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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 3460-3468

www.thepharmajournal.com
Received: 10-04-2023
Accepted: 13-05-2023

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Growth modulation of starter microbes using microwave treatment for the preparation of yoghurt cheese

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Abstract
The focus of the present study was to explore microwave (MW) treatment to the yoghurt starter microbes and evaluate the effect on their growth. Also, to develop a new processing technique in minimising acid whey production in Yoghurt cheese manufacture. The propagated experimental yoghurt cultures were subjected to MW treatment (180W for 3 min) and were inoculated in yoghurt milk for the preparation of yoghurt cheese by traditional method (Strained/Greek yoghurt (SY)) and new method (Greek style yoghurt (GSY)). The total solids (19% and 23%) and amount of culture addition (2% and 4%) were optimized in both the methods of yoghurt cheese manufacture. Desirable acidity and better sensory and textural properties were observed in SY with 2% culture and 23% solids and similarly for GSY with 4% culture and 23% solids. The comparative study of both the methods using optimised combination were carried out after testing for acidity and pH, physico chemical, texture and sensory analysis, nutritional analysis and yield. The GSY was higher in lactose and ash but lesser protein content when compared to the SY. The MW treatments to cultures did not have any impact on composition of the developed product. There was significant ($p<0.05$) difference between the acidity and pH values of control and MW treated cultures in GSY production. The developed GSY with 23% solids showed significantly ($p<0.05$) higher textural properties when compared to SY with 23% solids. There was significantly ($p<0.05$) higher hardness and consistency for MW treated samples when compared to the control GSY and SY. Sensory attributes were significantly ($p<0.05$) higher in GSY with 4% control and MW treated culture when compared to SY. The nutritional value of SY provides 120.25 kcal/100gm whereas GSY provides 121.29 kcal/100gm. The yield of the GSY incubated in cups, was approximately 100% whereas 50-55% of yield was observed in the SY. The developed GSY with 23% solids and 4% culture is the best alternative to SY. The MW treatment to cultures also enhanced the developed product.

Keywords: Microwave treatment, yoghurt cheese, Greek style yoghurt, strained yoghurt, yoghurt starter culture

1. Introduction

Fermentation is one of the most important and lengthier steps during the manufacture of fermented dairy products. It requires huge floor spaces and excessive energy consumption for balancing the temperature conditions. So, accelerating the fermentative processes without adversely affecting the final product quality has turned into a priority area of our research. There is great possibility to explore as acceleration of fermentation processes using non-conventional (NC) treatments would bring benefits like increased metabolic activity of microbes, reduction in fermentation time and better texture formation (Shershenkov and Suchkova 2015) [15]. Application of non-conventional conditions during fermentation propose potential development in the upcoming years, due to extensive biotechnological applications. One such application is the use of microwave treatment in the fermentation process.

This study focuses on the use of MW to improve yoghurt starter growth and fermentation condition at sub-lethal levels under mild stress conditions. Microorganisms can exhibit different response actions when exposed to stressful atmosphere (Zamfir and Grosu-Tudor, 2014) [20]. When mild stress conditions are applied through NC treatments (at sub-lethal levels), the microorganisms get recovered because of the actions of certain stress response mechanisms and thereby getting adjusted to the new conditions (Lado and Yousef, 2002) [9]. Bacterial stress responses depend on the various expressions of genes to enhance stress tolerance (Van De Guchte *et al.*, 2002) [19]. Therefore, it develops morphological changes in microbes and changes in metabolic reactions. The sub-lethal stress induces the expression of cell repair systems and thereby, adaptation of microorganisms to stress during treatment

(Huang *et al*., 2014; Lado and Yousef, 2002) [14, 9]. Microwaves are non-ionizing electromagnetic waves with their frequency ranges from 0.3-300 GHz (Balbani and Montovani 2008) [4]. When high energy MW is applied for long time period, it destroys the bacterial cells. But when applied at frequencies, their non-thermal effect is more powerful. So, MW generates considerable effects in improving the growth of microbial cultures. Low energy and low frequency MW improves the growth of microorganisms, whereas high energy and high frequency MW kills the microorganisms (Janković *et al*. 2014) [8].

Yoghurt has many desirable properties. Keeping quality improves if it is stored at <5 °C and it is normally stored at refrigerated temperature. However, shelf life can be extended when the moisture content in the product is reduced. This fact leads to the production of concentrated yoghurt (Yoghurt cheese or Greek Yoghurt) in order to extend the keeping quality of yoghurt. Yoghurt cheese contains double the protein content and three times more fat content than normal yoghurt, through a straining at the end of the production process (concentration of total solids) (Tamime and Robinson, 1999) [17]. However, straining also produces acid whey with lactic acid, thereby causes in serious environmental issues if not properly disposed. Thus, extra processing is essential for the proper disposal of the acid whey generated. So, various methods are used by the dairy industry to reduce the acid whey generation. Therefore, straining step in the Yoghurt cheese manufacture is to be avoided and subsequently alternate method of manufacture is to be developed to minimize acid whey generation. The study was intended to develop and standardize a method for the production of yoghurt cheese, which will bring about higher yield with better energy value and also aesthetic quality of the product (Nsabimana *et al*., 2005) [13]. Addition of milk solids like skimmed milk powder to the initial milk base increases the total solid level in the final product. Thereby, the nutritional value, yoghurt texture and mouth feel are improved and obtain final product with same chemical and physical characteristics of Yoghurt cheese made of traditional method (straining of curd).

The study was concerned with the evaluation of MW treatment on the growth modulation of yoghurt starter microbes. Also, optimization and characterization of the process parameters were conducted for the preparation of Yoghurt cheese. The present study relates to the fermentative performance of yoghurt starters using MW treatment and the preparation of yoghurt cheese by two different methods.

2. Materials and Methods

2.1 Materials

A commercially available freeze-dried yoghurt starter culture containing *Streptococcus thermophilus* (*St. thermophilus*) and *Lactobacillus delbrueckii* sub sp. *bulgaricus* (*Lb. bulgaricus*) strains as pure blend and were acquired from the reputed International firm (Danisco Cultures Division YOMIX 495). The culture was kept in a freezer until it was used. Fresh good quality of dried skim milk was acquired from the local market. Domestic microwave oven (SAMSUNG Model no: CE1041VD) operating at 2450MHz frequency with variable power supply device (180W) was used.

2.2 Activation of starter culture

Dried skim milk was reconstituted to 11-12% milk solids and heated at 90±2 °C for 15 min followed by cooling to 30 ºC. This was used as a medium for the growth of yoghurt starter culture. Freeze dried starter cultures were added at 0.06 g per litre of reconstituted milk. Inoculated cultures were incubated overnight at 42-43 ºC until the acidity reached to about 0.9% lactic acid.

2.3 Treatment of culture

150 mL propagated culture was taken in a separate 250 mL glass beaker which was subjected to microwave treatment. Yoghurt culture was treated with domestic microwave oven operating at 2450MHz frequency with a power of 180W for 3 min. Immediately after subjecting to the treatment, treated culture samples (TY) and non-treated control yoghurt cultures (CY) were utilised for yoghurt curd preparation and the fermentation performance of the culture was evaluated.

2.4 Preparation of milk samples

A yoghurt mix with 15 % total solids (TS) was prepared by adding calculated amounts of SMP to raw milk. The fat standardisation was done to maintain 3.5-4% level of fat and protein maintained at 3% level. Another yoghurt mix with 19-23% TS was prepared by adding calculated amounts of cream and SMP to raw milk using the Pearsons Square method (Tamime and Robinson, 1999) [17]. Fat standardisation was carried out to maintain 6% fat level and protein level maintained at 8%.

2.5 Production of Yoghurt cheese with straining

The yoghurt mix with 15% total solids (TS) was used for Yoghurt cheese manufacture with straining as per the method described by Tamime and Robinson (1988) [16], with certain modifications in standardization and heat treatment of milk. The yoghurt mix was standardized to 3.5-4% fat and 3% protein (15% TS) followed by homogenization at 60-65 ºC and heat treatment at 95 °C for 15 minutes. This milk was then cooled to around 42±1 °C and inoculated by adding 2-4% control and treated yoghurt culture. The inoculated milk was incubated at 42±1 °C for 4.5 to 5 hours or till pH 4.6 was reached. The prepared yoghurt was stored under refrigeration temperature (4-7 °C) for 4 hours so as to get a firm coagulum. Partial removal of whey was done in a muslin cloth or sieve for about 5.5 hrs in order to obtain 19-23% TS level. The cheese curd thus obtained was transferred to polypropylene cups and stored under refrigeration temperature (4-7 °C) till further use.

2.6 Production of Yoghurt cheese without straining

The yoghurt mix standardized to 19-23% TS was used for Yoghurt cheese manufacture without straining. Two batches of control and treated samples were fermented without the straining step as described in Fig. 1. Yoghurt mix containing 19-23% TS (6% fat and 8% protein) was homogenized at 60-65 ºC and followed by a batch pasteurisation using a water bath at 95 °C for 15 minutes. This milk was then cooled to around 42±1 °C and inoculated by adding 2-4% control and treated yoghurt culture. The mix was then transferred to polypropylene cups and incubated at 42 °C until a pH value of 4.6 was reached. They are stored under refrigeration temperature (4-7 °C) till further use.

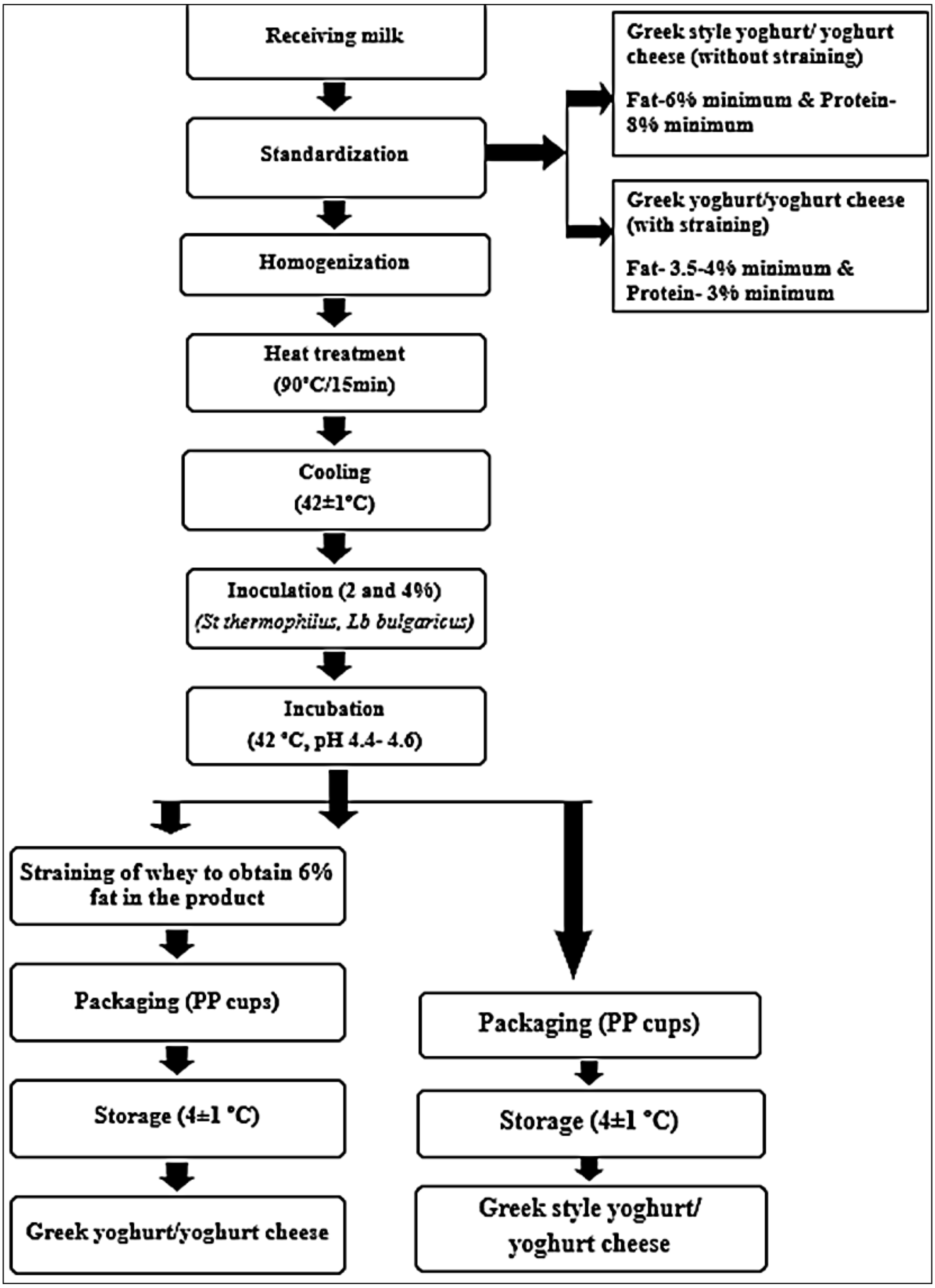


Fig 1: Flow diagram for manufacture of Greek yoghurt and Greek style yoghurt

2.7 Physico-chemical analysis of Yoghurt cheese

Ten grams of yoghurt cheese was mixed with 10 ml of distilled water and a slurry was prepared thereof. The pH of slurry was determined using a Digital pH meter (M/s EUTECH Instruments, Singapore) with combined electrode. The titratable acidity of Yoghurt cheese was measured as per AOAC (1992) [2]. To 10 g of sample, warm distilled water (40 °C) was added, mixed thoroughly and made up the volume to 100 ml. The contents were filtered through Whatman No. 1. Then 25 ml of filtrate was titrated against standard 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as indicator. Moisture content (gravimetric method) of Yoghurt cheese was determined as per AOAC 925.23 A (2012) [3] given for milk. About 2-3 g of Yoghurt cheese was weighed accurately on a previously dried and weighed dish. The sample was dried at 102±2 °C for 4 h. It was cooled and weighed. The process was repeated by re-drying for 1 h until difference in weight between two successive drying was less than 0.5 mg. Fat in Yoghurt cheese was determined as per the method AOAC 989.05. (2012) [3] given for milk with slight modification. Total nitrogen or total protein in Yoghurt cheese was determined as per the method described in AOAC 991.20 (2012) [3] for milk with slight modifications. Ash content of Yoghurt cheese was determined as per the method described in AOAC 945.46. (2012) [3] given for milk. Yoghurt cheese of 2-3 g was weighed into dried crucible and ignited to

≤ 550 °C in a muffle furnace, cooled and weighed. Samples were burned prior to ashing over hot plate.

2.8 Textural Analysis of Yoghurt cheese

The sample of yoghurt cheese was filled up to 3.5 cm height of sample container (100 ml capacity, made of Polypropylene) and evaluated for its textural attributes, using Texture Analyzer. The product (firmly set yoghurt in cups) was subjected to a trigger force of 5 g, test speed of 1 mm/s by a P/25 cylindrical aluminium probe attached to the texture analyser at a temperature of 15-20 ºC. Parameters measured consisted of firmness, consistency, index of viscosity and stickiness. The Firmness was measured in Newton (N), Consistency values in Newton. Sec (N.s), Index of viscosity in Newton. Sec (N.s) and Stickiness values in Newton (N).

2.9 Sensory analysis of Yoghurt cheese

The same samples selected for texture analysis was used for sensory evaluation in order to compare the sensorial attributes of the final yoghurt after complete fermentation. Sensory analysis was carried out for the final product using score card of 9 point hedonic scale. The judged parameters were: Flavour, Body and texture, Colour and appearance, and Overall acceptability. The evaluation was performed under appropriate lighting conditions at storage temperature by a judging panel of six members. On total, each judge will have 4 samples (2 treated yoghurt cheese with and without straining and 2 control yoghurt cheese with and without straining) to analyse. The sensory panel included trained faculty and some of the students.

2.10 Statistical analysis

The analyses of all the data obtained from various experiments were carried out using the statistical software SPSS 16.0 (Stat Soft Polska Sp. Z o. O., Krakow, Poland). One-way analysis of variance (ANOVA) was done and significant differences among various samples were reported as per the Duncan's test at 5% level ($p<0.05$). Also, the overall mean and standard error of compositional data was computed with the use of Microsoft Excel.

3. Results and Discussion

3.1 Effect of solids on textural properties of yoghurt cheese strained (YC-S)

Milk after standardized, homogenized, heated and cooled to 40-42 ºC was inoculated with 2% of MW treated and control yoghurt cultures and incubated at 42 ºC until pH 4.6. After incubation, the yoghurt was strained for 5 hrs and 5.5hrs in order to obtain 19% solids and 23% solids respectively. After packaged in cups, the various textural parameters for the final strained yoghurt cheese made with 19% and 23% solids were analysed and indicated in Figure 2. The product with 23% solids showed significantly ($p<0.05$) higher hardness, consistency, index of viscosity and stickiness when compared to yoghurt cheese with 19% solids. No significant ($p>0.05$) difference was observed in textural properties among the control and MW treated samples of SY. The superior textural properties were noted for yoghurt cheese with 23% solids because it showed a more compact protein matrix, with fewer and smaller pores. It is due to this property, higher aggregation of protein and a firmer gel is attained without any whey separation. The product was sensorily more acceptable due to comparatively lesser acidic taste than the yoghurt cheese of 19% solids.

3.2 Effect of solids on textural properties of Greek style yoghurt (without strained)

Milk was standardized to 19% solids and 23% solids, homogenized, heated and cooled to 40-42 ºC. Then it was inoculated with 2% of MW treated and control yoghurt cultures and incubated at 42 ºC until the end of fermentation. After incubation of about 7.5 hrs for 19% solids and 9 hrs for 23% solids, textural properties were carried out. The various textural parameters for the final GSY using 19% solids and 23% solids were analysed and indicated in Figure 3. The product with 23% solids showed significantly ($p<0.05$) higher hardness, consistency, index of viscosity when compared to GSY with 19% solids. No significant ($p>0.05$) difference was observed in stickiness between 19% and 23% solids in the product. There was significantly ($p<0.05$) higher hardness, consistency and index of viscosity for MW treated samples when compared to the control GSY of both 19% and 23% total solids.The superior textural properties were noted for GSY with 23% solids because it showed a more compact protein matrix and a firmer gel is attained without any whey separation. The product was sensorily more acceptable due to comparatively lesser acidic taste than the product of 19% solids.

3.3 Effect of culture on acidity and pH of yoghurt cheese (strained)

Milk after standardized, homogenized, heated and cooled to 40-42 ºC was inoculated with MW treated and control yoghurt cultures at the rate of 2% and 4% each and incubated at 42 ºC until pH 4.6. After incubation, the yoghurt was strained for 5.5 hrs in order to obtain 23% solids. After packaged in cups, acidity and pH values of different SY samples of 23% solids prepared using different levels of both treated and control yoghurt cultures are delineated in Table 1. Yoghurt cheese produced with 2% culture after incubation of 5 hrs and straining of 5.5 hrs reached the desirable acidity when compared to 4% culture after incubation of 4.5hrs and straining of 5.5 hrs. pH of yoghurt was also desirable. On the contrary, there was very high acidity formation (higher than normal) in the product with 4% culture, which resulted in highly acidic taste. Therefore, SY prepared with 2% culture was considered to be more acceptable over 4% culture product.

Table 1: Effect of culture on Acidity and pH of yoghurt cheese (strained)

Attributes	Control 2%	Treated 2%	Control 4%	Treated 4%
Acidity	1.22±0.05	1.24±0.03	1.30±0.04	1.32±0.03
pH	4.44±0.03	4.43±0.02	4.39±0.04	4.39±0.02

Values are means±standard deviation (SD), (n = 3)

3.4 Effect of culture on acidity and pH of Greek style yoghurt (without strained)

Milk was standardized to 23% solids, homogenized, heated and cooled to 40-42 ºC. Then it was inoculated with 2% and 4% each of MW treated and control yoghurt cultures and incubated at 42 ºC until the end of fermentation. Acidity and pH values of different GSY samples of 23% solids prepared using different levels of yoghurt cultures are delineated in Table 2. Yoghurt cheese prepared with 4% culture after incubation of 7 hrs without straining reached desirable acidity faster whereas the 2% culture product required 8.5 hrs. pH of yoghurt was also desirable. The desirable acidity was reached faster in 4% culture whereas longer time was required with 2% culture during the preparation of GSY. Therefore, yoghurt cheese prepared from 4% culture was considered to be more acceptable over 2% culture product.

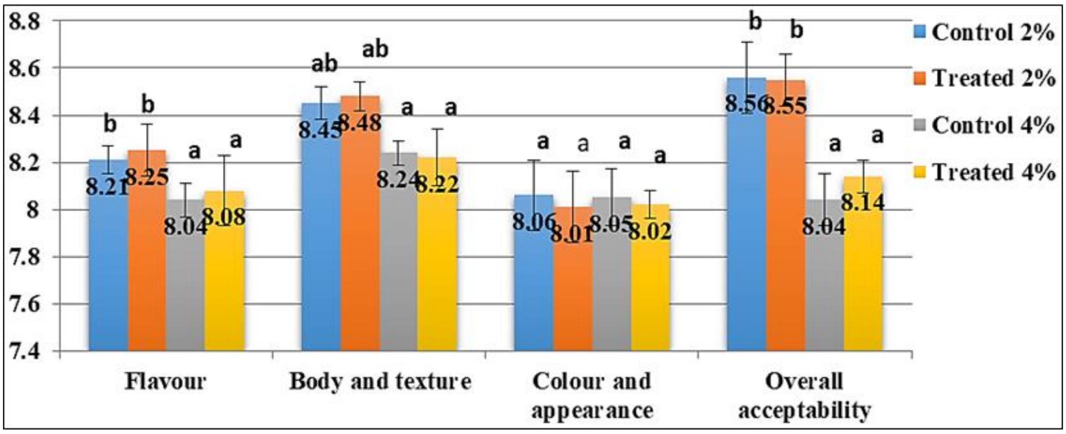
Table 2: Effect of culture on Acidity and pH of yoghurt cheese (without strained)

Attributes	Control 2%	Treated 2%	Control 4%	Treated 4%
Acidity	0.85±0.04	0.88±0.03	0.84±0.02	0.89±0.03
pH	4.88±0.04	4.87±0.05	4.89±0.04	4.86±0.03

Values are means±standard deviation (SD), (n = 3)

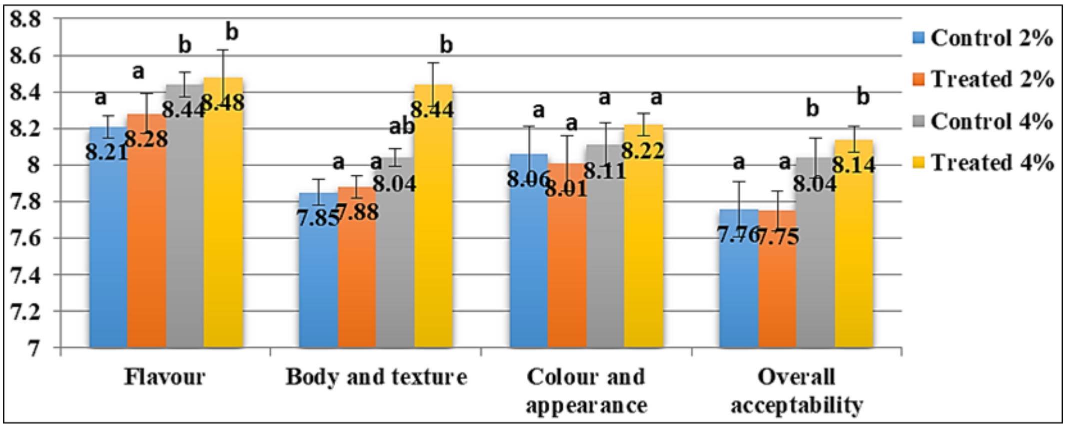
3.5 Effect of culture on sensory attributes of yoghurt cheese (strained)

Sensory attributes of SY samples of 23% solids prepared using different levels (2% and 4%) of control and MW treated yoghurt cultures are provided in Figure 4. Sensory attributes were significantly ($p<0.05$) higher in yoghurt cheese with 2% culture in terms of flavour, body and texture and overall acceptability when compared to 4% culture. As there was very high acidity generation (higher than normal) in the product with 4% culture, it resulted in highly acidic taste that was undesirable. No significant ($p>0.05$) difference was observed among all SY samples in terms of colour and appearance. Similarly, there was no significant ($p>0.05$) difference in sensory attributes between the MW treated and control cultures.



Values are means ±standard deviation (SD), error bars represent SD, (n = 3) means with different superscript differ significantly ($p<0.05$).

Fig 4: Effect of culture on sensory attributes of yoghurt cheese (strained)



Values are means±standard deviation (SD), error bars represent SD, (n = 3) means with different superscript differ significantly ($p<0.05$)

Fig 5: Effect of culture on sensory attributes of yoghurt cheese (without strained)

3.6 Effect of culture on sensory attributes of Greek style yoghurt (without strained)

Sensory attributes of GSY samples of 23% solids prepared using different levels (2 and 4%) of control and MW treated yoghurt cultures are provided in Figure 5. Sensory attributes were significantly ($p<0.05$) higher in yoghurt cheese with 4% culture in terms of flavour, body and texture and overall acceptability when compared to 2% culture. Since the acidity development in the product with 2 % culture was very slow due to the higher solids content (23% solids), it was appropriate to add 4% culture to the product in order to obtain the desired consistency. Addition of culture also improved the texture of the yoghurt as well as reduced the fermentation time. No significant ($p>0.05$) difference was observed among all GSY samples in terms of colour and appearance. Similarly, there was no significant ($p>0.05$) difference in sensory attributes between the MW treated and control cultures.

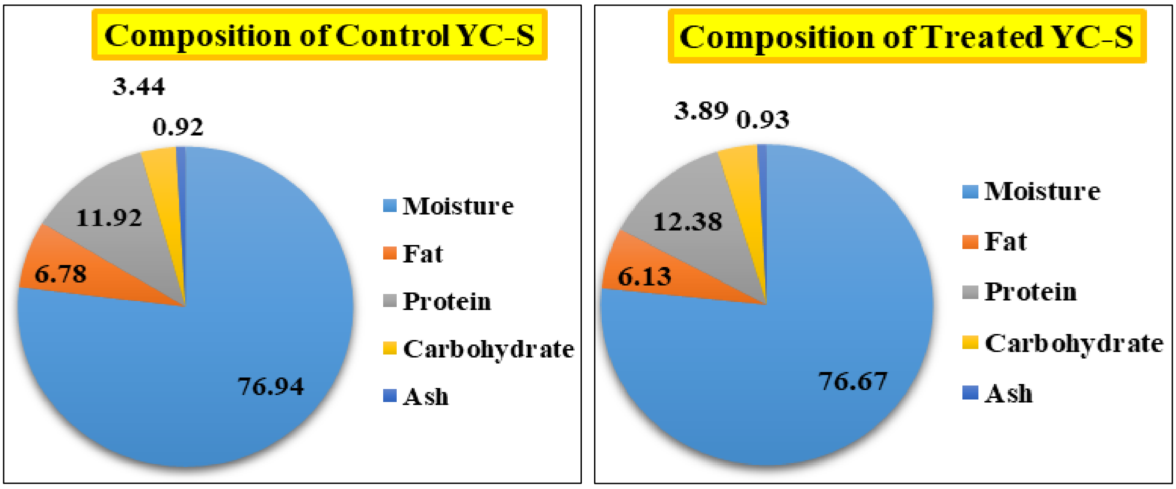
Desirable acidity was reached in SY with 2% culture whereas 4% culture was required in GSY to improve fermentation. Better sensory properties were observed in SY with 2% culture and 23% solids and similarly for GSY with 4% culture and 23% solids. So, this combination was considered to be the optimized combination.

3.7 Optimized process for the preparation of yoghurt cheese

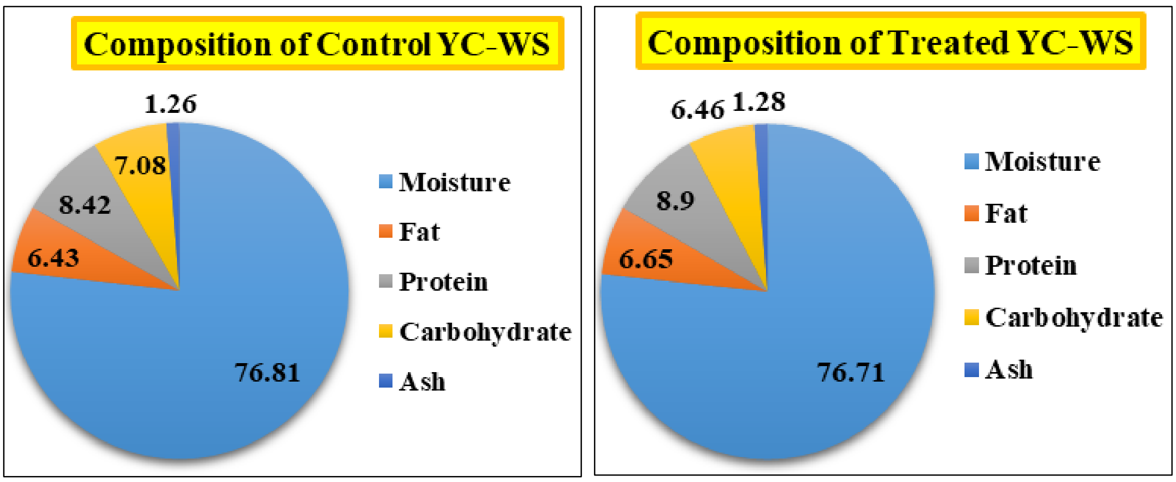
The major aim of this study was to use selected non-conventional treated yoghurt culture for the development and standardisation of manufacturing process for GSY, in which the required protein content is achieved as per Codex standards. Skim milk powder and cream was used to standardize yoghurt milk to 8% protein in Greek style yoghurt. SY (traditional method) of similar protein content was used as control. Yoghurt milk bases were inoculated with 2% control and MW treated starter culture for SY and 4% control and MW treated starter culture for GSY and are fermented until pH 4.6.

3.8 Physico-chemical analysis of developed yoghurt cheese

Yoghurt cheese was made by both the methods as described in Fig 1. Chemical composition of SY and expelled acid whey depends chiefly on the extent of the concentration of solids through straining during manufacturing. Chemical composition was evaluated by keeping the moisture content constant. The GSY was higher in lactose and ash compared to the SY samples (Fig 6), which can be because of the omission of the concentration step. On the contrary, the composition of SY had lesser lactose that was significantly different from their corresponding fermented GSY mix (control and treated YC-WS (Yoghurt cheese-without strained)). The straining step elevated the protein content by retaining almost all of the proteins while letting lactose to pass into the whey stream. Also, fat was concentrated along with the proteins mostly because of uniform distribution along the protein gel resulting from the homogenisation, which also would enhance the creamy mouth feel in the final product (Ozer & Robinson, 1999) [14]. But the GSY also did not compromise on the protein content. The GSY met the standards of concentrated yoghurt as per Codex. There was no significant difference in fat content between both the methods of manufacture. The MW treatments to cultures did not have any impact on composition of the developed product.



A) Strained **B) Without strained**



A) Control and Treated Strained Yoghurt cheese **B) Control and Treated Yoghurt cheese without strained**

Fig 6: Composition of control and treated Yoghurt cheese

3.9 Acidity and pH of developed yoghurt cheese

Acidity and pH values of control and treated SY samples of 23% solids and 2% culture and GSY without straining of 23% solids and 4% culture are delineated in Table 3. Yoghurt cheese produced with 2% culture after incubation of 5 hrs and straining of 5.5 hrs reached a comparatively higher acidity than that of GSY. Therefore, due to higher acidity generation (higher than normal) during straining, highly acidic taste was generated.

Even though GSY had an incubation period of 7 hrs with 4% culture addition, there was desirable acidity generation compared to SY. The acidity and pH values were significantly ($p<0.05$) different among both the methods of manufacture. On the contrary, there was no significant ($p>0.05$) difference between the acidity and pH values of control and MW treated cultures in SY, whereas significantly ($p<0.05$) higher values were observed for the control and MW treated cultures in GSY production.

Table 3: Acidity and pH of developed yoghurt cheese

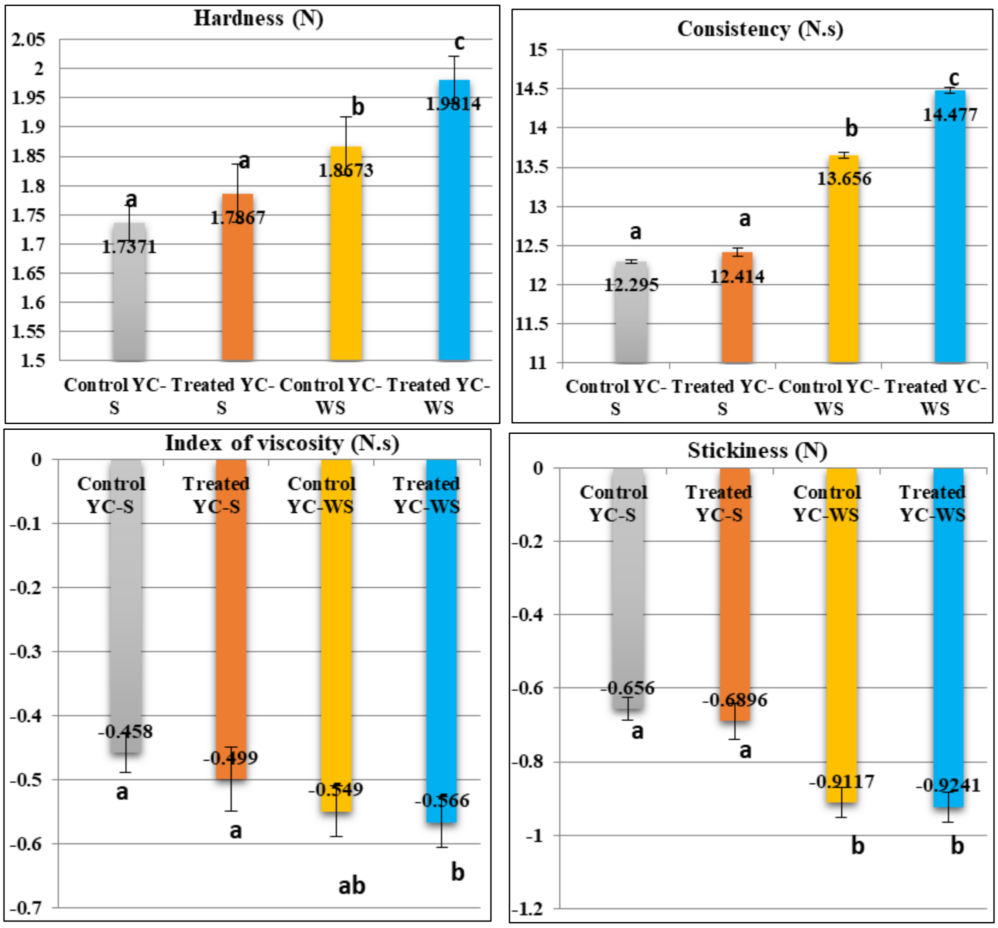
Attributes	Control YC-S	Treated YC-S	Control YC-WS	Treated YC-WS
Acidity	1.224±0.04^{c}	1.25±0.04^{c}	0.88±0.02^{a}	0.94±0.02^{b}
pH	4.45±0.04^{a}	4.43±0.03^{a}	4.87±0.01^{c}	4.82±0.02^{b}

Values are means±standard deviation (SD), means with different superscripts in a row differ significantly ($p<0.05$) (n = 3)

3.10 Textural analysis of developed yoghurt cheese

The various textural parameters for the SY and final GSY (without strained) with and without MW treatment to cultures were analysed and indicated in Figure 7. The developed GSY with 23% solids showed significantly ($p<0.05$) higher hardness, consistency, index of viscosity and stickiness when compared to SY with 23% solids. There was significantly ($p<0.05$) higher hardness and consistency for MW treated samples when compared to the control GSY and SY. No significant ($p>0.05$) difference was observed in index of viscosity and stickiness between control and MW treated GSY. Similarly, no significant ($p>0.05$) difference was observed in all the textural parameters between control and MW treated SY. The superior textural properties were noted for GSY with 23% solids because it showed a more compact protein matrix, and a firmer gel is attained without any whey separation.

This is very important because texture is one of the most remarkable sensory characteristics for consumers' preference and acceptance of a yogurt cheese product. As the gel was disturbed by stirring as one of the essential processing steps, the initial gel structure not ever recovered its original properties which gave rise to very low measured hardness. Marafon *et al*., (2011) [11] reported that the microstructure of normal yoghurt showed large number of large sized pores which are uniformly distributed in the protein matrix instead the microstructure of fortified yogurt at an equivalent protein content exhibit a more compact protein matrix having lesser and smaller pores. The presence of a numerous pores in the microstructure of yoghurt gels gives a weaker gel (Lee and Lucey, 2004) [10]. In the present study, it is anticipated that the structure of the GSY was more compact when compared to SY, which bring about a stronger, firmer gel network in the former.

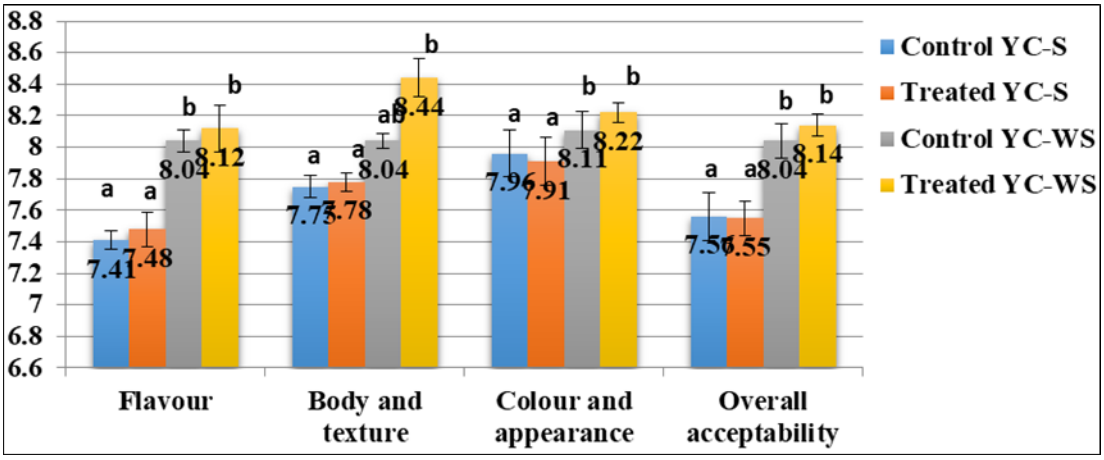


Values are means ±standard deviation (SD), error bars represent SD, (n = 3) means with different superscript differ significantly (p<0.05)

Fig 7: Textural analysis of developed yoghurt cheese

3.11 Sensory analysis

Sensory attributes of SY and GSY samples of 23% solids are provided in Figure 8. Sensory attributes were significantly ($p<0.05$) higher in GSY with 4% control and treated culture in terms of flavour, body and texture, colour and appearance as well as overall acceptability when compared to SY with 2% control and treated culture. No significant ($p>0.05$) difference was observed among all GSY samples in terms of colour and appearance. Similarly, there was no significant ($p>0.05$) difference in sensory attributes between the MW treated and control cultures of two methods. Since the acidity development in the SY was higher and resulted in more acidic taste its flavour was unpleasant when compared to the developed GSY. GSY with 23% solids showed a more compact protein matrix, and a firmer gel is attained without any whey separation. This brought about superior body and texture for the developed product when compared to SY.



Values are means±standard deviation (SD), error bars represent SD, (n = 3) means with different superscript differ significantly ($p<0.05$)

Fig 8: Sensory analysis of developed yoghurt cheese

3.12 Nutritional analysis and yield of the developed product

Nutritional value of SY and GSY of MW treated cultures were calculated based on its proximate composition (Fig 6). The energy value was calculated as, Energy value (kcal) = (Fat x 9) + (Protein x 4) + (lactose x 4).

Energy value of GSY (Table 4) was higher than the SY. SY provides 120.25 kcal/100gm whereas the developed GSY provides 121.29 kcal/100gm. The developed GSY provides maximum calories compared to SY due to the higher carbohydrate and fat content. Since the products were packed in 100mL polypropylene cups, we can say that per servings of SY and GSY has a calorie content of 120.25 and 121.29 kcal respectively.

Table 4: Nutritional value per 100 gm of Treated Yoghurt cheese with and without strained

Compositional Parameter	Treated YC-S	Treated YC-WS
Total Fat (g)	6.13	6.65
Protein (g)	12.38	8.9
Carbohydrate (g)	3.89	6.46
Energy value (kcal/100mL)	120.25	121.29

3.13 Yield of the developed product

The yield of the developed GSY was incubated in cups, which can be assumed to be approximately 100% whereas 50-55% of yield was observed in the SY. The reduction in yield of SY is due to the straining step involved in processing, which results in the removal of whey. The whey removed during the processing of SY was also tested for acidity, pH and total solids and delineated in Table 5. A comparatively higher acidity and total solids were observed in the generated whey of MW treated yoghurt cheese when compared to control yoghurt cheese.

Table 5: Chemical tests of whey obtained during straining of yoghurt cheese

Attributes	Control yoghurt cheese	Treated yoghurt cheese
Acidity of whey	0.71	0.729
pH of whey	4.53	4.52
Total solids of whey	5.24	5.26

3. Conclusion

The objective of the study was to explore microwave treatments to the yoghurt starter microbes and evaluates the effect on their growth and proliferation. Also, the effect of adjusting initial total solids content as per the volume to generate less/ no acid whey as an alternate method of Yoghurt cheese preparation. Low power MW for the cultures were generally found to be most favourable for achieving a shorter fermentation time and maintaining a substantial number of bacteria count at the end of fermentation. Overall performance of fermentation under NC conditions is still at its infancy, but the studies reported so far propose potential development in the upcoming years, due to extensive biotechnological applications.

The developed product of GSY with 23% solids and 4% culture is the best alternative to SY. The developed product had similar composition, optimum acidity and pH, superior textural properties, higher sensory scores, higher yield and nutritional value when compared to traditional method of manufacture. The MW treatment to cultures also enhanced the developed product in terms of acidity and pH, texture and sensory scores. Since there is no acid whey removal step in the developed product, the problems of higher production time due to straining, lesser yield, non-uniform product quality can be resolved through this alternative technique.

Therefore, this manufacturing process can lead to relatively reduced acid whey production and thereby low drainage requirement without compromising yoghurt quality. GSY (Yoghurt cheese) helps to resolve the challenges created by acid whey (both economic and environmental problems) in Yoghurt cheese production, which would bring financial benefits to the dairy industry.

4. Acknowledgement

The authors thank ICAR-National Dairy Research Institute, Bengaluru for the financial support.

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