

## RESEARCH ARTICLE

### Effect of incorporating *Lactocaseibacillus rhamnosus* GG and arrowroot (*Maranta arundinacea*) powder on physicochemical properties of buffalo milk curd

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#### ABSTRACT

Syneresis is one of the common textural quality defects found in traditionally prepared buffalo milk curd (*meekiri*). The current study aimed to determine the effect of incorporating *Lactocaseibacillus rhamnosus* GG (LGG) and arrowroot (AR) powder alone and in combination on the physicochemical properties of buffalo milk curd over refrigerated storage. Four buffalo milk curd formulations were prepared: control curd (without probiotic and prebiotic), probiotic curd (with 2% LGG), prebiotic curd (with 3% AR powder), and synbiotic curd (with both 2% LGG and 3% AR powder). The syneresis, pH, titratable acidity, and textural properties (hardness, cohesiveness, gumminess, and adhesiveness) were evaluated over the refrigerated storage at d 1, 4, 7, and 10. The addition of LGG resulted in decreased syneresis and acidity, and increased hardness, gumminess, and chewiness. In contrast, AR positively affected decreased syneresis and acidity. LGG and AR powder in combination significantly lowered syneresis however negatively affected on the hardness, gumminess, and chewiness.

**Keywords:** Lactic acid bacteria, Probiotic, Prebiotic, Synbiotic, Texture

#### INTRODUCTION

Curd (*meekiri* in Sinhalese) is one of the most popular dairy-based products that has long been used as an ethnic food from time immemorial in Sri Lanka. Curd is traditionally been manufactured by fermenting buffalo milk by using mesophilic starter cultures. Curd-making is mainly a cottage industry in Sri Lanka and most producers prepare curd from the milk of their buffalo herds. Traditionally the buffalo milk harvested within three hours is used for curd making. Firstly, the milk is boiled for 20-30 min. in an aluminium container on a hearth. Firewood is used as the heat source in the hearth. After boiling, the milk is cooled down to room temperature (30-35°C) and the curd starter is added before the milk cools completely (Siriweera, 2009). Traditionally, the source of starter culture is called “*muhum*” (in Sinhalese), which is a small portion of previously prepared curd (half to one day old). This method is called back-sloping (Siriweera, 2009; Priyashantha *et al.*, 2021). The temperature of the milk when

the *muhum* was added is determined by experience. After mixing the starter, the milk is then poured into clay pots and allowed to curdle at room temperature (30-35°C). The minimum time required for satisfactory curdling is usually 3-5 hours (Siriweera, 2009).

Nowadays, the general population embraces the use of fermented milk products containing probiotics. Probiotics are live microorganisms that, when administered in adequate amounts, confer health benefit on the host (Hill *et al.*, 2014). The health benefits of the probiotics to the host are mainly linked with the modulation of the immune system and the gut function in various mechanisms. The health benefits of probiotics have intensively been reviewed and these include the prevention of various types of diarrhoea, and beneficial effects against inflammatory bowel disease (IBD), urogenital infection, gastric ulcers, obesity, diabetes, and food allergies (Das *et al.*, 2022). The most significant probiotic microorganisms typically associated with the human gastrointestinal system are lactic acid bacteria (LAB). The family Lactobacillaceae contains the majority of the LAB that are utilized as probiotics (Meybodi *et al.*, 2020). Among these, *Lactocaseibacillus rhamnosus* GG (LGG) is an exopolysaccharide-producing LAB that is one of the most studied probiotics in foods with various proven health benefits (Westerik *et al.*, 2018). Exopolysaccharide producing starter cultures are becoming more popular due to their higher water binding capacity and texture promotion abilities, and they have the potential to replace or reduce the use of stabilisers and added dairy ingredients in dairy products (Amatayakul *et al.*, 2006). On the other hand, prebiotics are non-digestible substances that help the host's health by encouraging the activity or growth of one or more probiotic microorganisms. One of the most common methods for establishing a balanced microbiota or restoring it when disturbed is the use of prebiotics. The advantages of consuming dairy products enriched with prebiotics are enhancement of intestinal health, blood lipid profiles, immunity in addition to the antidiabetic and antihypertensive properties. Prebiotic application in dairy products can improve physicochemical, rheological, and sensory properties. However, the benefits are mostly influenced by the prebiotic type, food matrix, and concentration of the prebiotic (Rosa *et al.*, 2021). Previous research has shown that prebiotics improve the physicochemical properties and enhance probiotic survival in buffalo milk products (Ehsani *et al.*, 2016). The major limitation associated with commercial prebiotics is the high cost which is sometimes unaffordable for some medium-scale industries and most of the small-scale/cottage-level industries. In this context, arrowroot (*Maranta arundinacea*) (AR) powder is an ideal alternative to commercial prebiotics. The applicability of AR powder as a replacement for inulin (a commercial prebiotic) has successfully been studied (Jayatilake *et al.*, 2020). AR is rich in fructooligosaccharides (~55% of the AR carbohydrates) and is locally available (Abesinghe *et al.*, 2012). AR has antioxidant and immune stimulant characteristics, and its main properties are the ability of AR starch to bind large

amounts of water, increase the amount of fluid absorbed into the cell, and reduce the production of ice crystals after freezing (Mubarokah *et al.*, 2021).

The quality of the buffalo milk curd is determined by its firmness and flavour (Siriweera, 2009). Any quality defect may decrease the overall quality of the end product leading to lower consumer acceptability. The quality defects of curd can be texture-related and/or flavour-related. Loss of the gel structure, cracks, and syneresis are the common textural quality defects that can be found in buffalo milk curd (Priyashantha *et al.*, 2021). Syneresis is the most common textural quality defect in buffalo milk curd. In general terms, syneresis means the shrinkage of gel that happens concurrently with liquid expulsion or whey separation. It is caused by network instability in the gel, which prevents the gel from entrapping all of the serum. The composition of milk, total solid content, acidity, types of cultures, conditions of homogenization, and heat treatments of milk affect the texture and syneresis (Vareltzis *et al.*, 2016). Various strategies have been proposed to reduce syneresis in dairy products such as the addition of stabilisers, probiotics, prebiotics, exopolysaccharides producing starter cultures, and increasing the total solid content in the medium for example the addition of milk protein isolates. Among these, the incorporation of probiotics and prebiotics separately or in combination has successfully been utilized to control syneresis in fermented dairy products (Abesinghe *et al.*, 2020). In this context, the objective of the current research was to investigate the effect of the probiotic LGG and the potential prebiotic AR powder on physicochemical properties of buffalo milk curd when applied separately or in combination.

## **MATERIALS AND METHODS**

### **Materials**

Buffalo milk was obtained from a buffalo farm located in Anamaduwa, Sri Lanka during the months of September and November. Granulated curd starter culture was gifted by a manufacturer who has been involved in curd making for decades. The probiotic LGG (nu-trish® LGG®) were purchased from Chr. Hansen (Horsholm, Denmark). Commercially available AR powder (Brownson®, Sri Lanka) was purchased from the local market.

### **Curd Culture preparation**

A mother culture was prepared by inoculating 5% (w/v) of the granulated curd starter culture with 100 mL of pasteurized buffalo milk and incubating overnight (~18 h) at 30°C. This mixture was used to inoculate buffalo milk to prepare the four curd formulations in the current study.

### **Probiotic culture preparation**

Probiotics (LGG) were prepared according to the method previously described by Yapa *et al.* (2023). Briefly, the probiotic culture was activated by inoculating 0.05% (w/v) with 100 mL portions of pasteurized skim buffalo milk and

incubated overnight (~18 h) at 42°C and 37°C. Subsequent working cultures were prepared by inoculating skimmed milk with 5% (v/v) of the activated cultures.

### Preparation of curd

The ingredients were mixed in the ratios given in Table 1 to prepare different experimental curd samples. The inclusion levels of the LGG and AR powder were determined by pilot studies previously conducted.

**Table 1:** Proportion of the curd starter, probiotic (*Lactocaseibacillus rhamnosus* GG, LGG), arrowroot powder (prebiotic) and buffalo milk used to prepare experimental curd samples

Treatment	Curd starter % (w/v)	LGG % (v/v)	Arrowroot powder % (w/v)	Buffalo milk (mL)
Control	5	0	0	1000
Probiotic curd (Pro)	5	2	0	1000
Prebiotic curd (Pre)	5	0	3	1000
Synbiotic curd (Syn)	5	2	3	1000

The curd samples were prepared under sterile conditions. Buffalo milk was pasteurized at 80-85°C for 15 min. and then allowed to cool down to 40°C. Then the ingredients were mixed as summarized in Table 1 in separate milk bases labelled accordingly. The mixture was stirred thoroughly poured into 100 mL clay pots, covered by polythene sheet, and allowed to set under room temperature (27–30°C). After the curd was set, the pots were stored under refrigerated conditions (4°C) until analyses.

### Analysis of physicochemical properties of curd

#### Determination of syneresis

Fifteen grams of the sample were measured and centrifuged at  $650 \times g$  for 20 min. at 4°C using a benchtop centrifuge (Digicen 21 R, Orto Alrea, Spain). The separated whey was measured and the percentage of syneresis was calculated according to the following equation.

$$\text{Syneresis \%} = \frac{\text{Volume of whey separated (mL)} \times 100}{\text{Sample weight (g)}}$$

#### Determination of pH

The pH of the curd samples was determined using a digital pH meter (OHAUS, STARTER 3000, US).

### Determination of titratable acidity

The titratable acidity of the curd samples was determined by titration method using 0.1 N NaOH. Phenolphthalein [2% (w/v) in ethanol] was used as the indicator. Before the titration, 1 g of the sample was diluted in 9 mL of distilled water and homogenized. Titratable acidity was expressed as a percentage of lactic acid according to the following equation.

$$\% \text{ Lactic acid} = \frac{\text{Volume of 0.1 N NaOH consumed in titration} \times 0.009}{1 \text{ g of sample}} \times 100$$

### Determination of total solid content

The total solid content of the curd samples was determined by the oven-dry method (method 925.23) using the standard AOAC Protocols (AOAC, 1995).

### Texture analysis of curd samples

The texture analysis was performed using a texture analyser (TX-700, Shimadzu, Kyoto, Japan) equipped with a 50 kg load cell and a cylindrical probe (25 mm in diameter). The hardness, gumminess, chewiness, cohesiveness, adhesiveness, and firmness were measured through piercing and penetration tests using curd in clay pots at 4°C. The probe was moved at a speed of 1 mm/s from the surface until a depth of 18 mm. The force and time spent on penetration were recorded. The average of triplicates was obtained by performing the test on three different surface locations within a pot.

### Statistical analysis

All data were mentioned as the mean  $\pm$  standard deviation (SD) of the triplicates. A two-way ANOVA was used to determine the main effects of treatments and storage time on syneresis, post-acidification, total solid content, and textural quality parameters. A one-way ANOVA was used to determine the main effect of treatments on protein content. The turkey test was used to separate the means. All the experiments were duplicated to confirm the repeatability of the results. All the statistical analyses were performed using SPSS version 26.0 (SPSS Inc., Chicago, IL) with a significance level of  $p < 0.05$ .

## RESULTS AND DISCUSSION

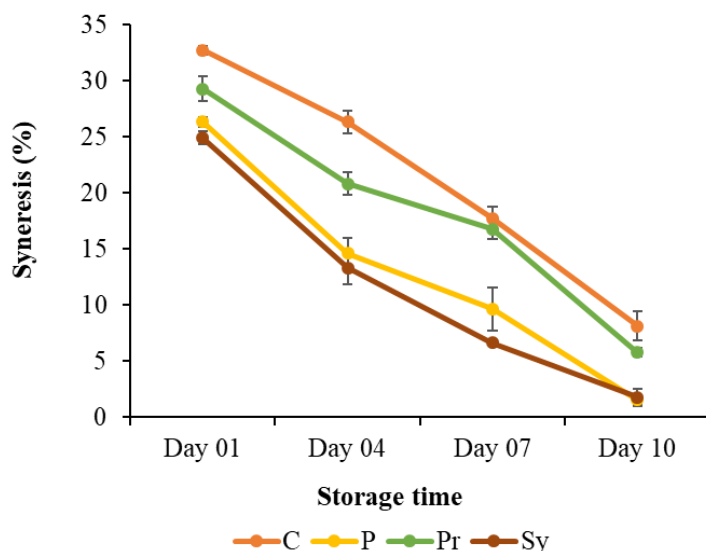
The physicochemical characteristics of a food product directly affect its organoleptic properties and thereby consumer acceptability of the product. The physicochemical properties of organoleptically optimum buffalo milk curd have a firm texture, pleasant aroma, and glossy surface. It is creamy, has a thick mouthfeel, higher viscosity, and tastes sour. In the current study, we evaluated the effect of adding LGG and AR powder on syneresis, post-acidification,

textural profile, and protein and total solid content in buffalo milk curd after 1, 4, 7, and 10 d of refrigerated storage.

### **Syneresis**

Syneresis in curd is the contraction of gel accompanied with the expulsion of whey from the curd mass that negatively affects the consumers' perception (Hallqvist, 2019; Yapa *et al.*, 2023). Therefore, excessive syneresis results in inferior quality in curd. Statistical analysis revealed that both the treatment and the storage period had a significant impact on the level of syneresis in buffalo milk curd. The syneresis in the plain buffalo curd (control) was approximately 33% after 1 d of refrigerated storage (Figure 1). The syneresis percentage observed in our study was comparable with previous studies for buffalo curd (Hallqvist, 2019) and buffalo yoghurt (Yapa *et al.*, 2023). In our study, the control curd showed the highest level of syneresis throughout the refrigerated storage. The addition of the probiotic LGG significantly decreased the level of syneresis over the storage ( $p < 0.05$ ). Similar observations were also reported by Yapa *et al.* (2023) in LGG-incorporated buffalo milk yoghurt. Probiotics are reported to affect syneresis by higher water-binding capacity and modification of the microstructure of the fermented dairy products (Amatayakul *et al.*, 2006; Priyashantha *et al.*, 2019). Compared to the level of syneresis in the control and probiotic-added curd, the syneresis in prebiotic curd and synbiotic curds was significantly lower throughout the storage period ( $p < 0.05$ ). Previous studies also showed that commercial prebiotics (lactulose, oligofructose, and inulin) significantly lower the syneresis during the storage of buffalo milk yoghurt by increasing the water-binding capacity (Ehsani *et al.*, 2016). Therefore, observing remarkably lower syneresis values in AR-incorporated curds, may be due to the increased water-binding capacity offered by the AR powder probably due to its higher total starch content that accounts for 51-68% (Malki *et al.*, 2023; Sholichah *et al.*, 2019). In general, there was a decreasing trend for syneresis values with advancing storage periods. Accordingly, the syneresis of control curd decreased by approximately 25% between the first and tenth day of storage. In contrast, the probiotic, prebiotic, and synbiotic curds showed a syneresis decrease of approximately 25, 24, and 23%, respectively, between the 1<sup>st</sup> and the 10<sup>th</sup> day of storage. Some authors have reported increased levels of syneresis (a 12% increase in syneresis compared to d-1 of the refrigerated storage) for buffalo milk yoghurt after 21 d of refrigerated storage when stored in plastic cups (Yapa *et al.*, 2023). The clay pots were reported to absorb excess whey from the curd matrix to maintain the textural properties of curd (Priyashantha *et al.*, 2021). Therefore, obtaining decreasing levels of syneresis over the storage in our study may be due to the use of clay pots that may absorb expelling whey from the curd matrix. Our results revealed that the syneresis in the prebiotic and synbiotic curds remained significantly lower than those of both control and the probiotic curd even after 10 d of refrigerated storage. Although the syneresis in the probiotic curd was significantly higher than the prebiotic and synbiotic curd, it remained significantly lower than that of the control curd. However, there was no

significant difference between the prebiotic and synbiotic curds after 10 d of storage. The lowest syneresis was observed in the synbiotic curd all over the storage. These results suggest that the addition of both the LGG and AR alone is effective in lowering syneresis. However, the effect of adding AR powder is more effective in controlling the syneresis of buffalo milk curd either alone or in combination with LGG.



**Figure 1:** Variation in syneresis percentage in different curd formulations over the 10-d refrigerated (4°C) storage. C (control): curd produced with conventional curd starter culture; P (probiotic curd): curd prepared with conventional starter culture plus 2% LGG; Pr (prebiotic): curd prepared with conventional starter plus 3% arrowroot powder; Sy (synbiotic): curd produced with conventional starter culture plus 2% LGG and 3% arrowroot powder.

### Post Acidification

During the storage, the acidity of the fermented products can be increased by the accumulation of organic acids that result from the metabolic activity of the lactic acid bacteria as they break down available carbohydrates into a range of organic acids (Yapa *et al.*, 2023). This phenomenon is called post-acidification in fermented products. Too much acid in the final product may negatively affect the sensory properties of the product. The variation in pH and titratable acidity of the experimental curds over the refrigerated storage are summarized in Table 2.

**Table 2:** The pH and titratable acidity of different experimental buffalo milk curds over the 10-d refrigerated storage.

Parameter	Day 1	Day 4	Day 7	Day 10
<b>pH</b>				
Control	4.21 ± 0.01	4.10 ± 0.01	3.92 ± 0.20	3.83 ± 0.09
Probiotic	4.21 ± 0.06	4.07 ± 0.01	4.03 ± 0.09	3.99 ± 0.14
Prebiotic	4.25 ± 0.02	4.16 ± 0.06	3.96 ± 0.23	4.07 ± 0.10
Synbiotic	4.20 ± 0.06	4.08 ± 0.02	3.93 ± 0.15	3.69 ± 0.44
<b>Titratable acidity</b>				
Control	0.45 ± 0.04	0.54 ± 0.07	0.70 ± 0.01	0.80 ± 0.04
Probiotic	0.58 ± 0.05	0.56 ± 0.10	0.73 ± 0.03	0.82 ± 0.07
Prebiotic	0.48 ± 0.05	0.54 ± 0.13	0.67 ± 0.07	0.75 ± 0.05
Synbiotic	0.51 ± 0.04	0.57 ± 0.05	0.70 ± 0.02	0.83 ± 0.05

Control: curd produced from conventional curd starter culture; Probiotic: curd prepared by conventional starter culture plus 2% LGG; Prebiotic: curd prepared by conventional starter plus 3% arrowroot powder; Synbiotic: curd produced with conventional starter culture plus 2% LGG and 3% arrowroot powder.

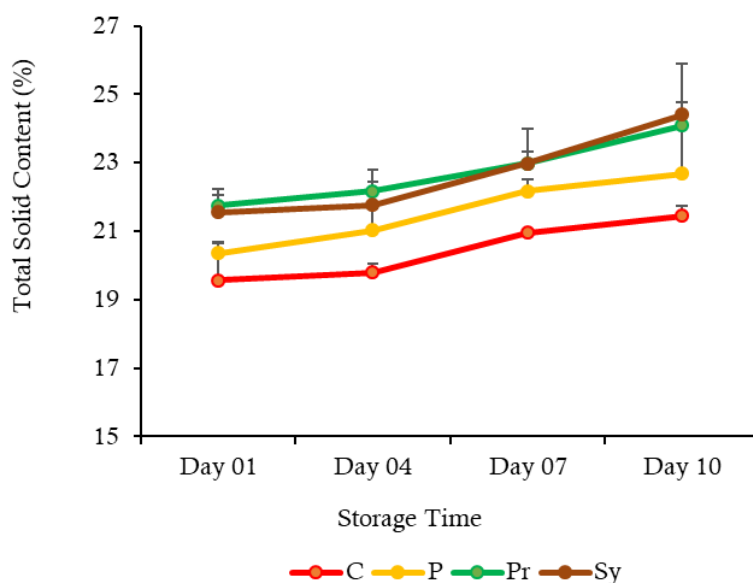
The initial pH of all curd formulations was almost the same (4.20-4.25). As a general trend, the pH of all treatments was decreased with the advancing storage time. Over the 10 d of storage, the highest decline was observed in the synbiotic curd (12% decline) which was higher than that of the control curd (9% decline). However, the pH decline after 10 d of storage in the probiotic and prebiotic curds was lower (5% and 4% decline, respectively) compared to that of the control. After 10 d of storage, the lowest pH was observed in the synbiotic curd and the highest was in the prebiotic curd.

The titratable acidity of all four treatments increased over the refrigerated storage. After 10 d of storage, the highest titratable acidity was observed in the synbiotic product followed by probiotic and control curds. The lowest was observed in the prebiotic curd. The largest increase in acidity was observed in the control curd followed by the synbiotic curd. The increase in acidity was lower in probiotic and prebiotic curds compared to that of the control and the synbiotic curd. Observing the lowest acidity in the probiotic curd may be due to the buffering capacity of the exopolysaccharides produced by LGG. Similar observations were previously reported by Yapa *et al.* (2023) for buffalo milk yoghurt. Observing higher acidity in the synbiotic curd suggests that the probiotic LGG and AR powder in combination may not result in a better food matrix that can buffer the acidity in curd during storage.



## Total solid content

The variation in total solid content of the four curd formulations over the 10-d refrigerated storage has been depicted in Figure 2. The initial total solid content of the curd samples ranged from 19.56% to 21.75%, and the lowest total solid content was observed in the control curd ( $19.56 \pm 1.08$ ). The prebiotic curd and synbiotic curd had higher levels of total solid content compared to control and there was no significant difference ( $p > 0.05$ ) between prebiotic and the synbiotic curds. There was a continuous increase in the total solid content over the storage period in all curd formulations. Moreover, the total solid contents among different treatments varied significantly ( $p < 0.05$ ). There was a significant difference in the total solid content of all curd formulations over the refrigerated storage. Accordingly, the total solid contents of the probiotic, prebiotic, and synbiotic curd preparations remained significantly higher throughout the storage compared to that of the control. The higher total solid content in the probiotic formulation may be due to the mass of the growing probiotic numbers in the matrix. The higher total solid content in the prebiotic and the synbiotic formulations may be due to the added arrowroot powder (3% by weight). However, the reason for continuously increasing total solid contents in all four formulations over the storage may be due to the increasing microbial mass.



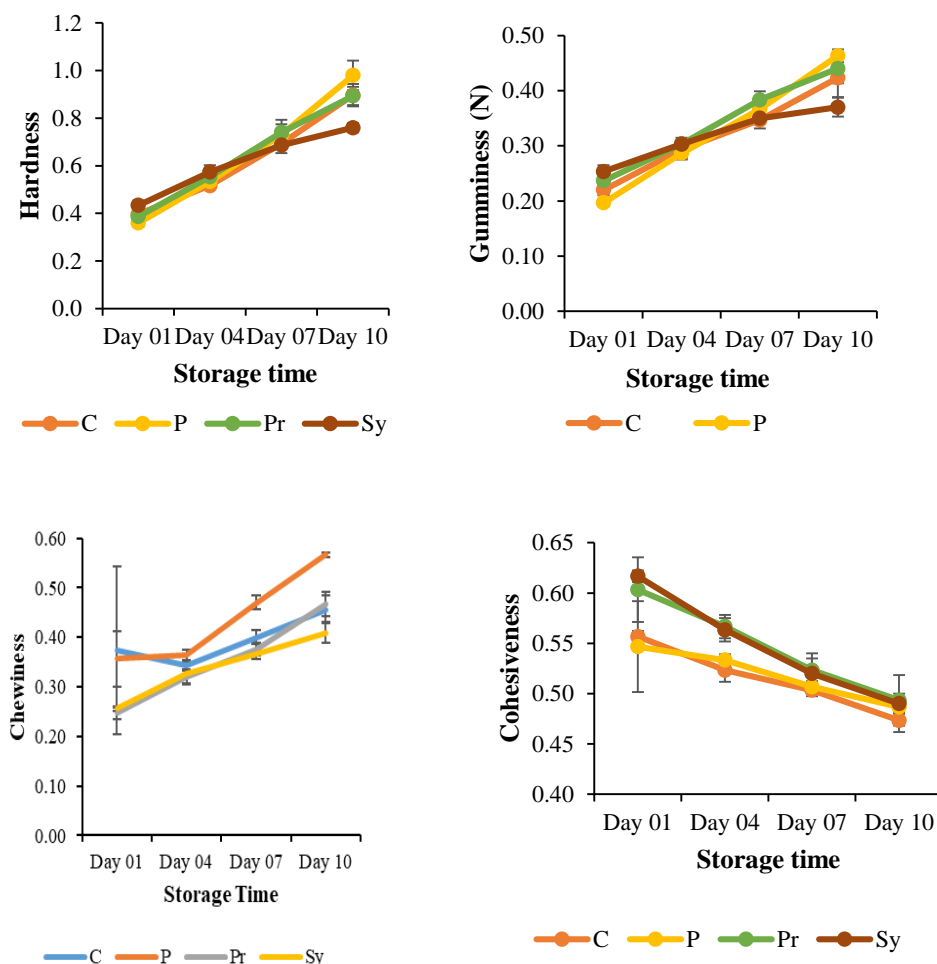
**Figure 2:** Variation in the total solid content (%) in the experimental curd formulations over the 10-d refrigerated (4°C) storage. C (control): curd produced with conventional curd starter culture; P (probiotic curd): curd prepared with conventional starter culture plus 2% LGG; Pr (prebiotic): curd prepared with conventional starter plus 3% arrowroot powder; Sy (synbiotic): curd produced with conventional starter culture plus 2% LGG and 3% arrowroot powder.

### Texture profile analysis

Textural parameters of a food product have a direct impact on the consumer appeal of that product. Hardness, springiness, cohesiveness, adhesiveness, and gumminess are significant properties for the textural evaluation. Hardness reflects the ability to fracture and consistency during the first bite. Gumminess is a combination of hardness and cohesiveness that reflects the effort required to put into the preparation of a food for swallowing. Chewiness is a measure of energy required to masticate the food. Cohesiveness defines how well a food retains its form between the first and second chew. The textural parameters determined over the storage of the experimental curd formulations are depicted in the Figure 3.

Statistical analysis showed that both the treatment and the storage time had a significant impact on hardness values of curds and there was an increasing trend in hardness values for all curd formulations with advancing storage time ( $p < 0.05$ ). A similar trend was also reported by Yapa *et al.* (2023) for probiotic and bael fruit pulp incorporated buffalo milk yoghurt. The probiotic curd had the lowest initial hardness ( $0.36 \pm 0.01$ ) and the synbiotic curd had the highest initial hardness value ( $0.43 \pm 0.02$ ). There was no significant difference among the treatments on the hardness value of curd from 1<sup>st</sup> to 7<sup>th</sup> d of the refrigerated storage. However, on the 10<sup>th</sup> d of storage, the hardness values of the control, probiotic, and prebiotic curds were comparable although the hardness of the probiotic curd was higher than the other two treatments. Previously, Amatayakul *et al.* (2006) reported relatively lower firmness values for yoghurts made with exopolysaccharide-producing starter cultures compared to that of yoghurts made without exopolysaccharide-producing starters.

Similar observations were reported by Yapa *et al.* (2023) in LGG-incorporated buffalo milk yoghurt and by Cui *et al.* (2021) in probiotic-incorporated cow milk yoghurt where the hardness values of the probiotic yoghurts were relatively higher than that of the plain yoghurts without probiotics. These observations suggested that the exopolysaccharides produced by LGG may increase the hardness of buffalo curd similarly in yoghurts. This improvement in the texture is due to the interaction of exopolysaccharides produced by LGG with the gel structure (Cui *et al.*, 2021). Interestingly, in our study, the hardness value of the synbiotic curd ( $0.76 \pm 0.02$  N) was significantly lower than that of the other three curd formulations. Previous studies showed that the addition of powders tends to increase the total solid content and thereby immobilize water molecules in the food matrix contributing to the increased firmness. Accordingly, these results showed that the incorporation of lactose-free spray-dried milk powder (Dantas *et al.*, 2021), inulin (Gyawali and Ibrahim, 2016), and persimmon and apple powders (Karaca *et al.*, 2019) significantly increased the firmness of various yoghurt products. These results suggest that the addition of LGG or AR powder did not affect the hardness value. However, in combination, it may result in lower hardness values after 7 d of refrigerated storage.



**Figure 3:** The variation in hardness, gumminess, chewiness, and cohesiveness of the experimental curd formulations over the 10-d refrigerated storage. C (control): curd produced with conventional curd starter culture; P (probiotic curd): curd prepared with conventional starter culture plus 2% LGG; Pr (prebiotic): curd prepared with conventional starter plus 3% arrowroot powder; Sy (synbiotic): curd produced with conventional starter culture plus 2% LGG and 3% arrowroot powder.

In the current study, the gumminess values followed the same trend as that of the hardness values. There was a significant difference among treatments on gumminess by incorporating LGG and AR powder ( $p < 0.05$ ). After 24 h of production of curd, the probiotic curd had the lowest gumminess value ( $0.19 \pm 0.01$  N) and the synbiotic curd had the highest gumminess value ( $0.25 \pm 0.01$  N).

There was no significant difference among the treatments in gumminess from 1<sup>st</sup> to 7<sup>th</sup> d of the refrigerated storage period. On the 10<sup>th</sup> d of storage, the synbiotic curd showed the lowest gumminess value and the probiotic curd showed the highest gumminess value. Moreover, the gumminess values of the synbiotic curd were significantly lower than the other three treatments. When the chewiness values were concerned, there was a significant difference among treatments and storage time by incorporating LGG and AR powder ( $p < 0.05$ ). A clear demarcation among the chewiness values of the four treatments was observed since d 4 of the refrigerated storage where the chewiness of the probiotic curd remained significantly higher throughout the remaining days in the storage compared to that of the other three treatments. The addition of the probiotic LGG did not have any effect on chewiness initially. In contrast, the addition of AR powder considerably decreased the chewiness and remained lower throughout the storage. The incorporation of LGG and AR powder and storage time had a significant influence ( $p < 0.05$ ) on the cohesiveness of curd. The incorporation of AR powder increased the cohesiveness of curd and there was no significant difference between prebiotic curd and synbiotic curd ( $p > 0.05$ ). Initially, probiotic curd had a lower cohesiveness value than the control but it had increased cohesiveness values compared to the control at 4, 7 and 10 d of refrigerated storage period perhaps due to the production and accumulation of exopolysaccharides produced by LGG.

## CONCLUSIONS

Both *Lactocaseibacillus rhamnosus* GG (LGG) and arrowroot (AR) powder offer multiple benefits to buffalo milk curd. Incorporation of LGG and AR powder either alone or in combination significantly reduced syneresis in buffalo milk curd during cold storage. Both the LGG and AR powder positively affected stabilizing post-fermentation acid development in curd when they were incorporated alone. However, in combination, it negatively affects the acid development leading to higher acidities at the end of the storage. The incorporation of AR powder into the curd food matrix results in higher total solid contents that positively affect lower syneresis. Adding the exopolysaccharide-producing probiotic LGG along with the traditional curd starter culture results in improved textural properties (firmness, gumminess, and chewiness) of the product. In contrast, AR powder alone had no considerable effect on the textural properties of the product. However, the use of LGG and AR powder in combination results in inferior textural properties. Results conclude that LGG positively affects the syneresis, end product acidity, and textural properties, and AR powder positively affects in lowering of syneresis and acid development. The use of LGG and AR powder alone is much more beneficial than using them in combination in terms of textural properties.

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