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Research Article

Impact of Sugar Reduction on Physicochemical and Nutritional Quality of Yogurt and Sensory Response with Label Stimulation

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This paper is aimed at developing yoghurts with reduced sugar content and evaluating their physicochemical, microbiological, and sensory characteristics including the stimulation of labels with nutritional indications. Four yoghurt formulations were developed (TY (traditional yoghurt), RSY (reduced sugar yoghurt), RSYL (yoghurt with reduced sugar and lactase), and RSYM (yogurt with reduced sugar and flavour modulator)). Yoghurts were evaluated on the first day of storage for physical-chemical aspects: fat, total protein, ash, total dry extract, reducing and nonreducing sugars, and pH, acidity in lactic acid, syneresis, and viscosity (non-Newtonian fluid) parameters were monitored until the end of refrigerated storage. Online questionnaires were carried out for sensory evaluation of acceptability and purchase intention of appearance. The labels were compared to each other to define which one communicated best with the consumer. The results showed that the reduction of sugar in yoghurt interferes with different physical-chemical parameters: pH, acidity, increasing syneresis, decreasing viscosity, total dry extract, and ash content. Storage influences the pH and acidity stabilization of all yogurts. Knowledge about lower sugar content positively influences acceptability and purchase intention, which preferred more flashy nutritional labels. The formulation adjustment associated with adequate labeling can encourage the consumption of yogurts with reduced added sugar content.

1. Introduction

Eating habits have become a worrying factor in recent years, as food can contribute positively or negatively to the health and well-being of consumers [1]. According to O'Sullivan [2], annually about 35 million people die from chronic noncommunicable diseases (NCDs), and many people with cardiovascular disease, type 2 diabetes, and some types of cancer could be reduced through healthy eating. To reduce the risks of developing NCDs, immediate application strategies aimed at reducing the consumption of high-calorie foods and effective interventions to minimize food reactivity are needed [3].

In 2015, the WHO (World Health Organization) published a guideline to encourage the creation of public policies aimed at reducing sugar consumption [4]. In line with this guideline, the Ministry of Health of Brazil started 2017, the creation of the sugar reduction plan in industrialized Foods, in partnership with several entities in the industrial sector, including ABIA (Brazilian Association of Food Industries) and *Viva Lácteos* (entity representing the dairy sector in Brazil) [5].

The dairy sector is prominent in the global market and presents growth prospects [6]. This can be influenced by the versatility of milk, used in the production of the most diverse by-products like cheese, butter, yoghurt, condensed milk, powdered milk, cream, and milk drinks, serving both as a main meal and as an ingredient in many recipes [7]. Among dairy products, yoghurt has been highlighted by a growing increase in its per capita consumption, due to a greater search for ready-to-eat foods with compounds that are beneficial to health like proteins, fibres, probiotics, and prebiotics. Yoghurt has a great capacity for incrementing new ingredients, which affect its nutritional value; it can be added to fruits that appear as the main source of vitamins, minerals, and other nutrients [8].

Yogurt is a product with a large commercial field, reaching a market of around 85 billion dollars worldwide [9]. For this reason, the clear display of information about its composition and nutrients on the label is of utmost importance. However, even today, the information contained in the labels of current foods is still considered complex, difficult to understand, and exhaustive for many consumers [10].

To minimize the problems of understanding the information on food labels, traffic light labelling was created in the United Kingdom, a simple tool that guides the consumer in identifying the content of some nutrients present in the purchased product using traffic light colours: green (low content), yellow (medium content), and red (high content) [11, 12]. In Brazil, the National Health Surveillance Agency (ANVISA) approved RDC no. 429, of October 8, 2020, which provides for the nutritional labelling of packaged foods, implements changes in the nutritional information table, and uses symbology to indicate high levels of sodium, saturated fat, and added sugar in foods [13].

Thus, based on the sugar reduction plan in processed foods, the present work is aimed at developing different formulations of strawberry-flavoured yoghurt with reduced sugar content, evaluating physical-chemical, microbiological, and sensory aspects, as well as different forms of nutritional labelling.

2. Material and Methods

2.1. Raw Material. The ingredients used in the preparation of the yoghurts were whole milk powder and skim powdered milk, modified starch, food gelatine, lactic culture consisting of *Streptococcus thermophilus* and *Lactobacillus* ssp. *bulgaricus*, strawberry preparation, lactase enzyme (β-galactosidase), flavour modulator (natural molasses aroma), cochineal carmine dye, and identical to natural strawberry aroma and sucrose. The ingredients were all donated by the *Laticínio Belo Vale*.

2.2. Yoghurt Processing. The production process for all strawberry yogurt formulations is detailed in Figure 1. The solid ingredients were weighed and mixed: whole milk powder (8 g 100 g^{-1}), skim powdered milk (2 g 100 g^{-1}), modified starch (0.64 g 100 g^{-1}), gelatine (0.16 g 100 g^{-1}), and sucrose (8 g 100 g^{-1}) in the production of conventional yoghurt (TY), or 5.75 g 100 g^{-1} in the production of low sugar yoghurt (RSY). These compositions were achieved after testing 7 different compositions of sugar, lactase enzyme, and flavour modulator. Other two low-sugar yoghurts were formulated: low-sugar yoghurt added of lactase enzyme (0.04 g 100 g^{-1}) (RSYL) and low-sugar yoghurt added of flavour modulator (0.04 g 100 g^{-1}) (RSYM). The lactase enzyme and the flavour modulator were only added after heat treatment, due to their sensitivity to heat.

After weighing the solid ingredients, they were diluted in water and subjected to heat treatment (heated to 90 ± 1°C for 2 min). Posteriorly, the milk was cooled to 45 ± 1°C, added with 2% (*v*/*v*) of the lactic culture (*Streptococcus thermophilus* and *Lactobacillus* ssp. *bulgaricus*), and incubated at 45 ± 1°C for 7 h or until pH reaches 4.7-4.8. Before incubation, lactase enzyme was added to the RSYL formulation and the flavour modulator in the RSYM formulation.

After fermentation, the gel was homogenized and cooled to temperatures between 15 and 20°C, and the strawberry preparation, colouring, and flavouring were added to all formulations (8 g 100 g^{-1}, 0.04 g 100 g^{-1}, and 0.07 g 100 g^{-1}, respectively), and they were cooled to 12°C. Finally, the yoghurts were filled in 450 mL plastic bottles and stored in a refrigerator at 10°C. The shelf life of yoghurts was determined at 45 days, considering the average period of refrigerated storage applied by most manufacturers, and monitored throughout this period through physical-chemical and microbiological analyses carried out on days 1, 15, 30, and 45. All ingredient proportions (Table 1) were established according to previous experiments, respecting the limits established by Brazilian legislation.

2.3. Preparation of Labels. Two labels were created for analysis and comparison. Label 1 was prepared following the new labelling standards published by the National Health Surveillance Agency (ANVISA) through RDC no. 429 of October 8, 2020, which provides for the nutritional labelling of packaged foods [13]. The new standards include the insertion of new terms in the nutritional table and the use of a magnifying glass symbol on the front of the package, indicating whether a food is "high in" added sugar, saturated fat, or sodium. Label 2 was prepared following the Food Standards Agency's (FSA) Nutritional Traffic Light labelling in the United Kingdom [14, 15].

2.4. Physicochemical Analysis. The yoghurts were analysed on the first day of refrigerated storage for physicochemical parameters: total dry extract (TDE %) [16], ash (%) [16], fat (%) by the Mojonnier method with adaptations [17], proteins (%) by the Kjeldahl method [16], and reducing and nonreducing sugars by the Lane-Eynon method (g.100 g^{-1}) [16].

For the study of product stability, yoghurts were evaluated at 1, 15, 30, and 45 days of refrigerated storage for the parameters: pH [16], acidity in lactic acid (%) [16], syneresis (%) [18], and viscosity (cP) (cup Ford no. 4 viscometer). Viscosity was calculated using the formula

$$\text{Viscosity} = [(3.846 \times t) - 17.3] \times d, \quad (1)$$

where t is the flow time of the yoghurt in the Ford cup and d is the density (calculated by the mass/volume ratio). All analyses were performed in three replicates.

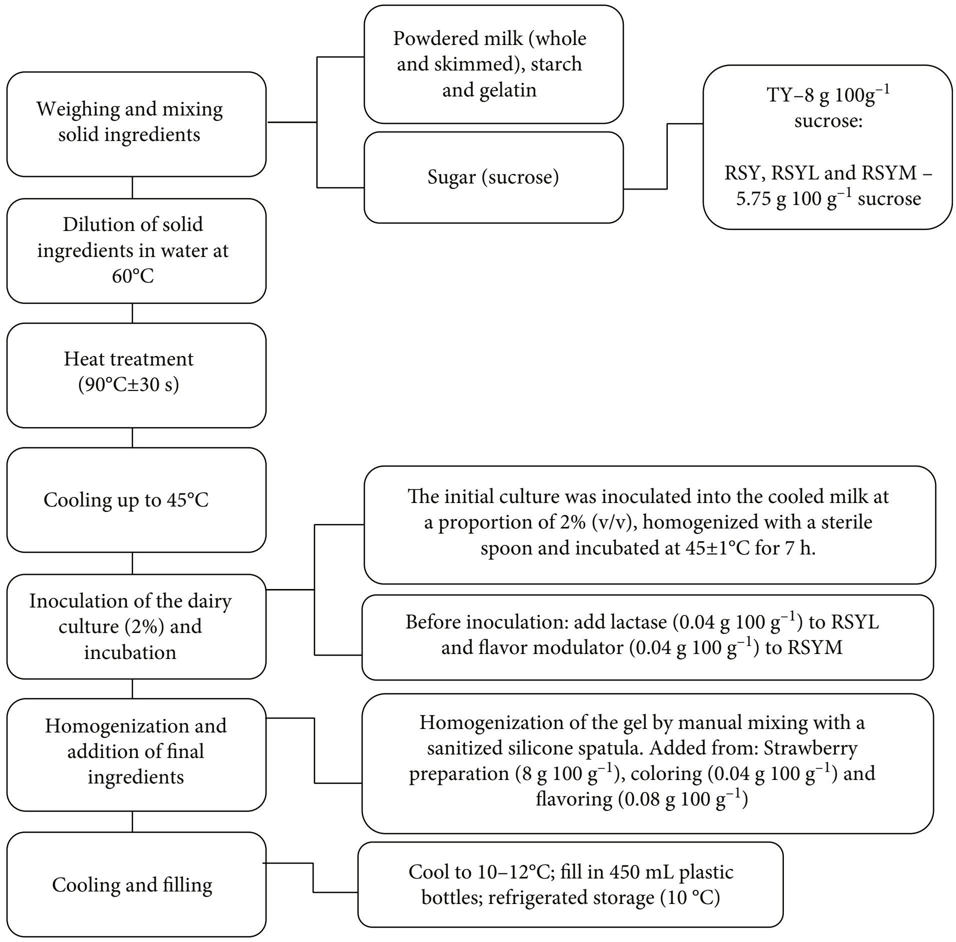

Figure 1: General flowchart of yoghurt processing. TY: conventional yoghurt; RSY: yoghurt with reduced sugar content; RSYL: yoghurt with reduced sugar content+lactase enzyme; RSYM: yoghurt with reduced sugar content+flavour modulator.

Table 1: Sugar-reduced strawberry yoghurt formulation: ingredients and proportions.

Ingredients (g 100 g^{-1})	TY	RSY	RSYL	RSYM
Whole powdered milk	8.00	8.00	8.00	8.00
Skim powdered milk	2.00	2.00	2.00	2.00
Modified starch	0.64	0.64	0.64	0.64
Gelatine	0.16	0.16	0.16	0.16
Sucrose	**8.00**	**5.75**	**5.75**	**5.75**
Strawberry preparation	8.00	8.00	8.00	8.00
Colouring	0.04	0.04	0.04	0.04
Flavouring	0.07	0.07	0.07	0.07
Lactase	—	—	**0.04**	—
Flavour modulator	—	—	—	**0.04**

TY: conventional yoghurt; RSY: sugar-reduced yoghurt; RSYL: sugar-reduced yoghurt + lactase enzyme; RSYM: sugar-reduced yoghurt+flavour modulator. Variable ingredients are highlighted in bold.

2.5. Microbiological Analysis. Microbiological quality was assessed on days 1 and 45 of refrigerated storage. The analysis performed in triplicate was coliform counts at 35°C and 45°C, through the most probable number method (MPN), and the counting of moulds and yeasts, through the counting of colony forming units (CFU) in plates. The analyses were carried out following the methodology described by Silva et al. [19] to fulfil the requirements of the technical regulation on the identity and quality of fermented milk [20].

2.6. Sensory Analysis. The sensory study was carried out through online questionnaires with Brazilian consumers. The snowball technique was used, through online questionnaires produced on the Google Forms platform (Google L.L.C., Mountain View, California, USA). The questionnaires were shared on social networks where the first participants shared with others, and so on, according to the methodologies of Martins et al. [21] and Olegario et al. [22] with adaptations.

At the beginning, participants were informed of the objectives and voluntary nature of participation in the research. Then, they were asked whether they agreed to participate in the research and asked to continue with the completion of the questionnaire in case of agreement. Yoghurt consumers answered sociodemographic questions (gender, age, education, and place of birth). Then, information on the frequency of consumption was collected on a 5-point scale (1: rarely consumption; 5: daily consumption), in addition to consumption habits (type and taste of yoghurt consumed), label reading (packaging information), food restriction, and the presence of any chronic noncommunicable disease. A total of 131 participants answered the complete questionnaire, of which 66.4% were women, 61.8% were between 18 and 25 years old, 64.1% were university students and/or graduates, and 22.9% were postgraduate students.

Images of the different yoghurt formulations were presented with three-digit code identification (Figure 2) and evaluated in a randomized order in two sessions: (1) without nutritional information and (2) with nutritional information. In each session, participants evaluated the appearance of the yoghurts and indicated how much they liked each one of them on a 5-point hedonic scale (1: I disliked it extremely; 2: I disliked it moderately; 3: neutral; 4: I liked it moderately; 5: I liked it extremely) and purchase intent on a 5-point attitude scale (1: certainly would not buy; 2: probably would not buy; 3: neutral; 4: would probably buy; 5: would certainly buy). Finally, two images of different front labels were presented (new standard approved by ANVISA and nutritional traffic light) (Figure 3) and asked to indicate which labelling model best communicates with the public.

All procedures performed in this study involving human participants were previously approved by the ethics committee of the *Universidade Federal de Campina Grande* (CAAE: 19794519.1.0000.5182) in accordance with the Declaration of Helsinki.

2.7. Statistical Analysis. For the variables analysed only on the first day of storage, an analysis of variance (ANOVA) was performed, and the means were compared using the Tukey test ($p < 0.05$), using the fully randomized design (FRD). The effect of treatments (strawberry yoghurt formulations—conventional yoghurt (TY); low sugar yoghurt (RSY); low-sugar yoghurt added of lactase enzyme (RSYL); low-sugar yoghurt added of flavour modulator (RSYM), time (1, 15, 30, and 45 days of refrigerated storage), and treatment×time interaction was evaluated using analysis of variance (ANOVA), and the treatment means were compared using a 4×4 factorial design (4 yoghurt formulations and 4 storage times), through SISVAR software version 5.6.

For sensory analysis, analysis of variance (ANOVA) was performed on the results of acceptability and purchase intention, and the means were compared using the t-test (LSD) ($p < 0.05$) to assess whether there was a significant difference between acceptability and purchase intent in relation to appearance between the two sessions: without and with knowledge of the sugar content in yoghurts. A fully randomized design (FRD) was used in SISVAR software version 5.6.

3. Results and Discussion

3.1. Physicochemical and Microbiological Aspects. The results obtained from the physicochemical composition of yogurts are shown in Table 2. The total dry extract values show that the conventional yoghurt (TY) presented a significant difference compared to the other formulations. This difference can be explained by the concentration of sugar between the different yoghurts: the conventional formulation was added with more sugar (8%), which implies a higher concentration of solids when compared to other formulations (RSY, RSYL, and RSYM) that were added with 5.75% sucrose. Among the formulations with reduced sugar, there was no statistically significant difference.

All formulations showed significant differences from each other for ash content, and the conventional yoghurt (TY) formulation showed the highest value. According to the Brazilian Food Composition Table [23], the ash content in yoghurts is between 0.68 and 0.98%. All formulations presented values within this range. Although they have shown statistically significant differences between them, the ash values are very close, having an average of 0.77% between the formulations and a variance equal to 0.0007.

There was no significant difference in fat and protein contents, as the sugar content added to yoghurts was not enough to change these parameters. The protein content in all formulations meets the requirements of the technical regulation on the identity and quality of fermented milk [20], which established a minimum value of 2.9% of milk proteins in yoghurts. Regarding the fat content, the studied yoghurts can be classified as "partially skimmed," as they present contents between 0.6 and 2.9%, as established by the technical regulation.

The reducing sugars differed significantly between all the formulations studied, and the RSYL formulation had the highest concentration (Table 2). This higher concentration can be explained by the principle of analysis and by the formulation itself: the result of the analysis of reducing sugars is expressed as a percentage of lactose in the product since lactose is the largest reducing sugar found in milk naturally [16, 24]. With the action of the lactase enzyme in the RSYL formulation, lactose is hydrolyzed and broken down into two reducing monosaccharides (glucose and galactose) [25], which explains the higher content of reducing sugars in RSYL. The TY and RSY formulations had the lowest concentrations of reducing sugars (5.57 and 5.62%, respectively) since, in these formulations, the predominant reducing sugar is natural lactose in milk. As for the RSYM formulation, a higher value was observed in relation to TY and RSY. This higher value may be linked to the addition of the flavour modulator (natural molasses aroma) which is made up of 58% carbohydrates and may have reducing sugars in its composition.

It was possible to observe that there was a statistical difference between the formulations concerning the concentration of nonreducing sugars, which are quantified in the percentage of sucrose. The conventional yoghurt formulation (TY) had the highest value. It can also be observed that the mean values found for this variable remain close to the percentage of sucrose added for each formulation (8% for TY and 5.75% for the others).

During storage, the pH of yoghurts (Figure 4(a)) varied significantly in all formulations: the lowest pH (4.56) was observed in the RSYM formulation at 45 days of storage, and the highest pH value (4.84) refers to conventional yoghurt (TY) in the first day of storage. There was a

Figure 2: Image of strawberry yoghurts used on the questionnaires.

Figure 3: Yoghurt labels (TY: conventional yoghurt): nutritional traffic light labelling (a) and new ANVISA nutritional labelling standard (b).

significant difference in pH during storage only in the TY and RSY formulations, which had the highest pH values on the first day of storage and continued the fermentation process during storage, reaching a value of 4.64 on day 45 of storage. This behaviour is justified by the fact that the TY and RSY formulations were only added with sucrose, while the RSYL and RSYM formulations received the addition of lactase and flavour modulators, respectively. The RSYL and RSYM formulations did not show pH variation during storage, which suggests that the addition of lactase and flavour modulator interfered with the fermentation process, decreasing the pH more quickly compared to TY and RSY formulations, in addition to showing greater stability for this variable during storage.

According to the Technical Regulation on the Identity and Quality of Fermented Milk [20], yoghurts must have acidity values between 0.6 and 2.0% in lactic acid. All formulations presented values between 0.66 and 0.71% (Figure 4(b)). The acidity showed significant differences during storage only in the RSY and TY formulations, with an increase in this content during storage, according to the Tukey test. The acidity of yoghurts was affected by the presence of lactase and flavour modulator in the RSYL and RSYM formulations, presenting more stable values during storage, while in the TY and RSY formulations, the percentage of lactic acid increased during the storage.

In all yoghurt formulations, an increase in the percentage of syneresis was observed (Figure 4(c)), with significant differences during the entire storage, according to the Tukey test. The lowest values observed for syneresis were related to conventional yoghurt (TY). The lower percentage of syneresis observed in the TY formulation is justified by the higher concentration of added sugar, which increases the solids content in the yoghurt and, consequently, increases the water retention capacity (WRC). However, during storage, due to the decrease in pH, which promotes rearrangements in milk proteins, WRC also decreases, and, consequently, there is an increase in syneresis.

Viscosity (Figure 4(d)) is a variable that is inversely associated with syneresis: the higher the viscosity, the lower the possibility of syneresis. Viscosity is a parameter that measures the flow properties of a fluid, which can be increased by adding solids to the product [18].

According to the results, it is possible to identify that the conventional yoghurt formulation (TY) has the highest viscosity values during all the storage, presenting a significant difference when compared to other yoghurt formulations. As explained earlier, an increase in the solids level causes the viscosity to increase as well. Then, the TY formulation has the highest values for this variable because it has a higher content of added sugar.

During storage, all formulations showed a reduction in viscosity (which is explained by the increase in syneresis during storage), with a statistical difference between the days of storage, according to the Tukey test. When compared to

Table 2: Physicochemical evaluation of strawberry yoghurts (mean ± standard deviation).

Analysis	Formulations				
	TY	RSY	RSYL	RSYM	CV (%)
TDE (%)	22.3 ± 0.02^a	19.3 ± 0.05^b	19.4 ± 0.26^b	19.5 ± 0.26^b	0.92
ASH (%)	0.80 ± 0.01^a	0.74 ± 0.01^d	0.78 ± 0.01^b	0.76 ± 0.01^c	0.61
PRT (%)	3.45 ± 0.09^a	3.45 ± 0.03^a	3.47 ± 0.03^a	3.52 ± 0.09^a	1.97
FAT (%)	2.69 ± 0.01^a	2.70 ± 0.01^a	2.70 ± 0.01^a	2.71 ± 0.01^a	0.26
RS (%)	5.57 ± 0.01^d	5.62 ± 0.02^c	7.06 ± 0.02^a	6.31 ± 0.01^b	0.26
NRS (%)	8.25 ± 0.03^a	5.80 ± 0.02^b	5.61 ± 0.05^c	5.75 ± 0.06^b	0.63

TY: conventional yoghurt; RSY: yoghurt with reduced sugar content; RSYL: yoghurt with reduced sugar content+lactase enzyme; RSYM: yoghurt with reduced sugar content+flavour modulator; TDE: total dry extract; ASH: ash; PRT: protein; FAT: fat; RS: reducing sugar; NRS: nonreducing sugar; CV: coefficient of variation. Equal lowercase letters on the line do not differ statistically from each other (Tukey test $p < 0.05$).

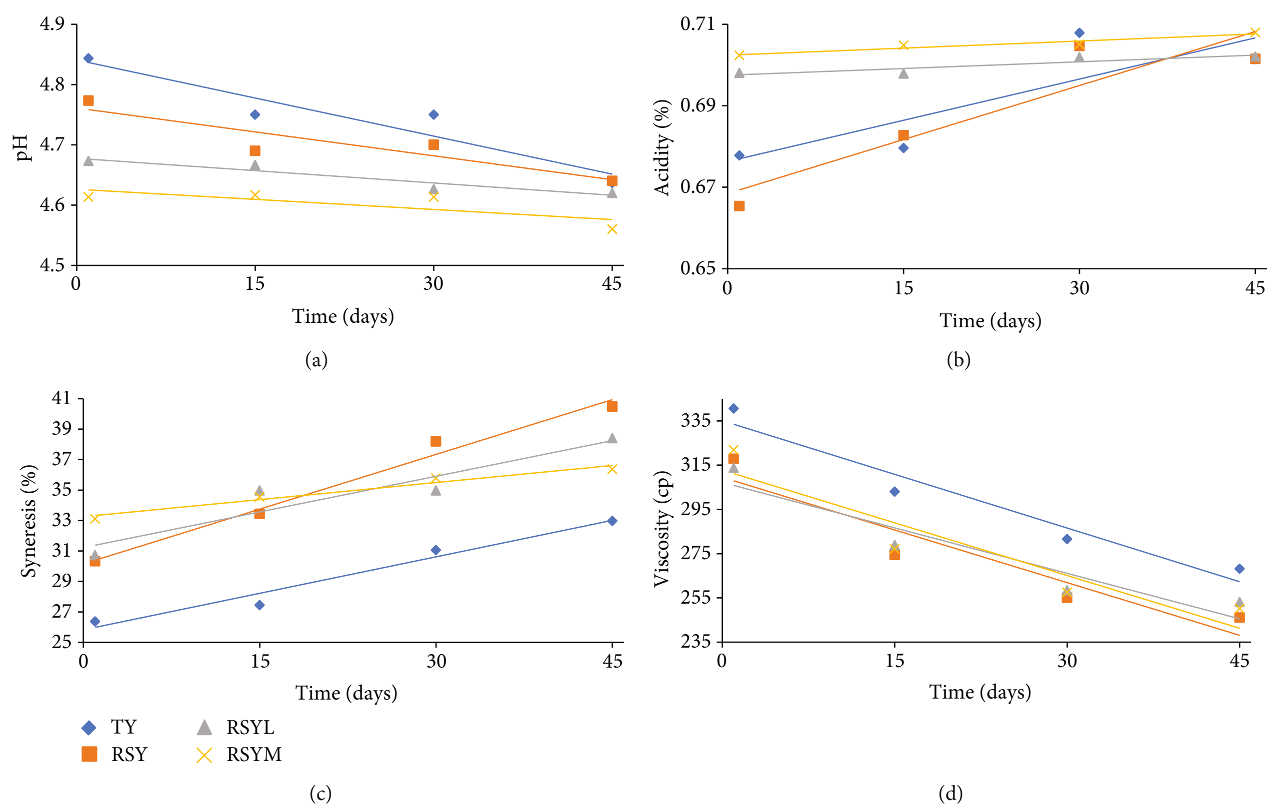

Figure 4: Results of pH (a), acidity (b), syneresis (c), and viscosity (d) of strawberry yoghurts during storage. TY: conventional yoghurt; RSY: yoghurt with reduced sugar content; RSYL: yoghurt with reduced sugar content+lactase enzyme; RSYM: yoghurt with reduced sugar content+flavour modulator.

each other, on all days of storage, the RSY, RSYL, and RSYM formulations did not show significant differences between them since the three formulations were added with the same amount of sugar (5.75%).

Values within the standards required by the technical regulation on the identity and quality of fermented milk [20] were observed for microbiological parameters, as shown in Table 3.

3.2. Consumer Sensory Response. In the sensory analysis, when asked about the consumption of yoghurt, most participants (37.4%) said they consume yoghurt neither rarely nor daily, 35.1% said they consume it rarely, and 27.5% consume it daily. As for the type of yoghurt consumed, 53.4% of the evaluators stated that they consume plain yoghurt, 41.2% whole yoghurt, and 27.5% Greek yoghurt. The lowest percentages of consumption were evidenced for partially skimmed yoghurt (18.3%) and skimmed yoghurt (15.3%). Regarding the yoghurt flavours consumed, 83.8% of the participants reported consuming strawberry-flavoured yoghurt, 40.0% mixed fruit-flavoured yoghurt, 39.2% plum-flavoured yoghurt, and 35.4% berry-flavoured yoghurt.

Among the 131 people who participated in the survey, 14 people (10.7%) claimed to consume other flavours (soursop,

Table 3: Average values for microbiological analysis of strawberry yoghurts on days 1 and 45 of storage.

Microbiological parameters	Formulations				Standards
	TY	RSY	RSYL	RSYM	
Coliform bacteria at 35°C (MPN/g)	23.0	23.0	23.0	23.0	≤100
Coliform bacteria at 45°C (MPN/g)	<3.0	<3.0	<3.0	<3.0	≤10
Moulds and yeasts (CFU g^{-1})	<1.0	<1.0	<1.0	<1.0	≤200

TY: conventional yoghurt; RSY: yoghurt with reduced sugar content; RSYL: yoghurt with reduced sugar content+lactase enzyme; RSYM: yoghurt with reduced sugar content+flavour modulator.

banana, banana, apple, coconut, peach, honey, açai, and grape), and only 7 of them (5.3%) claimed to consume natural yoghurt (unflavoured).

As for the labels of the yoghurts consumed, only 29.8% (39 participants) declared to verify the nutritional information. 126 participants (96.2%) said they did not have any dietary restrictions, 3 participants (2.3%) said they had lactose intolerance, and two participants (1.5%) said they had another type of restriction. When asked about having any CNCD (chronic noncommunicable disease), 126 of the participants (96.2%) said they did not have any, and 5 participants (3.8%) said they did.

Figure 5 presents the acceptability and purchase intention results regarding the appearance of yoghurts in two scenarios: without knowledge of the yoghurt's sugar content (SC) and with knowledge about the sugar content (CC). The appearance of yoghurts can be evaluated by considering factors such as apparent viscosity, brightness, colour, fluidity, and uniformity. According to Figure 5(a) and the comments of the sensory analysis participants, conventional yoghurt (TY) had greater acceptance among evaluators, which may be associated with the fact that this formulation has a higher apparent viscosity compared to other formulations. Among the evaluators, 48.1% marked the option "I liked it extremely" on the 5-point scale for the conventional yoghurt formulation. The RSY, RSYL, and RSYM formulations had the highest percentage for the option "I liked it moderately" on the 5-point scale (51.1, 49.6, and 33.6%, respectively).

With knowledge of the level of added sugar in the formulations, survey participants changed their opinions about the appearance of yoghurts (Figure 5(b)), and a smaller variation was detected for RSYL and RSYM formulations. This change in assessment is due to an emotional response provoked by the food, and, according to Olegario et al. [22], it is context-dependent and is characterized by 5 components: expression, action tendency, body reaction, feeling, and evaluation. In other words, when consuming food, the human organism generates a series of expressions, sensations, and actions that, depending on the context, incite the brain to produce an emotional response to that food. Therefore, with the new information, the context changes and generates interference in each person's response, which may or may not change their first response.

Knowledge about the sugar content in yoghurts interfered with the acceptability of RSY and TY formulations, with a reduction in TY acceptability and an increase in RSY acceptability. The RSYL and RSYM formulations showed no significant difference between the different scenarios. These differences can be statistically confirmed by comparing the means of the evaluators' responses (Table 4). Among the formulations, no significant differences were found.

As for the purchase intention (Figures 5(c) and 5(d), it also presents the results in two scenarios. In the first scenario, the TY and RSYM formulations had higher percentages for the option "would certainly buy" (48.1 and 43.5%). Although they have different apparent viscosities, some of the consumers stated that they like yoghurts with a more fluid appearance such as the RSYM formulation. The RSY and RSYL formulations had higher percentages for the "would probably buy" option. The lactose content also influences texture perceptions [26] which in this scenario may have had a positive influence. In general, all formulations showed good acceptability in terms of purchase intent.

In the second scenario, differences were observed due to knowledge of the sugar content of yoghurts. For the TY formulation, 48.1% of people said they "would certainly buy" on a 5-point scale before knowing the sugar content. With nutritional information, this percentage in the option "would certainly buy" dropped to 21.4%, and the highest percentage for this formulation was observed in the option "neutral" (26%). In the other formulations, an increase in purchase intention was observed, more specifically in the option "would probably buy" with percentages for RSY, RSYL, and RSYM equal to 38.2, 43.5, and 40.5%, respectively.

Table 4 presents the results of acceptability and purchase intention in the scenarios with and without knowledge of sugar content. Most of the samples showed a satisfactory level of acceptability and purchase intention with averages close to 4 which would indicate that consumers liked it moderately and would probably buy the samples. Different levels of acceptability ($p < 0.05$) were found between the SC and CC scenarios for the TY and RSY formulations. The same was observed for purchase intention. Thus, the presence of information on sugar content significantly reduced the acceptability and purchase intention of the TY sample and significantly increased it for the RSY sample. For the RSYL and RSYM formulations, no significant difference was found between the scenarios. It can be indicated, therefore, that the addition of lactose and the modulator may have influenced the appearance characteristics, in such a way that the information on the sugar content did not increase the degree of affectivity of consumers, as was observed for RSY.

Finally, the evaluators received two forms of frontal labelling in the questionnaire (Figure 3) for the labels' observation, evaluation, and comparison, aiming to establish

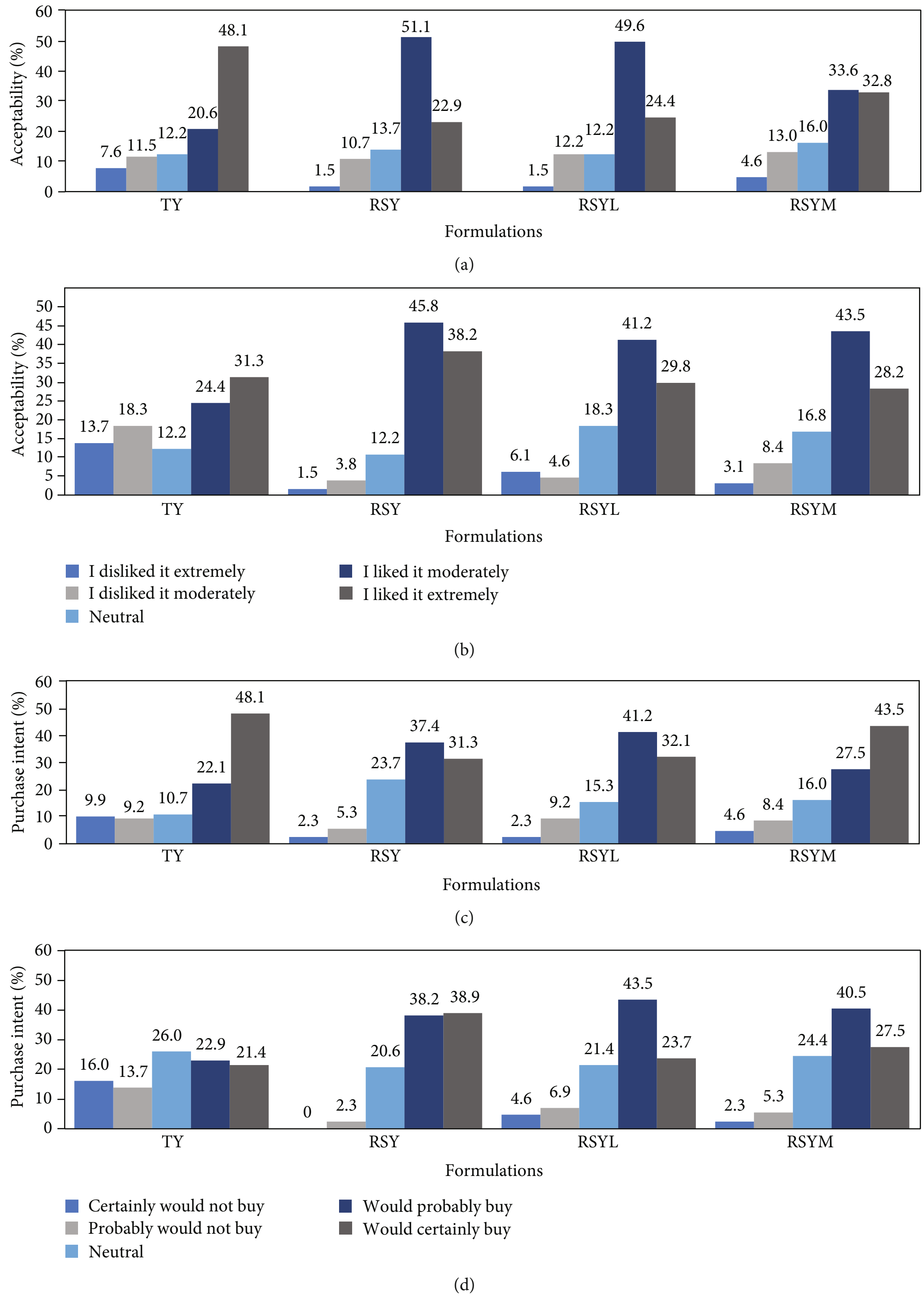

Figure 5: Acceptability and yoghurt purchase intention index as to the appearance of yoghurts, without (a, c) and with (b, d), respectively, knowledge of the sugar content of the formulations. TY: conventional yoghurt; RSY: yoghurt with reduced sugar content; RSYL: yoghurt with reduced sugar content+lactase enzyme; RSYM: yoghurt with reduced sugar content+flavour modulator.

which one communicated better with the consumer. According to the opinion of most participants, the labelling "nutritional traffic light" has a better way of communicating with the consumer due to two factors: the traffic light colours and the display of the percentage of sugar on the front of the package. Of the 131 survey participants, 66.4% expressed a preference for traffic light labelling.

Table 4: Comparison of acceptability and purchase intention of yoghurts in terms of appearance in different scenarios with and without knowledge of sugar content.

Scenarios	Formulations			
	TY	RSY	RSYL	RSYM
Acceptability†				
SC	3.90 (0.12)^a	3.83 (0.08)^b	3.83 (0.09)^a	3.77 (0.11)^a
CC	3.41 (0.13)^b	4.15 (0.08)^a	3.84 (0.10)^a	3.85 (0.09)^a
Purchase intention†				
SC	3.89 (0.12)^a	3.90 (0.09)^b	3.92 (0.09)^a	3.97 (0.10)^a
CC	3.20 (0.12)^b	4.14 (0.07)^a	3.75 (0.09)^a	3.85 (0.08)^a

†Data expressed in mean (standard error). TY: conventional yoghurt; RSY: yoghurt with reduced sugar content; RSYL: yoghurt with reduced sugar content+lactase enzyme; RSYM: yoghurt with reduced sugar content+flavour modulator; SC: without knowledge of sugar content; CC: with knowledge of sugar content. Equal lowercase letters in the column do not differ statistically from each other (t-test (LSD) $p < 0.05$).

4. Conclusions

The reduction of sugar positively influences the physicochemical characteristics of strawberry-flavoured yogurts. The use of lactase and flavour-modulating additives can be useful for the production of yogurts with reduced sugar content, favouring the stability of the fermentation process and storage. Sugar reduction can positively affect the acceptability and purchase intention of yogurt when they are informed of the nutritional composition. Consumers prefer to receive clear information about yogurt composition through more interactive labels, with colours and percentage values of important components displayed on the front of the pack. Improving nutritional labelling, making it more informative and visually attractive may encourage consumers to choose yogurt options with less sugar. Finally, the findings of this study bring light to the food industry sector on yogurt composition alternatives to achieve sugar reduction goals while meeting consumer expectations.

Data Availability

Data available on request from the authors.

Ethical Approval

All procedures performed in this study involving 327 human participants were previously approved by the Ethics Committee of the Federal University of Paraiba (CAAE: 328 26383519.3.0000.5188) in accordance with the Declaration of Helsinki.

Conflicts of Interest

The authors declare no conflict of interest.

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