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Physicochemical Properties, Sensory Evaluation and Shelf Life Characteristics of Chia Enriched Yoghurt

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ABSTRACT

Consumers today are showing increased concern about food and health. The nutritional value of food can be improved by enriching with other nutritious products. In Kenya, the demand for yoghurt has been on a constant increase with some processors seek to incorporate artificial and highly processed ingredients such as stabilizers and emulsifiers as additives in order to improve nutritional value, thickening and stabilizing properties. Besides having good gelling properties, chia seeds (*Salvia hispanica*L.) have been reported to contain essential nutrients and phytochemicals. This study sought to develop chia enriched yoghurt and determine the physicochemical (pH, total titratable acidity and syneresis), sensory and shelf life characteristics of chia enriched yoghurt (CEY). The treatment involved enriching yoghurt with varied amounts of chia seeds as follows; 1.5% m/v (CEY1.5), 2.5% m/v (CEY2.5), 3.5% m/v (CEY3.5), and corn starch (2%) (CEY0). The results of physicochemical characteristics showed chia seeds had no effect on the pH and titratable acidity values of the yoghurt. From the results of sensory analysis, the panelists preferred the texture, taste, colour and appearance of CEY0 and CEY1.5 over those of CEY2.5 and CEY3.5. In shelf life studies, pH decreased significantly while titratable acidity and syneresis increased significantly during refrigerated storage in both CEY0 and CEY1.5, CEY2.5 and CEY3.5. In conclusion, CEY1.5, CEY2.5 and CEY3.5 showed enhanced physicochemical (pH and titratable acidity) and sensory properties compared to CEY0 thus chia seeds could be a potential ingredient in yoghurt formulation.

KEYWORDS: chia, yoghurt, physicochemical, sensory, shelf life, enrich.

INTRODUCTION

Consumer food acceptability and choices have continuously shifted from eating to satisfy hunger to accessing healthy and quality food with functional appeal, low caloric value and good sensory quality. Currently, there is an increasing interest in the utilization of natural food additives which might incorporate health promoting ingredients. Some of the dairy products that are processed, packaged, and marketed by Kenyan dairy companies include yoghurt, cheese, salted and unsalted butter, ghee, condensed milk, evaporated milk, different types of cream and desserts[1, 2]. Yoghurt consumption has significantly increased with many small scale vendors in Kenya opting for the business in both rural and urban set ups. With the continuing rise in the popularity of probiotic yoghurt, dairy based food manufacturers are always looking into novel ingredients which would enhance its health benefits and sensory properties [3].Utilization of various synthetic and highly processed ingredients in yoghurt production is a common phenomenon. These ingredients lack adequate nutritional value and chia seeds could serve the purpose for these ingredients when incorporated in yoghurt. Some of the food additives such as food color and stabilizers are chemicals that have no nutritional benefit. Therefore, most of the yoghurt that is available in the Kenyan market today fails to provide the consumers' preferences since its health benefits are affected by the presence of these additives. The continued use of the chemical and highly processed food additives such as food color, flavor enhancers and stabilizers might cause consumers to reduce their consumption of processed yoghurt which may hinder them from benefiting from the functional properties of yoghurt.

Chia (*Salvia hispanica*L.), is an exotic plant which has recently been introduced in Kenya and is gaining popularity as evident in many people presently using the seeds in drinking water, and also mixing them with other foods. Chia seed gum, contained in the seed coat or adjacent layer, has slimy properties which is evident even at very low concentrations. Chia gum begins to form as seeds are placed in water[4] and hence can be used for thickening as well as a stabilizer in food products. Therefore, incorporation of chia seeds in yoghurt could act as a gelling and stabilizing agent to improve the sensory characteristics. Although chia seeds have been used to enhance

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the health outcomes of bread and cake, there is no report in the literature on the possible utilization of these oilseeds in conventional yoghurt particularly in view of enhancement of gelling and stabilization properties. A previous study has shown that enriching yoghurt with chia seeds would improve its nutritional value significantly [5]. It was anticipated that the enrichment of yoghurt with chia seeds may enhance its physicochemical, sensory and shelf life properties as well as improve its consumption.
With justification from the above points, this study sought to enrich yoghurt with chia seeds as an interesting way to improve consumers' intake of nutrients not naturally present in the plain yoghurt.

MATERIALS AND METHODS

Sample collection and storage

The dried mixture of black and white chia seeds were purchased from an identified farmer in King'ong'o, Nyeri County, Kenya, where the seeds were also grown. Fresh whole milk was obtained from the Dedan Kimathi University of Technology (DeKUT) dairy farm. The chia seeds were stored in sample bags in a cool dry place while the fresh milk was stored in the refrigerator at 4ºC until use. Sugar was purchased from the supermarket in Nyeri, Kenya and stored in a cool dry place during the period of use. The cornstarch and the starter culture of *Streptococcus salivarius subsp. Thermophiles* and *Lactobacillus delbruckee subsp. Bulgaricus* strains were purchased from Promaco Limited, a commercial starter culture supplier based in Nairobi, Kenya. The starter culture was stored in the freezer at -20°C.

Experimental design

A laboratory-based experimental method was used for this study. To collect both qualitative and quantitative data in this study, all the experiments were carried out under laboratory conditions while still observing the technological conditions and requirements for industrial yoghurt production. For this study, each treatment consisting of chia enriched yoghurt (CEY) made from whole milk with varied proportions of chia seeds and corn starch treatments in triplicate as illustrated in Table 1, based on findings of preliminary work conducted before the actual study. Most yoghurt products found in the market today usually has starch added to thicken and stabilize it. This study focused on replacement of ingredients such as starch which are used in dairy industry for thickening and stabilizing yoghurt hence CEY0 had starch added in its formulation.

Table 1: Formulation of chia enriched yoghurt

	Chia seeds	Cornstarch (m/v)
CEY0	0	20g/ L
CEY 1.5	15 g/ L	0
CEY 2.5	25 g/ L	0
CEY 3.5	35 g/ L	0

Production of chia enriched yoghurt

Pure cultures of *Streptococci thermophillus* and *Lactobacillus delbruckiibulgaricus* were used as shown in the flow diagram below (Figure 1). For each of the four treatments, 2 litres of whole cow milk was used. They dry ingredients were as follows; 70g chia seeds for CEY3.5, 50g chia seeds for CEY2.5, 30g chia seeds for CEY1.5, 40g corn starch for the starch-thickened yoghurt and 120g sugar for each treatment .

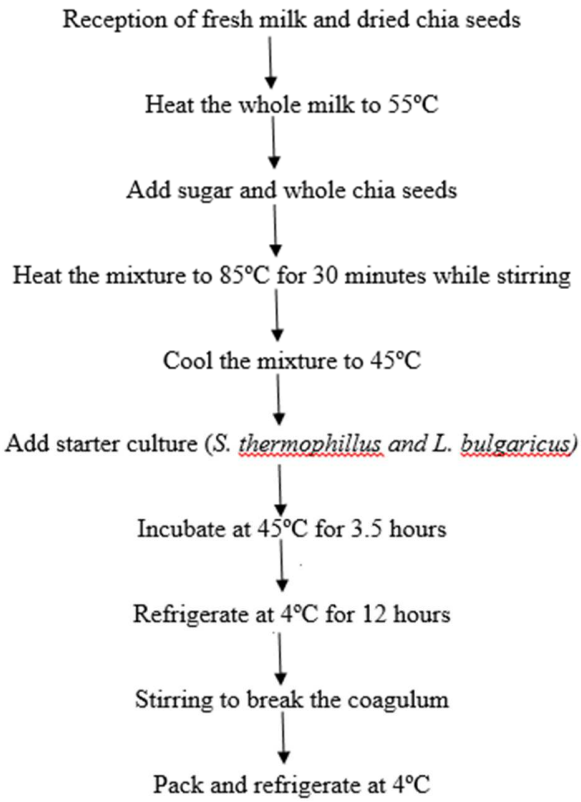

Figure 1: manufacturing process of CEY

Physicochemical analysis of chia enriched yoghurt (CEY)

Syneresis

The syneresis index was evaluated using a method described by Tarakçi, (2003) with modification[6].

pH

The yoghurt samples (10 g each) were mixed with distilled water (1:1) and the pH was measured using a digital pH meter (PL-600 pH/mV/Temp Meter) which was routinely calibrated with pH 4.0 and 7.0 standard buffers.

Titratable acidity

Measurement of acidity was carried out by the method of AOAC method 942.15 [7].

Determination of total solids

The total solids content of the yoghurt samples was carried out using AOAC method 925.23 with minor modifications [7].

Solids-not-fat

The percent solids-not-fat content was determined by subtracting the amounts fat from the total solids as shown in equation (1) below;

$$\% \text{ Solids-not-fat} = \% \text{ Total solids} - \% \text{ Fat content} \quad (1)$$

Sensory evaluation of chia enriched yoghurt

The yoghurt samples were subjected to sensory evaluation using 31 semi trained panelists on the second day of storage. The panelists were drawn from among the students and staff in the Institute of Food and Bioresources Technology (IFBT) of Dedan Kimathi University of Technology, Nyeri, Kenya. Simple random sampling procedure was applied when selecting the subjects to take part in this study. The temperature was controlled so as to remain the same for all samples. The volume (15mL) of the yoghurt served was equal for all samples and it was put into covered cups each, for every panelist. The samples were labeled with 3-digit codes to avoid bias and then served in counterbalanced order whereby if 2 different samples were served; the first half of the panel would receive the first one while the other half received the next sample. The panelists were provided with clean water to rinse their mouths between sample tasting.

The sensory evaluation was done using tables which compared the results. The parameters observed were color, aroma, texture, taste (sourness), appearance and overall acceptability. The tasting room was well lit and ventilated. Sensory analysis was done to determine the consumer acceptance by using 9-points hedonic rating scale (9-like extremely, 8-like very much, 7-like moderately, 6- like slightly, 5-neither like nor dislike, 4- dislike slightly, 3-dislike moderately, 2-dislike very much, 1-dislike extremely)

Shelf life determination

The shelf life of the enriched yoghurt was determined through chemical analysis (pH and titratable acidity) and syneresis after fermentation at intervals of 1, 10, 20 and 30 days as discussed earlier. The yoghurt samples were stored under refrigeration (4ºC) for the whole period.

Statistical analysis

The collected data was subjected to statistical analysis using the Statistical Package of Social Sciences (version 21.0; Inc, Chicago IL) software. One-way analysis of variance (ANOVA) was performed for all the data. Duncan's Multiple Range Test was used for physicochemical and shelf life analyses to compare the mean values between samples while Tukey's Multiple Range Test was used for sensory evaluation, and the data was significant if the p-value was found to be < 0.05. Results are presented as the mean and the standard deviation of the mean (± SD).

RESULTS AND DISCUSSIONS

Physicochemical analyses

The results of the physicochemical properties of the different yoghurt samples are summarized in Table 2. From the results, the total solids of the samples ranged from 18.03% in CEY0 to 20.14% in CEY3.5. A significant difference in total solids content was observed between all the samples. This content is similar to the range of 18.4% to 21.41% reported in a previous study[8]. This amount of total solids was helpful because low percentage of total solids in yoghurt can lead to malfunctions of the starter culture [9]. The results showed that the solids-not-fat for the different yoghurt samples ranged from 7.78% in CEY3.5 and 8.23% in the CEY0. The total solids-not-fat for all yoghurt samples were reasonably low as compared to the expected value of not less than 8.5% stated in the standard for yoghurt [10]. It appears that the whole milk used had high fat content since CEY0 did not also meet this requirement. However, some of these restrictions 'may limit the options of manufacturers to diversify and provide the consumers with a wide range of products'[11]. The total solids-not fat differed significantly ($p<0.05$) between CEY0 and the chia enriched yoghurt samples. However, no significant difference ($p>0.05$) in total solids-not-fat was observed between the yoghurt enriched yoghurt samples.

Table 2: Physicochemical analysis of chia enriched yoghurt

Samples	Parameters				
	Total Solids (%)	Total Solids Not-Fat (%)	pH	Titratable acidity (%)	Syneresis (%)
CEY0	18.03±0.01^{a}	8.23±0.01^{a}	4.66±0.01^{a}	0.65±0.01^{a}	2.68±0.45^{a}
CEY1.5	18.62±0.07^{b}	8.02±0.07^{b}	4.67±0.01^{a}	0.66±0.01^{b}	2.31±0.09^{b}
CEY2.5	19.29±0.28^{c}	7.94±0.28^{b}	4.68±0.06^{a}	0.68±0.01^{b}	2.26±0.13^{b}
CEY3.5	20.14±0.24^{d}	7.78±0.24^{b}	4.67±0.00^{a}	0.67±0.01^{b}	1.86±0.09^{b}

The values shown are means of two replicates. Means are ±SD having different superscript letters in a column are significantly different ($p<0.05$) by Duncan's Multiple Range Test

The pH of the samples ranged from 4.66 in CEY0 to 4.68 in CEY2.5. This value was within the range recommended by Kenya Bureau of standards (KEBS) (4.0 to 4.5). From the results, no significant difference ($p<0.05$) was observed in the acidic level of all the yoghurt samples. This could mean that the chia seeds had no reasonable effect on the fermentation of lactose. The results of total titratable acidity (TTA) of the samples as indicated in Table 2 ranged from 0.65% in CEY0 to 0.68% in CEY2.5. These values are within the range of 0.6 to 1.2% recommended by KEBS and 0.6% to 0.8%[12]. The results indicated that there was no significant difference ($p<0.05$) in TTA between the chia enriched yoghurt samples. A significant difference was observed between the TTA of CEY0 and that of the chia enriched samples (CEY1.5, CEY2.5, and CEY3.5). The syneresis index of the samples ranged from 1.86% in CEY3.5 to 2.68% in the CEY0. There existed a significant difference ($p>0.05$) in the syneresis index between CEY0 and all the chia enriched yoghurt samples. Incorporation of chia seeds into yoghurt considerably reduced the syneresis effect.

Sensory analysis

The mean sensory data of the evaluation and acceptability for the different yoghurt samples are shown in Table 3. The statistical analysis revealed that there were significant differences ($p<0.05$) among the yoghurt samples in the sensory attributes observed.

Texture

The results of hedonic rating for texture ranged between 6.13 (like slightly) in CEY3.5 to 7.94 (like very much) for CEY0. The results showed that there was no significant difference in texture between CEY0 and the CEY1.5, as shown in Table 3, which contained the lowest amount of chia seeds. However, there was a significant difference ($p>0.05$) in texture between the CEY0 and CEY3.5 as well as CEY2.5. Similarly, there was a significant difference in texture between CEY1.5 and CEY2.5 ($p<0.05$) but no significant difference between CEY1.5 and CEY2.5. The textures of CEY2.5 and CEY3.5 were also significantly different. The texture of CEY0 was the most preferred while that of CEY3.5 was the least preferred. Among the chia enriched yoghurts, CEY1.5 had a better preference based on the panelists' acceptance for texture. Chia seeds formed mucilage which acted as a thickener and a stabilizer of the yoghurt while becoming relatively soft and chewy in the process.

Taste

For taste, the hedonic rating ranged from 6.65 in CEY3.5 to 8.10 in the CEY0. There was a significant difference in taste between the CEY0 and CEY2.5 as well as CEY3.5 ($p<0.05$) while there was no significant difference in taste between CEY0 and CEY1.5 ($p>0.05$) based on the acceptance by the panelists. There was no significant difference in taste between CEY2.5 and CEY3.5 based on the panelists' acceptance. CEY0 and CEY1.5 had the highest score in taste while CEY3.5 had the lowest score. Most panelists appreciated a lower quantity of chia seeds being incorporated into the yoghurt. Among the chia enriched samples, CEY1.5 had the highest hedonic rating in taste, meaning it was the most preferred.

Table 3: Mean sensory scores of the sensory evaluation and acceptability for yoghurt samples

Parameters	CEY0	CEY1.5	CEY 2.5	CEY 3.5
Texture	7.94±0.81^{a}	7.16±1.10^{a}	6.87±1.38^{b}	6.13±1.31^{c}
Taste	8.10±0.75^{a}	7.42±1.06^{a}	7.10±1.23^{b}	6.65±1.14^{b}
Aroma	7.61±0.99^{a}	7.55±1.10^{a}	7.26±1.13^{a}	6.97±1.22^{a}
Colour	7.90±0.87^{a}	7.48±0.96^{a}	7.13±1.09^{b}	6.68±1.40^{c}
Appearance	8.13±0.72^{a}	7.10±1.25^{b}	6.94±1.50^{c}	6.23±1.48^{c}
Overall acceptance	8.13±0.67^{a}	7.55±0.96^{a}	7.26±1.15^{b}	6.42±1.21^{c}

The scores shown are means of 31 panelists. Means are ±SD having different superscript letters in a row are significantly different ($p<0.05$) by Tukey's Multiple Range Test

Aroma

The results indicated that the hedonic rating for aroma ranged from 6.97 in CEY3.5 to 7.61 in the CEY0. Most of the panelists did not detect a significant difference in aroma between the CEY0 and the chia enriched yoghurts ($p>0.05$), as shown in Table 3. The aroma of all the yoghurt formulations was rated as 'like moderately'. The CEY0 had the highest mean for aroma in hedonic rating compared to all the other samples, based on the panelists' acceptance. The aroma of CEY1.5 had a better acceptability by the panelists compared to CEY2.5 and CEY3.5, which were also enriched with chia seeds. It is worth noting that there was a resemblance in the trend of taste and aroma, which serves as an indicator that the panelists could differentiate taste from aroma because aroma is the sensation judged by nostril while taste is determined by the tongue[9]. The aroma of chia-enriched yoghurt samples could be attributed to the fat contained in the seeds. The fat may have been released into the yoghurt from chia seeds during pasteurization. The fat content in yoghurt has a considerable influence on its sensory and instrumental characteristics, because the oil acts as an aroma solvent and has good impact on rheology[13].

Colour

From the results for colour, the hedonic rating for the yoghurt samples ranged between 6.68 in CEY3.5 and 7.90 in CEY0 (Table 3). The results showed that there was a significant difference in colour between CEY0 and CEY2.5, as well as CEY2.5 ($p<0.05$). However, there was no significant difference in colour between CEY2.5 and CEY1.5 but there was a significant difference in colour between CEY2.5 and CEY3.5 based panelists' acceptance. There was a significant difference in colour between CEY1.5 and CEY2.5. CEY0 and CEY1.5 had the highest score for colour while CEY3.5 scored the least. However, there was no significant difference in colour between the two samples. The panelists showed a preference for lighter colour of the CEY0 but also appreciated the colour that the chia seeds impacted on the yoghurt. The dislike for the darker colour that chia impacts on food products is consistent with other studies; on bread and cakes [14], on ice cream[15], on frankfurters [16] and on pan bread [17].

Appearance

The results for appearance as illustrated in Table 3 show that the appearance score ranged from 6.23 in CEY3.5 to 1.83 in CEY0. Similar trend was reported when yoghurt was enriched with coconut cake[18] and when walnut and hazel nuts were incorporated in yoghurt[19]. The results indicated a significant difference in appearance between CEY0 and CEY1.5, CEY2.5 as well as CEY3.5 ($p<0.05$), based on the panelists' acceptance. A significant difference in appearance was shown between CEY2.5 and CEY3.5. There was no significant difference in appearance between CEY1.5 and CEY2.5 based on the panelists' acceptance. Among the chia enriched samples, panelists significantly preferred the appearance of CEY1.5 to CEY2.5 and CEY3.5. From the results, it is clear that the sensory scores for appearance were affected by the enrichment of yoghurt with chia seeds. This was however not expected as the appearance relates to the colour, which showed different results. CEY0 had the highest score for appearance while CEY3.5 had the lowest score. This could be attributed by the fact that the chia seeds were incorporated whole and most panelists might not have been very familiar with the formulation.

Overall acceptance

CEY0 was rated highest for overall acceptance at 8.13 (Table 3) although there was no significance difference between CEY0 and CEY1.5 (7.55). It was indicated that there was a significant difference in the overall acceptance between CEY3.5 and CEY2.5 as well as CEY1.5 based on the panelists' acceptance. The results further indicate that the panelists did not detect a significant difference in overall acceptance between CEY1.5 and CEY2.5. The high score for CEY0 may be attributed to the fact that the panelists were fairly familiar with it, unlike the chia enriched yoghurt.

Based on the results, the panelists showed an appreciation for the increased viscosity and chewability factors in the yoghurt samples enriched with chia seeds, similar to an earlier observation [18]. Table 3 shows that all yoghurts are above average on the scale, in all the sensory parameters, and that they were all liked by the panelists. In general, increasing the percent concentration of chia seeds in yoghurt gradually reduced the panelists' acceptability with most preferring the lower concentrations.

Shelf life of chia enriched yoghurt

The results of the changes in pH during refrigerated storage of the yoghurt samples are illustrated in Table 4. On day 1, the pH ranged from 4.66 to 4.68 for the yoghurt samples. This was higher than the recommended pH range of 4.0-4.5 by KEBS. The yoghurt fermentation process should be stopped before the normal values are attained so as to achieve good results. The statistical analysis showed that there was no significant difference in the pH among the different samples on day 1[12]. This could mean that the chia seeds had no significant effect on the fermentation process of the yoghurt. A significant difference in pH change was observed at day 10 of storage at 4ºC. For all the samples analyzed, the pH values kept on decreasing with storage. This could be attributed to the continuous conversion of lactose to lactic acid during storage. During the 30 days storage period, the pH values for all yoghurt types ranged from 4.60 to 4.32. Similar tendencies for pH values have been reported among commercial yoghurts during their storage[20]. During fermentation of milk sugar (lactose), the lactic acid bacteria produce lactic acid thus lowering the pH of the yoghurt [21]. Generally the average pH value for yoghurts ranges between 4.0-4.5.This is because the bacteria convert milk sugar, or lactose, into lactic acid, which ultimately increases the acidity of the final product [3]. Based on the requirement of Food Standard Code, the pH of yoghurt should be a maximum of 4.50 so as to prevent the growth of pathogenic microorganisms [20, 22]. Therefore, this indicates that all yoghurt samples had relatively good and acceptable amounts of acidity at day 30.

Table 4: pH values of the chia enriched yoghurt samples during refrigerated storage

pH	Storage days				
	1	10	20	30	KEBS Standard
CEY0	4.66±0.01^{a}	4.44±0.08^{a}	4.36±0.04^{a}	4.33±0.01^{a}	4.0-4.5
CEY1.5	4.67±0.01^{a}	4.59±0.08^{a}	4.41±0.04^{a}	4.38±0.00^{a}	4.0-4.5
CEY2.5	4.68±0.06^{a}	4.66±0.04^{b}	4.55±0.08^{b}	4.46±0.01^{b}	4.0-4.5
CEY3.5	4.67±0.00^{a}	4.57±0.04^{a}	4.50±0.04^{b}	4.47±0.04^{b}	4.0-4.5

The values shown are means of two replicates. Mean are ±SD having different superscript letters in a column are significantly different ($p<0.05$) by Duncan's Multiple Range Test

The mean results for titratable acidity of the yoghurt samples under refrigerated storage are shown in Table 5. On day 1, the titratable acidity ranged from 0.65% in CEY0 to 0.68% in CEY2.5. These value differ with the findings of a previous study which reported higher acidity values for yoghurt enriched with gac fruit aril and passion[3]. The values obtained indicate that yoghurt samples were of good quality even during storage as previously documented

that the average acidity recommended for yoghurt as above 0.6%[21]. The results showed that there was no significant difference in titratable acidity for all the samples in day 1 and day 20. This indicates that the chia seeds did not have a significant effect on the fermentation as well as the acidity of the yoghurt. On day 10 and day 30, a significant difference in titratable acidity was reported between CEY0 and all the samples that had chia seeds.
The acidity values for chia-enriched yoghurt samples were lower compared to those of the CEY0. This could be resulting from greater availability of lactose to the fermenting microbes in CEY0[23]. In all the other samples, the values obtained for titratable acidity, after 20 days storage, at 4ºC were generally below 0.7% which is below the standard set by the Food and Drug Administration [24]. Although all the samples gained an increasing acidity during the storage period, the acidity varied in different samples.

Table 5: Means of titratable acidity values of the chia enriched yoghurt during refrigerated storage

TTA	Storage period (days)				
	1	10	20	30	KEBS standard
CEY0	0.65±0.01^{a}	0.70±0.03^{a}	1.10±0.04^{a}	1.33±0.01^{a}	0.6-1.2
CEY1.5	0.66±0.01^{b}	0.70±0.02^{a}	1.01±0.01^{b}	1.35±0.01^{a}	0.6-1.2
CEY2.5	0.68±0.01^{b}	0.72±0.00^{a}	1.01±0.01^{b}	1.34±0.02^{a}	0.6-1.2
CEY3.5	0.67±0.01^{b}	0.71±0.01^{a}	1.02±0.04^{b}	1.34±0.01^{a}	0.6-1.2

The values shown are means of two replicates. Mean±SD having different superscript letters in a column are significantly different ($p<0.05$) by Duncan's Multiple Range Test

Syneresis

Syneresis is the condition that increases the moisture content of yoghurt. It results in the enhancement of microbiological infection and the reduction of nutritive value [3]. There is therefore, a relationship between resistance on syneresis and the quality of yoghurt. The results on Table 6 show that syneresis increased in all the samples during refrigerated storage. On day 1, syneresis index ranged between 1.86% in CEY3.5 and 2.68% in CEY0 whose trend was similar to the one previously reported [3]. These values of the separated serum were lower compared to the ones reported earlier among fruit flavoured yoghurts[6]. CEY 3.5 and CEY 2.5 had the highest resistance for syneresis as it was at 1.86% and 2.26% respectively. This variable could be attributed to the formation of gel networks upon interaction between chia and milk. On day 10, the syneresis index did not differ significantly with that of day1 during refrigerated storage. There was a significant ($p>0.05$) increase in syneresis after day 20 of refrigerated storage. This could be attributed to the increase in acidity after the 20th day of storage [25]. Similar trends of occurrence of syneresis in enriched yoghurt samples were observed by when fruits were used to enrich yoghurt[6] and during enrichment of yoghurt with nuts[19]. Syneresis continued to increase but at different rates for all samples. The CEY1.5 had the highest resistance to syneresis up to day 30 while CEY0 was the lowest. The statistical analysis failed to detect a significant difference in syneresis index between CEY 2.5 and CEY3.5 ($P<0.05$).

Table 6: Syneresis indices (%) of chia enriched yoghurt during refrigerated storage

Syneresis (%)	Storage period (days)			
	1	10	20	30
CEY0	2.68±0.45^{a}	6.72±0.51^{a}	12.12±0.82^{a}	13.79±28^{a}
CEY1.5	2.31±0.09^{b}	6.08±0.28^{a}	7.28±0.48^{b}	11.19±0.20^{b}
CEY2.5	2.26±0.13^{b}	4.38±0.67^{b}	8.54±0.45^{b}	11.43±0.30^{b}
CEY3.5	1.86±0.09^{b}	4.41±0.04^{b}	8.02±0.06^{b}	11.72±0.10^{b}

The values shown are means of two replicates. Mean±SD having different superscript letters in a column are significantly different ($p<0.05$) by Duncan's Multiple Range Test

On day 10, syneresis was observed in all the yoghurt samples although it was within the recommended ranges. There was no significant differences in syneresis index of CEY0 and CEY1.5 and also between CEY2.5 and CEY3.5. The syneresis indices for CEY1.5, CEY2.5 and CEY3.5 increased significantly after day 20 of refrigerated storage. Among the chia-enriched yoghurt samples, the syneresis may have been influenced by a collapse by the gel structure of the chia mucilage leading to water being squeezed out. This change might result to negative changes on the sensory characteristics of chia enriched yoghurt hence rendering them unacceptable after 20 days storage at 4ºC. On day 30, the syneresis index for all the yoghurt samples was beyond the recommended levels, an indication that their quality was lower compared to the expectation. Syneresis increases the moisture content of the yoghurt which might allow microbiological infection as a result [3].

CONCLUSION

In the current study, a functional yoghurt product was successfully developed by enriching yoghurt with whole chia seeds. The results of physicochemical characteristics showed that the chia seeds had no effect on the pH and titratable acidity values of the yoghurt. From the results of sensory analysis, the panelists appeared to prefer the texture, taste, colour and appearance of CEY0 and CEY1.5 over those of CEY2.5 and CEY3.5.
In shelf life studies, pH decreased significantly while titratable acidity and syneresis increased significantly during 30 days refrigerated storage in both CEY0 and chia enriched samples. The study observed that the yoghurt enriched with chia seeds showed superiority in nutritional quality and CEY1.5 also performed just like CEY0 in the sensory evaluation. The presented data indicate that enriching yoghurt with chia seeds as a substitute of corn starch, allows supplementation of yoghurt with various nutrients which are deficient in milk. The enriched yoghurt samples were evaluated and proved to be of good quality, high nutritional value and could be kept for at least 20 days without significant loss of texture and acidity.

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