences on consumer acceptability of yoghurt and yoghurt-like products. *International Dairy Journal*, 21(2), 111–118.
- Bruzzone, F., Ares, G., & Giménez, A. (2013). Temporal aspects of yoghurt texture perception. *International Dairy Journal*, 29(2), 124–134.
- Cheng, H. (2010). Volatile flavor compounds in yogurt: A review. *Critical Reviews in Food Science and Nutrition*, 50(10), 938–950.
- Coggins, P. C., Schilling, M. W., Kumari, S., & Gerrard, P. D. (2008). Development of a sensory lexicon for conventional milk yogurt in the United States. *Journal of Sensory Studies*, 23(5), 671–687.
- Dabija, A., Codinã, G. G., & Gätlan, A. (2018). Quality assessment of yogurt enriched with different types of fibers. *CyTA - Journal of Food*, 16(1), 859–867.
- de Wijk, R. A., Terpstra, M. E. J., Janssen, A. M., & Prinz, J. F. (2006). Perceived creaminess of semi-solid foods. *Trends in Food Science and Technology*, 17(8), 412–422.
- Delikanli, B., & Ozcan, T. (2014). Effects of various whey proteins on the physicochemical and textural properties of set type nonfat yoghurt. *International Journal of Dairy Technology*, 67(4), 495–503.
- Dube, M., Schäfer, C., Neidhart, S., & Carle, R. (2007). Texturisation and modification of vegetable proteins for food applications using microbial transglutaminase. *European Food Research and Technology*, 225(2), 287–299.
- Faergemand, M., Otte, J., & Qvist, K. B. (1998). Emulsifying properties of milk proteins cross-linked with microbial transglutaminase. *International Dairy Journal*, 8(8), 715–723.
- Fisberg, M., & Machado, R. (2015). History of yogurt and current patterns of consumption. *Nutrition Reviews*, 73, 4–7.
- Gallina Toschi, T., Bendini, A., Barbieri, S., Valli, E., Cezanne, M. L., Buchecker, K., & Canavari, M. (2012). Organic and conventional non-flavored yogurts from the Italian market: Study on sensory profiles and consumer acceptability. *Journal of the Science of Food and Agriculture*, 92(14), 2788–2795.
- García-Gómez, B., Romero-Rodríguez, Á., Vázquez-Odériz, L., Muñoz-Ferreiro, N., & Vázquez, M. (2018). Physicochemical evaluation of low-fat yoghurt produced with microbial transglutaminase. *Journal of the Science of Food and Agriculture*, 98(14), 5479–5485.
- García-Gómez, B., Romero-Rodríguez, Á., Vázquez-Odériz, L., Muñoz-Ferreiro, N., & Vázquez, M. (2019). Sensory evaluation of low-fat yoghurt produced with microbial transglutaminase and comparison with physicochemical evaluation. *Journal of the Science of Food and Agriculture*, in Press. doi:10.1002/jsfa.9401
- Gardini, F., Lanciotti, R., Guerzoni, M. E., & Torriani, S. (1999). Evaluation of aroma production and survival of *Streptococcus thermophilus*, *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Lactobacillus acidophilus* in fermented milks. *International Dairy Journal*, 9, 125–134.
- Glanville, J. M., Brown, S., Shamir, R., Szajewska, H., & Eales, J. F. (2015). The scale of the evidence base on the health effects of conventional yogurt consumption: Findings of a scoping review. *Frontiers in Pharmacology*, 6(OCT), 1–12.
- Grossowicz, N., Wainfan, E., Borek, E., & Waelsch, H. (1950). The enzymatic formation of hydroxamic acids from glutamine and asparagine. *Journal of Biological Chemistry*, 187(1), 111–125.
- Grygorczyk, A., Lesschaeve, I., Corredig, M., & Duizer, L. (2013). Extraction of consumer texture preferences for yogurt: Comparison of the preferred attribute elicitation method to conventional profiling. *Food Quality and Preference*, 27(2), 215–222.
- Guinard, J. X., & Mazzucchelli, R. (1996). The sensory perception of texture and mouthfeel. *Trends in Food Science and Technology*, 7(7), 213–219.
- Harper, S. J., Barnes, D. L., Bodyfelt, F. W., & McDaniel, M. R. (1991). Sensory ratings of commercial plain yoghurts by consumer and descriptive panels. *Journal of Dairy Science*, 74(9), 2927–2935.
- Hekmat, S., & Reid, G. (2006). Sensory properties of probiotic yogurt is comparable to standard yogurt. *Nutrition Research*, 26(4), 163–166.
- Isleten, M., & Karagul-Yuceer, Y. (2006). Effects of dried dairy ingredients on physical and sensory properties of nonfat yogurt. *Journal of Dairy Science*, 89(8), 2865–2872.
- Janhøj, T., Bom Frøst, M., & Ipsen, R. (2008). Sensory and rheological characterization of acidified milk drinks. *Food Hydrocolloids*, 22(5), 798–806.

- Janhøj, T., Petersen, C. B., Frøst, M. B., & Ipsen, R. (2006). Sensory and rheological characterization of low-fat stirred yogurt. *Journal of Texture Studies*, 37(3), 276–299.
- Jaworska, D., & Hoffmann, M. (2008). Relative importance of texture properties in the sensory quality and acceptance of commercial crispy products. *Journal of the Science of Food and Agriculture*, 88(10), 1804–1812.
- Johansen, S. B., Næs, T., Øyaas, J., & Hersleth, M. (2010). Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information. *Food Quality and Preference*, 21(1), 13–21.
- Karagül-Yüceer, Y., Coggins, P. C., Wilson, J. C., & White, C. H. (1999). Carbonated yogurt—sensory properties and consumer acceptance. *Journal of Dairy Science*, 82(7), 1394–1398.
- Kresic, G., Herceg, Z., Lelas, V., & Jambrak, A. R. (2010). Consumers' behaviour and motives for selection of dairy beverages in Kvarner region: A pilot study. *Mljekarstvo*, 60(1), 50–58.
- Kuraishi, C., Yamazaki, K., & Susa, Y. (2001). Transglutaminase: Its utilization in the food industry. *Food Reviews International*, 17(172), 221–246.
- Lee, W. J., & Lucey, J. A. (2010). Formation and physical properties of yogurt. *Asian-Australasian Journal of Animal Sciences*, 23(9), 1127–1136.
- Lorenzen, P. C., Neve, H., Mautner, A., & Schlimme, E. (2002). Effect of enzymatic cross-linking of milk proteins on functional properties of set-style yoghurt. *International Journal of Dairy Technology*, 55(3), 152–157.
- Mahmood, W. A., & Sebo, N. H. (2012). Improvement of yogurt properties by microbial transglutaminase. *Jordan Journal of Agricultural Sciences*, 8(3), 333–342.
- Majchrzak, D., Lahm, B., & Dürschmid, K. (2010). Conventional and probiotic yogurts differ in sensory properties but not in consumers' preferences. *Journal of Sensory Studies*, 25(3), 431–446.
- Masson, M., Saint-Eve, A., Delarue, J., & Blumenthal, D. (2016). Identifying the ideal profile of French yogurts for different clusters of consumers. *Journal of Dairy Science*, 99(5), 3421–3433.
- Matumoto-Pintro, P. T., Rabiey, L., Robitaille, G., & Britten, M. (2011). Use of modified whey protein in yoghurt formulations. *International Dairy Journal*, 21(1), 21–26.
- McKinley, M. C. (2005). The nutrition and health benefits of yoghurt. *International Journal of Dairy Technology*, 58(1), 1–12.
- Motoki, M., & Seguro, K. (1998). Transglutaminase and its use for food processing. *Trends in Food Science & Technology*, 9(5), 204–210.
- Ozer, B., Avni Kirmaci, H., Oztekin, S., Hayaloglu, A., & Atamer, M. (2007). Incorporation of microbial transglutaminase into non-fat yogurt production. *International Dairy Journal*, 17(3), 199–207.
- Pereira, R. B., Singh, H., Munro, P. A., & Luckman, M. S. (2003). Sensory and instrumental textural characteristics of acid milk gels. *International Dairy Journal*, 13(8), 655–667.
- Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: The role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal*, 19(8), 459–466.
- R Core Team. (2018). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from <https://www.r-project.org/>
- Routray, W., & Mishra, H. N. (2011). Scientific and technical aspects of yogurt aroma and taste: A review. *Comprehensive Reviews in Food Science and Food Safety*, 10(4), 208–220.
- Sahan, N., Yasar, K., & Hayaloglu, A. A. (2008). Physical, chemical and flavour quality of non-fat yogurt as affected by a ??-glucan hydrocolloidal composite during storage. *Food Hydrocolloids*, 22(7), 1291–1297.
- Sodini, I., Remeuf, F., Haddad, S., & Corrieu, G. (2004). The relative effect of milk base, starter, and process on yogurt texture: A review. *Critical Reviews in Food Science and Nutrition*, 44(2), 113–137.
- Tamine, A. Y., & Robinson, R. K. (1999). *Yoghurt: Science and technology* (2nd ed.). Florida: Boca Raton.
- Ünal, G., & Akalin, A. S. (2013). Influence of fortification with sodium-calcium caseinate and whey protein concentrate on microbiological, textural and sensory properties of set-type yoghurt. *International Journal of Dairy Technology*, 66(2), 264–272.
- Valli, C., & Traill, W. B. (2005). Culture and food: A model of yoghurt consumption in the EU. *Food Quality and Preference*, 16(4), 291–304.
- Vázquez, M., & Guerra-Rodríguez, M. E. (2012). Spanish Patent No. ES 2376439. doi: 10.1094/PDIS-11-11-0999-PDN
- Yüksel, Z., & Erdem, Y. K. (2010). The influence of transglutaminase treatment on functional properties of set yoghurt. *International Journal of Dairy Technology*, 63(1), 86–97.
- Zhao, L., Feng, R., Ren, F., & Mao, X. (2018). Addition of buttermilk improves the flavor and volatile compound profiles of low-fat yogurt. *Lwt*, 98(March), 9–17.
- Zhi, N.N., Zong, K., Thakur, K., Qu, J., Shi, J.J., Yang, J.L., ... Wei, Z.J. (2017). Development of a dynamic prediction model for shelf-life evaluation of yogurt by using physicochemical, microbiological and sensory parameters. *CyTA - Journal of Food*, 16(1), 1–8.