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Implementing Maltodextrin, Polydextrose and Inulin in Making a Synbiotic Fermented Dairy Product

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Synbiotic products contain both probiotic bacteria and prebiotic compounds. The aim of this study was to produce a symbiotic Fermented dairy product with the polysaccharides / fibers (maltodextrin, polydextrose and inulin) with a 3% concentration in combining them with *Bifidobacterium longum* ATCC 15707, *Streptococcus thermophiles* Texl 5842 and *Lactococcus lactis subsp lactis* ATCC 53214 (*Lac. lactis* spp *lactis*) in either skimmed or full fat fermented milk, and testing, the sensory and physicochemical and microbiological properties for fresh product and after incubation for 7 days. It was shown that the pH was having a clear decrease and acidity was showing an increase that was lowered by increasing the storage days at 5-7°C as well as a significant decreasing in the syneresis and increase in log 10 cfu/g of B. longumATCC 15707 count and viscosity was markedly increased at maltodextrin treatment. Finally, it was concluded that Maltodextrin was found to have good results in stimulation the probiotic bacterial count and enhancing the sensory properties of fermented milk compared with inulin and that is recommended by our work to use it in industry.

Keywords: Synbiotic polysaccharide; maltodextrin; polydextrose; inulin.

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ABBREVIATIONS

B. longum	*Bifidobacterium longum*
L. acidophilus	*Lactobacillus acidophilus*
L. plantarum	*Lactobacillus plantarum*
L. rhamnosus	*Lactobacillus rhamnosus*
L. paracasei	*Lactobacillus paracasei*
L. reuteri	*Lactobacillus reuteri*
Lac.	*Lactis spp lactis lactococcus lactis spp lactis*
St. thermophilus	*Streptococcus thermophilus*
CFU/ml	*Colony-forming unit / milliliter*
CFU/g	*Colony-forming unit /gram*
DP	*Degree of polymerization*
MRS	*de Man, Rogosa and Sharpe*
FOS	*Fructo oligosaccharides*
cP	*Centipoise*
°c	*Degree Celsius*
ASMD	*Artificial sweetened mistidahi*

1. INTRODUCTION

Synbiotics consist of both useful bacteria (probiotics) and indigestible carbohydrates (prebiotics) for stimulating beneficial bacterial growth [1,2]. Synbiotics have antimicrobial, anticancer, anti-allergic and immune–stimulating properties. They improve absorption of minerals, prevent incidence of diarreah, and optimize assimilation of nutrients [3].

An example of fermented milk products is the Misti dahi originated in eastern India, the traditional fermented dairy product dahi, has been elevated to a dessert by sweetening it. The sweetened variety of dahi is popularly known as misti dahi or misthidoi. Misti dahi has creamish to light brown color, firm consistency, smooth texture and pleasant aroma. Traditionally, it is prepared by boiling cow, buffalo or mixed milk with a required quantity of sugar and partially concentrated by simmering over a low fire during which milk develops a distinctive light cream to light brown caramel color and flavor. This is followed by cooling and culturing at ambient temperature using lactic culture and pouring into retail earthen cups and left undisturbed overnight for fermentation. When a firm body curd has set, it is stored at a low temperature 4ºC and served chilled [4-6].

Yoghurt is among the most common fermented dairy products consumed around the world, and its sensory attributes have a large effect on consumer acceptability [7].

Drinkable yoghurt, categorized as stirred yoghurt with a low viscosity, is a growing area of interest based on its convenience, portability, and ability to deliver all of the health and nutritional benefits of stirred or set yoghurt [8,9]. The low viscosity is obtained through high agitation, which breaks the coagulum after the fermentation period, before the product is bottled and refrigerated [10]. Consumers began to look for low fat variants of yoghurt with acquainted sensory qualities available in full-fat yoghurts. However, too-much reduced or very low fat levels in milk can possibly result in the products with impaired physicochemical and sensory properties. Therefore, such prebiotics as inulin, maltodextrin and polydextrose can be used as fat substitutes in low-fat dairy-based products owing to their advantageous functionalities. Numerous researchers have tried to improve textural and functional properties of low-fat yoghurt by using these fat replacers. For example, [11] found that the yoghurt containing inulin had a stable color and water activity and syneresis did not prevail during storage, being similar to the other dietary-fiber containing yoghurts.

With regards to dairy products, an extensive amount of research has been done on the effectiveness of the three polysaccharides (inulin, polydextrose and maltodextrin) to be used as a fat replacer [12] or in comparison to other dietary fibers [13] or other carbohydrate-based fat replacers [14].

The addition of Inulin decreased the syneresis in low fat [14,15] and fat free [16]. The water activity, pH, color and appearance of these inulin-fortified yoghurt were stable over the storage period [13,16].

Several researchers have described the effects of inulin as a fat mimetic at a molecular level. Also, [15] suggested that the water soluble inulin could act as a thickener and formed hydrogen bonds with protein aggregates in the yoghurt during fermentation. The viscosities of stirred yoghurts were studied by [17]. They suggested that inulin reduced brush friction by interacting with the extracellular polysaccharides that were located outside the protein aggregates. The mobility of protein aggregates thus increased when compressed by the tongue, which in turn provided the perceived improved airiness and creaminess in yoghurt.

Maltodextrin increased acidity, water activity and viscosity of Artificial sweetened mistidahi (ASMD) while decreased syneresis compared to other bulking agents. Maltodextrin increased hardness, adhesiveness and gumminess values of ASMD compared to sorbitol and polydextrose. Maltodextrin was found to be the most suitable bulking agent in the preparation of ASMD using aspartame and acesulfame-K. Reported by [18].

The aim of this study was to determine the effects of using maltodextrin, polydextrose and inulin in preparation of full fat and skimmed fermented milk on their physicochemical, microbiological and sensory properties.

2. MATERIALS AND METHODS

2.1 Milk

2.1.1 Whole cow's milk

Fresh milk was obtained from the dairy pilot plant of the Faculty of Agriculture that was obtained previously from the faculty's farm, Alexandria University. With total solids 12.39%, fat 3.5% and pH 6.7.

2.1.2 Skim milk

It was obtained by separation of whole milk using a milk separator, with total solids of 9.33%, fat 0.2 % and pH 6.7.

2.1.3 Milk powder

A low heat treated milk powder made from fresh pasteurized cow's milk with a fat 1.25%, lactose 52%, protein 36% and ash 8%. Obtained from Valio Company Finland origin.

2.2 Tested Cultures

St.thermophilusTexl5842, Lac. Lactissplactis ATCC 53214 and*B. LongumATCC 15707*

They were obtained from cultures store of Dairy Science and Technology department, Faculty of Agriculture, Alexandria University.

2.3 Polysaccharides

2.3.1 Polydextrose

Polydextrose is a randomly bonded condensation polymer of D-glucose with some bound sorbitol and a suitable acid with a molecular weight of 2200 was obtained from MENGZHOU TAILIJIE CO., LTD in town China. It has a white to cream white color, odorless and slightly sweet, soluble in water. pH range from 3.5-7.

2.3.2 Maltodextrine

Maltodextrine C*Dry MD 01915 was obtained from Cargill company, town France. It is a Spray-dried product obtained by enzymatic conversion of starch, with 6% moisture, DE 16, soluble in water, bulk density 440 g/l, pH 3.5 and Granulometry< 63 μm 35%.

2.3.3 Inulin

Long chain inulin was obtained from Fenchem Biotek LTD town China. It's botanical source Jerusalem Artichoke, used part is the root, having a white color, carbohydrate 99.6% min density 500 g/l, ash 0.5%, water 5%, good solubility in water and pH range from 5-7.

2.4 Fermented Dairy Product Manufacture

Two kinds of milk were used in the preparation of fermented milk products;

1- whole fat milk +2% milk powder
2- skim milk +2% milk powder

The polysaccharides (3%) were mixed with the milk fortified with milk powder (2%) at 45°C and heated at 85ºC for 30 min [19,20]. The bacterial culture combinations (*Lac. Lactisspplactis ATCC 53214*, *St. thermophilus Texl 5842* and *B. longum ATCC 15707*) were added at 42ºC and mixed. The milk mixture was distributed in 130 ml plastic cups and incubated at 42±1º Cuntil complete coagulation as sown in (Fig. 1). The pH, total acidity % and the $\log_{10}$ cfu/g of *B. longum* were determined in fresh product and after 2 days, 4 days and 7 days of storage at 5-7ºC.

2.5 Chemical Analysis

Proximate analysis were carried out according [21]. Titratable acidity was estimated as lactic acid %. The convenient Gerber method was used to determine fat %. The pH was determined by using glass electrode pH meter 3310Jenway, Germany.

2.6 Syneresis

An amount of 20 g of sample was spread on a thin layer to cover the surface of the wattmann paper no 1(that was pre- moistened by whey). The fermented milk product was filtered under vacuum via Buchner funnel for 10 min. The liquid that passed through the filter paper was collected and recorded. The percentage of syneresis was

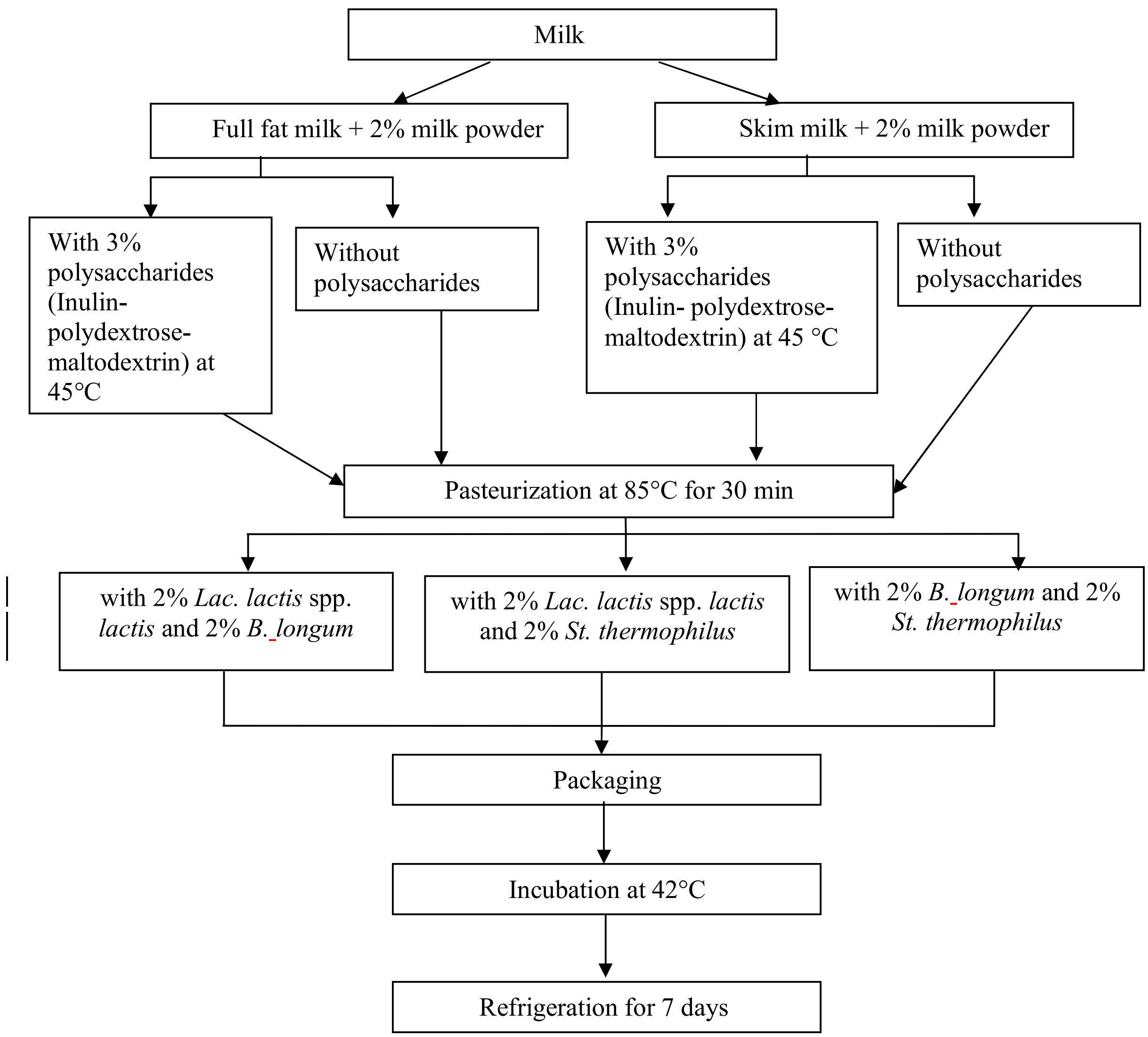

Fig. 1. Full fat and skimmed fermented dairy product flow chart

calculated as the weight of the filtrate been dropping down from the sample was collected and divided by the weight of the initial sample multiplied by 100 (as demonstrated in the following equation) [22].

$$\text{Synersis } \% = \frac{\text{weight of the collected filtrate}}{\text{initial weight (20 gm)}} \times 100$$

2.7 Viscosity Determination

This test was carried out to determine the effect showed by adding the polysaccharides (maltodextrin, polydextrose and inulin) to fermented milk. Apparent viscosity of the test sample (130 g at 10°C) was evaluated using a Spanish origin viscometer (MYR viscosoft plus V1.05) equipped with L1 spindle PE (yoghurt) head rotating at 100 rpm. At test, the spindle head started moving and the apparent viscosity value was recorded as cp. [23].

2.8 Sensory Evaluation

The sensory evaluation was used for appraising the sensory traits for the product. It was carried out by a panel consisting of 5-7 panelists including staff members and assistants, engineers and post graduate students at Faculty of Agriculture El-Shatby, Dairy Science Department and Food Science and Technology Department. Each panel member assessed the fermented dairy product sample separately, taking into account the following features; body and texture, flavor and finally appearance and color [24].

2.9 Statistical Analysis

The experimental design was a factorial experiment in a completely randomized design-test, with two replications and analysis of variance of treatments difference was performed according to Steel and Torrie [25]. Statistical analysis was done by, ANOVA, F-test, and L.S.D procedures available within the SAS software package.

3. RESULTS AND DISCUSSION

3.1 Determination of pH Value and total Acidity

Concerning the effect of polysaccharide on the growth activity of tested cultures combination depending on the changes in total acidity and pH values, Table (1) show the changes in pH during the manufacturing of full fat and skimmed fermented milk made by starter composed of *B. longum ATCC 15707* with *St. thermophilus Texl 5842* or *lac. lactis. Spp lactis ATCC 53214* in comparison with those made with *St. thermophilus Texl 5842* and *lac. lactis. Spplactis ATCC 53214* in the presence of 3% polysaccharides. The results in Table (1) revealed that the addition of polysaccharides by 3% decreased the pH in the fermented product made from full fat or skimmed fermented milk, the pH of the control (*B. longum ATCC 15707 + St. thermophilus Texl 5842*) and that made with maltodextrin, polydextrose and inulin were 4.68, 4.29, 4.52 and 4.31 respectively, in the full fat fermented milk, while the corresponding pH values in skimmed fermented milk were 4.70, 4.32, 4.45 and 4.33 respectively almost the same trend was noticed for all treatments with different culture combinations and selected polysaccharides which concluded that the addition of polysaccharides may enhance the starter activity specially *B. longum ATCC 15707*. Storing the product at 5-7°C decrease the pH values gradually as the storing time increased the statistical analysis revealed a significant decrease in pH at (α 0.01), while there were no significant difference between the full fat and skimmed fermented milk products either in fresh and after storing at 5-7°C.

It was noticed that the culture combination containing *B. longum ATCC 15707* and maltodextrin have a significant effect on growth activity of starter combination in comparison with other polysaccharides and starter free of *B. longum ATCC 15707*, which may be due to synergistic effect between *B. longum ATCC 15707*, *lac. lactis. Spplactis ATCC 53214* and *St. thermophilus Texl 5842.* [26] reported that the decrease in pH values may be due to short chain fatty acid which produced in varying quantities. Polydextrose pH values were significantly lower than control and higher than the maltodextrin and inulin. On contrary with [27] concluded that polydextrose increased the acidity more than the control where inulin results shown to be significantly lower than the control and Polydextrose same as pH. For inulin it show a significant lower pH value than polydextrose and higher than maltodextrin where different results were illustrated by [28] found that titratable acidity and pH values of set type yogurt (low fat) added with (1-3%) inulin/100 ml milk were not significantly different, possibly due to no adverse change in activity of yoghurt culture. same results of inulin were highlighted by [18] where they mentioned that the rate of pH decrease of fermented milk products was increased by addition of inulin.

Also it was reported that 1% of inulin addition to yoghurt samples exhibited the lowest pH values throughout the storage period (21 day) comparable to control [29-31].

Different results were obtained by [32] where they showed that the pH values of functional white soft cheese made with 3 probiotic strains in the presence of 3% polydextrose were significantly lower than the control made without any prebiotic and had the highest titratable acidity values at the end of storage period.

On the other hand the total acidity % of the full fat and skimmed fermented product showed a significant increase in the presence of *B. longum ATCC 15707* and selected polysaccharide specially maltodextrin , as shown in Table (1). The total acidity of polydextrose was significantly lower than the maltodextrin but more than the control and there were no significant difference between inulin and polydextrose, where composition of maltodextrin reveals that it contains a mixture of low molecular weight polysaccharides, oligosaccharide and simple sugar previously reported by [33] these sugars might have been ready utilized by lactic acid bacteria and increased the acidity. [34] illustrated that using polydextrose supplementation accelerated the acidification and fermentation thus providing interesting prebiotics to improve the yoghurt, the results appears to confirm the effect of polydextrose highlighted by [35,36]. Different results were obtained by [34] where they mentioned that polydextrose led to lower the pH and increase lactic acid release with respect to maltodextrin whose effect on the contrary where almost negligible when compared to control.

Also, [18] observed that different bulking agents (polydextrose, maltodextrin and sorbitol) had a significant effect ($P < 0.01$) on the acidity of artificial sweetened Mistidahi, there were a significant ($P < 0.01$) increase with maltodixtrin compared to control.

3.2 Measurement of Syneresis

The results in (Fig. 2) revealed that the syneresis for control full fat fermented milk made by the 3 culture combinations were ranged between 13.37 to 15 % while it was ranged between 15-16% in the control skim milk fermented product. Adding 3% of maltodextrin to the milk fermented by the 3 culture combination decrease the syneresis % to be ranged between 9.25-9.75% in the full fermented milk and 10-11% for the skimmed fermented milk. In the case of polydextrose this value were ranged between 10.62-10.75 in the full fat products and about 11% in the skimmed fermented product respectively. The corresponding value when inulin added, a significant increase in ($\alpha = 0.01$) the syneresis % where 11.25-11.37% and 12.25-12.75 % respectively. It could be concluded that the polysaccharide tested could be arranged according to their effect on decreasing the syneresis asmaltodextrin then polydextrose and finally inulin on which this difference is significant.

Maltodextrin treatments showed the significant lowest syneresis rate comparing to the other treatments specially the culture combination *B. longum ATCC 15707* and *St. thermophilusTexl5842* that was significantly lower than the other 2 culture combinations under maltodextrin treatment where [37] stated that prebiotics added are water-structuring agents, hence act as a thickeners and can form complexes (H-bridge formation) with the protein aggregates in the yoghurt. Similar results were obtained by [18] were they stated that maltodextrin containing ASMD had significantly lower syneresis than the control. Also Syneresis value of polydextrose containing Mistidahi was significantly higher than maltodextrin containing Mistidahi.

Polydextrose treatments followed in the lower syneresis rate which was significantly higher than maltodextrin and significantly lower than the inulin at $\alpha = 0.01$. Similar results were obtained by [27] were they stated that the polydextrose-added samples had lower values than those of the inulin-added ones. This might be due to different structures and chemical compositions of each prebiotic. Polydextrose (DP 12) comprises mainly glucose in its highly branched polymer and with small quantities of sorbitol and citric acid randomly distributed, whereas inulin (DP 23) comprises mainly fructose and possibly with small proportion of glucose in its polymer [38] Thus, polydextrose, due to its shorter chain, might extend their branching structure more evenly into casein aggregates resulting in more extensive protein carbohydrate interactions. This would give the gel with better curd stability as reflected by lower syneresis. Increased syneresis might also be related to porosity of yoghurt [39].

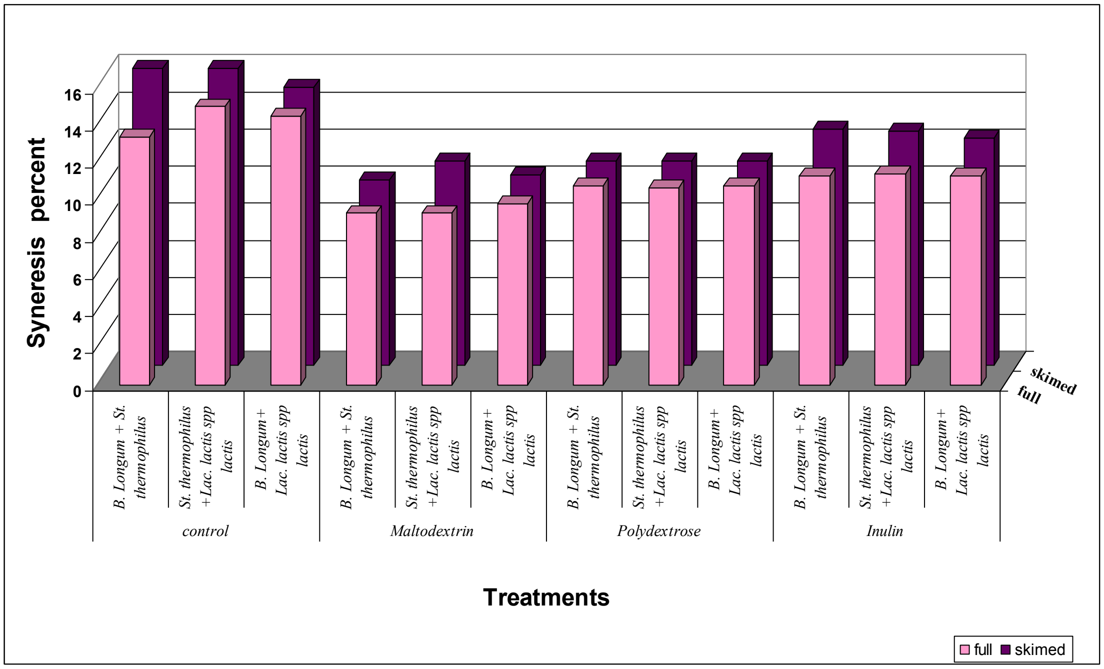

Fig. 2. Determination of syneresis percent for full fat/skimmed fermented milk made with different cultures combinations and polysacchrides after 7 days of storage

Inulin has significantly higher syneresis rate than the maltodextrin and polydextrose but still significantly lower than the control may be due to the high dosage percent (3%) for the inulin addition that was explained by [40,41] were they stated that syneresis may increase with inulin concentration because inulin has a greater affinity for water than starch polysaccharides and as inulin has a lower molecular weight than the starch polymers, water bound to inulin is more mobile and more prone to syneresis.

Same outcome were shown by [42] on which they manufactured fermented milk with 2.5% inulin which gave high syneresis. The sample containing 1.5% inulin had the lowest syneresis, It was also stated that inulin decreased the syneresis in low fat and fat free yoghurt [15,16,14]. On the contrary [37] reported that addition of inulin and FOS to set yoghurt caused significant decrease in syneresis also different results were obtained by [43] were they stated that the 1% inulin addition caused decrease in set type yoghurt syneresis. The most significant decrease in syneresis was observed during refrigerated storage of yoghurt. Also different results obtained by [44] were the addition of inulin reduced the gelation time, and syneresis, with an effect of concentration and chain length. Long chain inulins significantly ($P<0.05$) increased curd yield and decreased syneresis rate ($P < 0.05$) at 1% concentration and most effectively at 3% concentration.

3.3 Effect of Adding 3% of the Selected Polysaccharides on the Viscosity of Full Fat and Skimmed Fermented Milk Products

As shown Fig. (3) it was illustrated that adding a 3% polysaccharide to either full fat and skimmed fermented milk has an significant effect at $\alpha = 0.05$, on increasing the viscosity of the product. Maltodextrin addition revealed a higher viscosity in both full fat and skimmed fermented milk with values of 46526 and 30715 respectively. The high viscosity could be attributed to partial hydrolysis of starch from a variety of initiation and acceleration of maltodextrin gel formation. The outerlinear chains of amylopectin are thought to interact with amylose, thus reducing their self-association, and leading to the formation of a hydrated common network. While the nature of starch hydrolysis and the process used will influence the composition of maltodextrin, the concentration and temperature will affect the formation of gel in aqueous solutions [45].

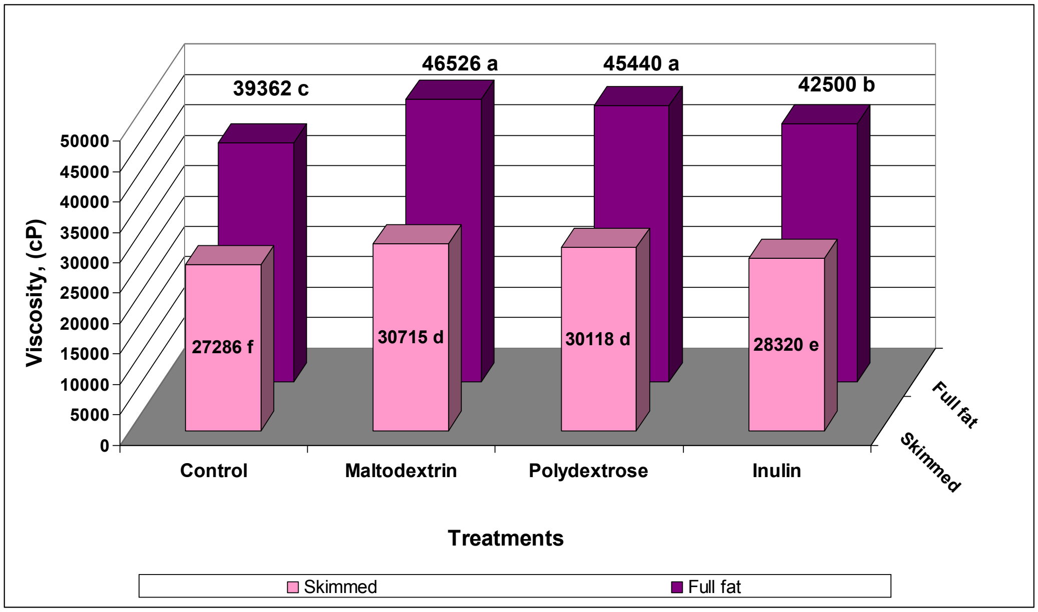

Fig. 3. Effect of adding 3% of the selected polysaccharides on the viscosity of full fat and skimmed fermented milk products

Also, [46] observed that the dissolution temperature has a major influence on gelation behavior and reported that among the temperatures studied the gelation was much faster at (45°C). On the other hand, mechanism of the acid gels formed by the lactic acid fermentation of milk is well established and has been attributed to lowering of pH that reduces the repulsive forces and allows for hydrophobic interactions causing the casein micelles to coagulate [47]. All ingredient were added, and subjected to 85°C for 30 min during pasteurization, with the rise in temperature, the gelation of maltodextrin might have occurred. Further, during incubation with starter cultures, pH of the mix decreased favoring formation of coagulum or gel. In the present study, the higher viscosity and lower syneresis of skimmed and full fat fermented dairy product containing maltodextrin could be attributed to entrapment of water in the gel due to the combined effect of gelation of maltodextrin and milk. On the other hand there were no significant differences between maltodextrin and polydextrose in viscosity results. Although maltodextrin showed a higher viscosity than polydextrose where polydextrose viscosity values in cP were as follows 45440 and 30118 for full fat and skimmed fermented milk, respectively.

Samples with inulin had significant lower viscosity values than maltodextrin and polydextrose counterparts and significantly higher than the control samples at α= 0.05, on which viscosity values were as follows 42500 and 28320 cP respectively. The lowest values were found in the control samples which lack of any polysaccharide, were values of viscosity were as follows 39362 and 27286 cP respectively. Same results were shown by [48] on which they found that the set-type yoghurts added with commercial inulin (0.5 and 1.5 g/100 g) had significantly higher apparent viscosities than the control. Also [18] showed that maltodextrin containing ASMD recorded the highest viscosity value (1.27 Pa s) in comparing to polydextrose, sorbitol and control samples of mistidahi. Also it was reported that viscosity of artificially sweetened frozen dessert increased when maltodextrin and sorbitol were used [49].

Also, [42] demonstrated that the highest viscosity for yoghurt value was for sample containing 2% inulin. The sample containing 1.5% inulin had the lowest viscosity.

On contrary [16] evaluated the effect of three types of inulin with different chain lengths (short, medium and long) on fat-free yoghurt. Inulin chain length did not have any significant effect on viscosity. Also [48] reported that addition of inulin and hi-maize to yoghurt increased viscosity in comparison to the control; however, supplementation with hi-maizes lightly decreased the viscosity of yoghurt during storage at 4°C, whereas inulin showed an increasing trend. Also [50] mentioned that beverages containing polydextrose at a high level and inulin at high and low levels were significantly more viscous than the control ($P < 0.05$). Increasing the concentration of prebiotics, especially inulin, has been shown to increase the viscosity and other mouth feel characteristics of products.

On contrary, [27] listed that addition of 3% polydextrose to a low fat set yoghurt results in lower apparent viscosity than the control samples. But they indicated that Polydextrose, at a suitably chosen level (2 g/100 mL) used in the storage trial, is a soluble polysaccharide capable of forming H-bonds with water. Thus, it could help reduce syneresis and, as being a thickener, it could also increase apparent viscosity of the yoghurt at the beginning of the storage period. However, if the storage time was extended from 14 to 21 days, these two parameters would be adversely affected. Also, [16] found similar results regarding syneresis of the fat free plain yoghurts added with inulins of various chain lengths and revealed that the apparent viscosity decreased with time.

3.4 Effect of Adding Polysaccharides on the Growth Rate of B. longum, Lac. Lactis spp lactis and St. thermophilus

Table (2) illustrate that the viable cells of B. longumATCC 15707 decreased as the storage period at 5-7°C increase either in full fat fermented milk or skimmed fermented milk free of polysaccharides where the mean log_{10}cfu/g for fresh fermented milk was 7.6, 8.03 and 7.2, 6.7 after 7 days of storage. Same findings were obtained by [31,51] who stated that the lactobacillus and bifidobacteria growth declined in their viability during storage. Also [52,53,54] observed that the initial counts of bifidobacteria ranged from 10^6 to 10^7 cfu/ml, while final counts were lower than 10^4 cfu/ml.

From Table (2) we can find out that maltodextrin was dominating all the other polysaccharides on which it exhibited the highest bacterial growth within the bacterial combinations B. longum ATCC 15707 + Lac. Lactissspplactis ATCC 53214, B. Longum ATCC 15707 + St. thermophilus Texl 5842, Where it's log_{10}cfu/g for B. longum ATCC 15707 + lac. lactis. SpplactisATCC 53214 were as follows 9.66, 9.72, 8.09 and 7.68 for full fat fermented milk manufactured in the following durations fresh, 2 days , 4 days and 7 days respectively, and 8.82, 9.19, 8.32 and 7.73 for skimmed fermented milk manufactured in the following durations fresh, 2 days, 4 days and 7 days respectively. And for B. longum ATCC 15707 + St. thermophilus Texl 5842, 8.94, 9.45, 8.54 and 7.59 respectively for full fat fermented milk manufactured in the following durations fresh, 2 days , 4 days and 7 days, and for the skimmed ones were 9.05,9.35,8.94 and 6.30 in the following durations fresh, 2 days, 4 days and 7 days respectively, following the polydextrose where its count was significantly lower than the maltodextrin and significantly higher than the culture combination B. longum ATCC 15707 + lac. lactis. spplactisATCC 53214 under inulin treatment where α=0.01 level of significance and showed no significant difference to culture combination B. Longum ATCC 15707 + St. thermophilusTexl 5842 lying under inulin treatment. The log_{10} cfu/g for the cultures combinations under the polydextrose the B. longum ATCC 15707 + lac. lactis. spplactisATCC 53214 and B. longum ATCC 15707 + St. thermophilusTexl 5842 in full fermented milk 8.77, 8.38, 8.30 and 7.75 , for the former type and 8.51,8.47,7.94 and 7,45 for the latter type in the following durations fresh , 2 , 4 and 7 days respectively. Same case was noticed concerning to skimmed fermented milk. For inulin counterparts log_{10} cfu/g for culture combination B. longum ATCC 15707 + Lac. lactis. spplactisATCC 53214 and B. longum ATCC 15707 + St. thermophilusTexl 5842 in full fermented milk 9.27,9.30,7.70 and 7.12 for the former type and 8.74, 9.05, 8.45 and 7.45 for the latter type in the following durations fresh, 2,4 and 7 days respectively, same trend was noticed in the skimmed fermented milk.

The polysaccharides tested can be arranged in descending according of their assimilation and activation of B. longum ATCC 15707 as maltodextrin then polydextrose and inulin on the bifidobacteria selective media (maltose MRS medium).

The culture combination St. thermophilusTexl 5842 + lac. lactis. spplactisATCC 53214 under the 3 polysaccharides maltodextrin, polydextrsoe and inulin were shown to exhibit a low bacterial count, were significantly lower than the control culture's combinations B. longum ATCC 15707 + lac. lactis. spplactisATCC 53214 and B. longum ATCC 15707+ St. thermophilusTexl 5842.

Polydextrose gave lower levels of growth when compared to maltodextrin. As polydextrose is a randomly-bonded polymer of glucose, where nonlinear structure is more difficult to break down than the linear structure of most prebiotic oligosaccharides that was previously explained by [55,35].

Similar findings showed that higher concentration levels proved to have a beneficial effect on *B. longum*growth in 10% reconstituted milk [30]. [27] also stated that the number of *L. paracasei* were always higher the 8.0 log CFU/ l, by using polydextrose and inulin as a prebiotic source. [16] reported that *L. casei*with the use of prebiotics short DP=5 medium DP= 10 and long DP = 23 of inulin were significantly ($P \leq 0.05$) higher than the control.

Also data agreed with [56,34] who reported that polydextrose were shown to significantly accelerate either the acidification or the fermentation, thus proving interesting prebiotics to improve the production of yoghurts thus these results appear to confirm the prebiotic effect of polydextrose lighted by [36,35].

For inulin similar findings were observed by [34] where they reported that the acidification rate of probiotic cultures increased with inulin concentration increase and reduced fermentation time of *St. thermophilus* Lactobacillus rhamnosus (*L. rhamnosus),* greater acidification was observed when inulin was added. Also [57] reported that addition of inulin showed a better growth and survival ($p<0.05$) than control and they promoted the growth of *bifidobacterium* and *lactobacillus* but not for harmful bacteria as *Esherichia coli* and bacteriods [59-61] reported that the inulin with DP=23 promoted the growth of Lactobacillus plantarum (*L. plantarum)* without promoting the growth of pathogenic bacteria salmonella and *Staphylococcus aureus*, coliform, yeast and molds in white cheese. Same findings by [62,63] they stated that inulin was the least effective in stimulating the growth of bifidobacteria among the used carbohydrate sources Also, [64] stated that inulin do not stimulate the growth of acidophilus in acidophilus *B. longum*-yoghurts. Also Different results was shown by [65] whom highlighted that the lack of bifidobacteria growth was stimulated by feeding rats with diet containing inulin (DP=23). [66] stated that the application of synbiotic cheese failed to exert a significant effect on the gastrointestinal microflora of rats, the statistical insignificant changes observed might be due to the nature of inulin used in the study with a concentration of 2.5%.

Similar results obtained by [42] where they showed that using 2% of inulin in synbiotic yoghurt contain Lactobacillus acidophilus (*L. acidophilus)* and *L. casei*, increased the viability of probiotic bacteria. Also, [48] sited that supplementation of set type yoghurt with prebiotic improved the retention and the viability of *L. acidophilus* and Lactobacillus paracasei (*L. paracasei)* in yoghurt especially in presence of inulin.

Also similar results shown by [43] where they listed that inulin addition to yoghurt cause an increase in the number of all bacteria than the control, where *B. longum*growth reached to 7.5 Log cfu/g. Also [67] stated that the polydextrose were an acceptable vehicle to deliver a probiotic culture in yoghurt drink. Different findings were reported by [34] on which they reported that Polydextrose behaved as the best prebiotic ensuring the highest counts in comparing it with maltodextrin counts, that was a little higher than the control.

On contrary results for inulin where [67] listed that (inulin at a concentration of 1-5%) did not exhibited any significant influence on the survival *L. acidophilus*. Also [68] claimed that Polydextrose hardly showed selective growth towards *Bifidobacterium* and *lactobacillus* when used alone or in combination with other polysaccharides.

3.5 Sensory Evaluation of Full Fat Fermented Milk

Fig. 4 results showed that the addition of polydextrose gave the highest texture and body as well as appearance and color results, on which polydextrose added treatments where significantly higher than the control , but there were no significant difference between polydextrose, maltodextrin and inulin .on which the texture and body as well as the appearance score for the fermented milk made with cultures combination lying under the polydextrose treatment *St. thermophilusTexl 5842 + B. longumATCC 15707*, *B. longumATCC 15707 + lac. lactis. spplactisATCC 53214,* and *lac. lactis. spplactisATCC 53214 + St. thermophilusTexl 5842* were 8.6 and 4, 8.4 and 3.6 and finally 8.4and 3.6 respectively. On the other hand texture and body scores for maltodextrin and inulin treatments revealed an insignificant differences between both of them and also with the control, however their texture scores were higher than the control ones. Where the scores for full fat fermented milk made with maltodextrin and culture combination *B. longumATCC 15707 + lac. lactis. spplactisATCC 53214*, *B. longumATCC 15707 + St. thermophilusTexl 5842* and *St. thermophilusTexl 5842 + lac. lactis. spplactisATCC 53214* were 7.4, 7.2 and 7.4 respectively, while inulin treatments were 7.6,7.4 and 7.2 respectively. Regarding to appearance and color scores there were no significant difference within the results of the 3 added polysaccharides as mentioned previously but the 3 of them were significantly higher than control α= 0.01. The maltodextrin treatments for *B. longumATCC 15707 + lac. lactis. spplactisATCC 53214*, *B. longumATCC 15707 + St. thermophilusTexl 5842* and *St. thermophilusTexl 5842+ lac. lactis. spplactisATCC 53214* values were 3.4 for all of them, while in case of inulin treatments the values were 3.4 for the 3 treatments examined. Control treatments values were 6.8, 6.4 and 6.6 for texture and for appearance 2.4, 2.4 and 2.4 respectively. The flavor sores showed insignificant differences within all treatments. On contrary to our results many studies have mentioned the effect of inulin in modifying the sensory attributes for dairy products [50], where they illustrated that inulin have the ability to be a fat substitute, bulking agent, low-calorie sweetener and texture modifier when added to yoghurt, therefore potentially altering the sensory perception of the product. Also [69], found that yoghurt containing inulin had a good flavor and a smooth texture. [42] mentioned that inulin with DP 25 showed a good and significant texture scores than the control as well as the flavor. Also, [13] studied effect of inulin as a dietary fiber, positive sensory, sensory and textural attributed were found in cow's milk full-fat dairy dessert fortified, with 1.1% inulin. [28], reported that the addition of high molecular-weight inulins (DP ≥ 23) at 1, 2 and 3% negatively affect the quality of set-type low-fat yoghurt. More than 1% inulin negatively affected tyrosine and volatile fatty acid levels, appearance, color, taste, consistency and aroma of the yoghurt. Inulin have been used to improve the texture attributes in ice cream samples mentioned by [70,71].

Inulin when tested its compatibility with probiotic bacterial growth, the addition of probiotic bacteria and inulin did not change taste or texture of the cottage cheese after 15 days of storage at 5°C in comparison with the control non-probiotic cheese [72] For flavor scores there were different results listed by [73] where he mentioned that synbiotic ice-cream made with inulin had a stronger sour after taste than control. Polydextrose results coincide with those obtained by [74,32] whom illustrated that sensory evaluation of functional white soft cheese behaved the same trend in all cheese treatments, as gradual enhancement was noticed during the first 20 days of the refrigeration period. Also it was reported that polydextrose provided excellent bulking ability in terms of texture in sweetened frozen dessert [75].

On contrary [76] showed that maltodextrin improved the body and texture score ($p< 0.05$) of ASMD compared with other bulking agents batches. Maltodextrins are frequently complex mixtures of molecular species ranging from glucose to long polymeric (linear and branched) chains [77]. Saccharides, oligosaccharides and polysaccharides form complexes with proteins and lipids which are known to contribute to the texture of food stuffs, the increased body and texture scores of maltodextrin containing ASMD could be due to the water binding capacity of low molecular weight polymers (dextrins) present in maltodextrin [78].

3.6 Sensory Evaluation of Skimmed Fermented

As shown in Fig. (5), thesensory evaluation for the control samples of skimmed fermented milk revealed lower score for texture when compared to full fat fermented milk and that was ranged between 4, 4.5 and 6.4, 6.8 respectively. Maltodextrin treatments (3%) in the skimmed fermented milk was significantly higher than the inulin and control treatments in texture and body, where the score of cultures combination lying beneath maltodextrin were 7, 6.4 and 6.4 respectively for *B. longum ATCC 15707+ lac. lactis. Spplactis ATCC 53214*, *B. longum ATCC 15707 + St. thermophilusTexl 5842* and *St. thermophilus Texl 5842 + lac. lactis.*

Spplactis ATCC 53214. These results were nearly as the control results for the full fat fermented milk, whereas there is no significant difference between it and the culture combination lying beneath the polydextrose treatment which had the following values 6.4,6.4 and 6.5 for *B. longumATCC 15707 + lac. lactis. spplactisATCC 53214*, *B. longumATCC 15707 + St. thermophilusTexl 5842* and *St. thermophilusTexl 5842 + lac. lactis. spplactisATCC 53214*, respectively. Corresponding texture values for inulin treatment were 5.4 for *B. longumATCC 15707 + lac. lactis. spplactisATCC 53214*, *B. longumATCC 15707 + St. thermophilusTexl 5842* and *St. thermophilusTexl 5842 + lac. lactis. spplactisATCC 53214*on which it's results significantly higher than the control.

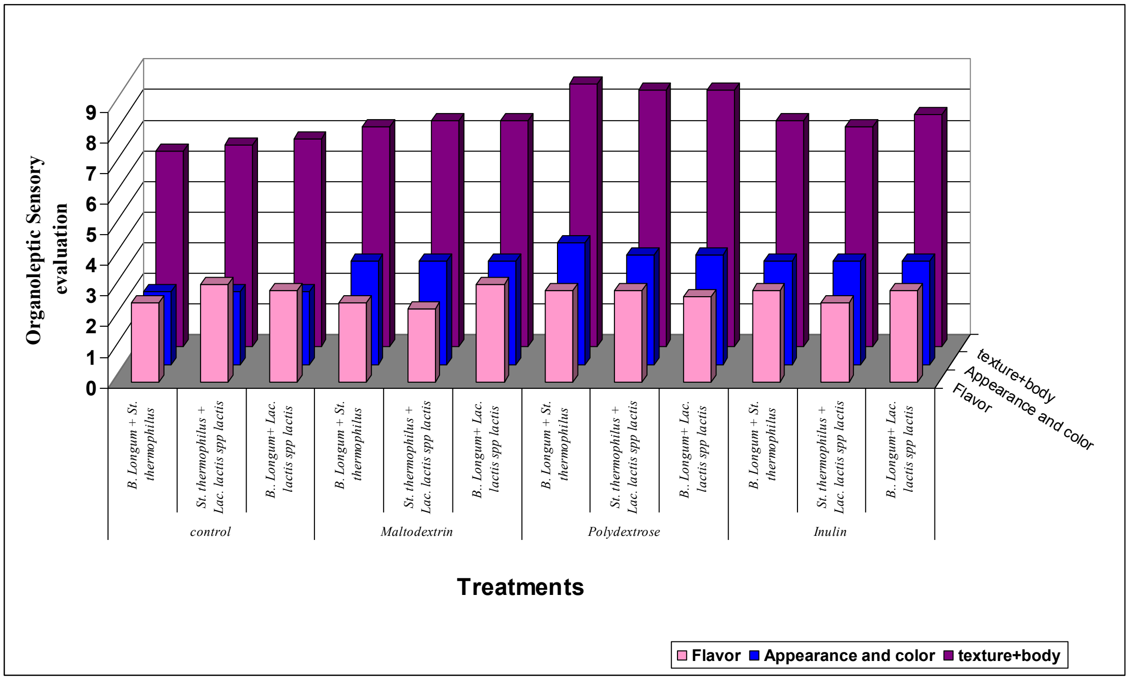

Fig. 4. Sensory evaluation of full fat fermented milk manufactured with different culture combinations and polysaccharides after 7 days of cold storage

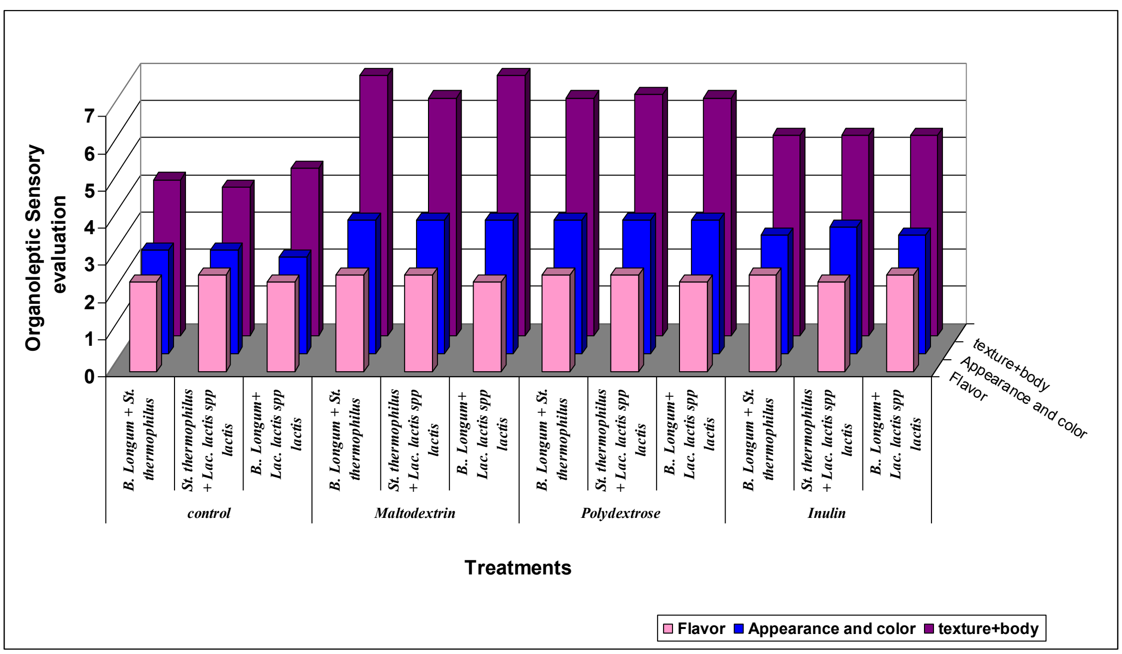

Fig. 5. Sensory evaluation of skimmed fermented milk manufactured with different culture combinations and polysaccharides after 7 days of cold storage

Table 1. Changes in pH and total acidity of full fat and skimmed fermented milk made with different cultures combinations and the selected polysaccharides mean±?? Standard error? 2 digits will be sufficient after ±

Treatments			**pH value**				**Titratable acidity**			
			Full fat fermented milk	**Skimmed fermented milk**	**Mean Treatment**	**Times**	**Full fat fermented milk**	**Skimmed fermented milk**	**Mean Treatment**	**Times**
B. Longum ATCC 15707 +St. thermophilusTexl 5842	**Control**	**Fresh**	4.68±0.01	4.70±0.01	4.53 ^{a}	4.65 ^{a}	1.00±0.07	1.01±0.07	1.10 ^{c}	1.01 ^{d}
		2 days	4.60± 0.00	4.66±0.01		4.63 ^{b}	1.10±0.00	1.05±0.07		1.07 ^{c}
		4 days	4.46±0.01	4.48±0.01		4.47 ^{c}	1.10±0.00	1.10±0.00		1.10 ^{b}
		7 days	4.32±0.01	4.37±0.01		4.34 ^{d}	1.25±0.07	1.20±0.07		1.22 ^{a}
	Maltodextrin	**Fresh**	4.29± 0.01	4.32±0.01	4.25 ^{d}	4.30 ^{a}	1.17± 0.00	1.16± 0.00	1.26 ^{a}	1.16 ^{d}
		2 days	4.25±0.01	4.27±0.00		4.26 ^{b}	1.25±0.14	1.25±0.14		1.25 ^{c}
		4 days	4.23±0.01	4.24±0.01		4.23 ^{c}	1.32±0.00	1.33± 0.00		1.31 ^{b}
		7 days	4.20±0.02	4.22±0.01		4.21 ^{d}	1.30± 0.00	1.31±0.00		1.30 ^{a}
	Polydextrose	**Fresh**	4.52±0.01	4.45±0.21	4.36 ^{b}	4.48 ^{a}	1.10±0.00	1.10±0.00	1.19 ^{b}	1.10 ^{d}
		2 days	4.48±0.01	4.42±0.21		4.45 ^{b}	1.20±0.07	1.19± 0.07		1.19 ^{c}
		4 days	4.29±0.02	4.30±0.01		4.29 ^{c}	1.22±0.07	1.22± 0.07		1.22 ^{b}
		7 days	4.20±0.03	4.32±0.01		4.26 ^{d}	1.27±0.06	1.26± 0.06		1.26 ^{a}
	Inulin	**Fresh**	4.31±0.01	4.33±0.01	4.28 ^{c}	4.32 ^{a}	1.15±0.00	1.16± 0.00	1.20 ^{b}	1.15 ^{d}
		2 days	4.29±0.01	4.30±0.01		4.29 ^{b}	1.22± 0.14	1.22± 0.14		1.22 ^{c}
		4 days	4.26±0.01	4.28±0.01		4.27 ^{c}	1.26± 0.14	1.27±0.14		1.26 ^{b}
		7 days	4.22±0.03	4.26±0.03		4.24 ^{d}	1.30±0.0	1.31±0.00		1.30 ^{a}
St. thermophilusTexl 5842+Lac. lactissplactis ATCC 53214	**Control**	**Fresh**	4.7 ±0.01	4.77±0.01	4.59 ^{a}	4.70 ^{a}	0.90±0.07	1.00± 0.07	1.12 ^{e}	0.95 ^{d}
		2 days	4.68±0.01	4.74±0.01		4.71 ^{b}	1.03±0.07	1.03± 0.07		1.03 ^{c}
		4 days	4.50±0.01	4.55±0.01		4.52 ^{c}	1.18±0.14	1.19± 0.14		1.18 ^{b}
		7 days	4.35±0.01	4.42±0.01		4.38 ^{d}	1.32±0.07	1.30± 0.07		1.31 ^{a}
	Maltodextrin	**Fresh**	4.30±0.01	4.33±0.01	4.27 ^{d}	4.31 ^{a}	1.03±0.07	1.04±0.07	1.17 ^{d}	1.03 ^{d}
		2 days	4.27±0.01	4.31±0.01		4.29 ^{b}	1.06 ±0.07	1.05±0.07		1.05 ^{c}
		4 days	4.26±0.01	4.29±0.01		4.27 ^{c}	1.20±0.07	1.23±0.07		1.21 ^{b}
		7 days	4.22±0.01	4.25±0.01		4.23 ^{d}	1.38±0.00	1.37±0.00		1.37 ^{a}
	Polydextrose	**Fresh**	4.52±0.02	4.55±0.02	4.38 ^{b}	4.53 ^{a}	0.97±0.00	0.98±0.00	1.14 ^{de}	0.97 ^{d}
		2 days	4.48±0.2	4.53±0.02		4.50 ^{b}	1.04±0.00	1.05± 0.00		1.04 ^{c}
		4 days	4.29±0.01	4.30±0.01		4.29 ^{c}	1.22±0.07	1.23±0.07		1.22 ^{b}
		7 days	4.20±0.03	4.22±0.01		4.21 ^{d}	1.35±0.00	1.35±0.00		1.35 ^{a}
	Inulin	**Fresh**	4.34±0.01	4.35±0.01	4.30 ^{c}	4.34 ^{a}	0.99±0.00	0.98±0.00	1.14 ^{de}	0.98 ^{d}
		2 days	4.30±0.01	4.33±0.01		4.31 ^{b}	1.05±0.00	1.02± 0.00		1.03 ^{c}
		4 days	4.27±0.03	4.30±0.01		4.28 ^{c}	1.20±0.00	1.22±0.07		1.21 ^{b}
		7 days	4.23±0.01	4.24±0.01		4.23 ^{d}	1.36±0.00	1.35±0.00		1.35 ^{a}

Table 2. Changes in (Log_{10}cfu/g) of fresh full fat and skimmed fermented milk during storage at 5-7°C for 7 days made with bifidobacteria and strains of lactic acid cultures and 3% of selected polysaccharides on bifidobacteria selective media

Culture			Log_{10}cfu/g viable cell count		Mean	
			Full fat fermented milk	**Skimmed fermented milk**		
B. longum ATCC 15707 +St. thermophilusTexl 5842	**Control**	**Fresh**	7.42	7.88	7.65 [a]	7.44 [d]
		2 days	7.17	7.49	7.33 [c]	
		4 days	7.61	7.47	7.54 [b]	
		7 days	7.31	7.18	7.24 [d]	
	Maltodextrin	**Fresh**	8.94	9.05	8.99 [a]	8.53 [ab]
		2 days	9.45	9.35	9.40 [b]	
		4 days	8.54	8.94	8.69 [c]	
		7 days	7.59	6.30	6.94 [d]	
	Polydextrose	**Fresh**	8.51	9.08	8.79 [b]	8.47 [b]
		2 days	8.47	9.37	8.92 [a]	
		4 days	7.95	8.91	8.43 [c]	
		7 days	7.45	8.08	7.76 [d]	
	Inulin	**Fresh**	8.74	8.75	8.74 [b]	8.43 [b]
		2 days	9.05	8.54	8.79 [a]	
		4 days	8.45	7.87	8.16 [c]	
		7 days	7.45	8.00	7.72 [d]	
St. thermophilusTexl 5842+ Lac. lactissplactis ATCC 53214	**Control**	**Fresh**	5.46	4.00	4.73 [a]	3.20 [f]
		2 days	3.19	3.64	3.41 [b]	
		4 days	2.41	2.96	2.68 [c]	
		7 days	2.14	2.55	2.34 [d]	
	Maltodextrin	**Fresh**	4.76	4.10	4.43 [a]	3.53 [f]
		2 days	2.90	3.99	3.44 [b]	
		4 days	3.17	3.03	3.10 [c]	
		7 days	3.51	2.80	3.15 [d]	
	Polydextrose	**Fresh**	4.35	4.46	4.40 [a]	3.40 [f]
		2 days	3.48	3.75	3.61 [b]	
		4 days	2.67	3.19	2.93 [c]	
		7 days	2.37	2.99	2.68 [d]	
	Inulin	**Fresh**	6.39	3.77	5.08 [a]	3.48 [f]
		2 days	3.49	3.44	3.46 [b]	
		4 days	2.82	3.10	2.96 [c]	
		7 days	2.38	2.49	2.43 [d]	
B. longum ATCC 15707+Lac. lactissplactis ATCC 53214	**Control**	**Fresh**	8.18	7.89	8.03 [a]	7.20 [d]
		2 days	6.85	7.35	7.1 [b]	
		4 days	6.86	6.96	6.91 [c]	
		7 days	6.70	6.75	6.72 [d]	
	Maltodextrin	**Fresh**	9.66	8.82	9.24 [b]	8.60 [a]
		2 days	9.72	9.19	9.45 [a]	
		4 days	8.09	8.32	8.20 [c]	
		7 days	7.68	7.73	7.70 [d]	
	Polydextrose	**Fresh**	8.77	9.38	9.07 [a]	8.43 [b]
		2 days	8.38	8.94	8.66 [b]	
		4 days	8.30	8.98	8.64 [c]	
		7 days	7.75	7.76	7.75 [d]	
	Inulin	**Fresh**	9.27	8.53	8.90 [a]	8.17 [c]
		2 days	9.30	8.01	8.65 [b]	
		4 days	7.70	8.34	8.02 [c]	
		7 days	7.12	7.09	7.10 [d]	
Mean			**6.67 [a]**	**6.62 [a]**		

*Means followed by the same upper case letter(s) are not significant, but different letters are significant according to LSD procedure where α = 0.01, the LSD for treatment = 0.116 and the LSD for duration = 0.018 levels of producer the interaction between type *duration * treatment is NS, the LSD for type *duration is N.S*

Appearance results for polydextrose and maltodextrin show an insignificant differences between them which was 3.6 point out of 5 points these scores were higher than the control of the full fat fermented milk and contributed the highest scores within all the treatments, while the control showed the least score in appearance comparing with Inulin that was significantly higher than the control on which the 3 scores for inulin were 3.2 for *B. longumATCC 15707 + lac. lactis. spplactisATCC*

53214, *B. longumATCC 15707 +St. thermophilusTexl 5842* and *St. thermophilusTexl 5842 + lac. lactis. spplactisATCC 53214*, respectively, for control the results were as follows 2.8,2.8 and 2.6 for *B. longumATCC 15707 + St. thermophilusTexl 5842*, *St. thermophilusTexl 5842+ lac. lactis. spplactisATCC 53214* and *B. longumATCC 15707 + lac. lactis. spplactisATCC 53214*, respectively.

Flavor scores was similar to the full fat fermented milk there were no significant difference between all the treatments. Our results agreed with [79] were they stated that polydextrose is a bulking agent used to provide body and texture in reduced-caloric foods also it was studied as a fat replacer in dairy products [80]. Moreover [81] reported that polydextrose and maltodextrin working as bodying agents in the fat-free ice creams significantly increase flavor release, fattiness, creaminess and melting rate of the ice cream [82] mentioned that polydextrose has a relatively high viscosity in solution so that it can contribute to the mouth feel and creaminess of fat-reduced formulations [83,84,85] stated that long chain inulin would be more ideal as fat mimetic in low fat dairy products such as dairy dessertsand fresh chesses. Furthermore [72] stated that inulin when tested its compatibility with probiotic bacterial growth, the addition of probiotic bacteria and inulin did not change taste or texture of the cottage cheese after 15 days of storage at 5°C in comparison with the control non-probiotic cheese. [77] stated that low-fat cheddar cheese enriched with 5% inulin had improved textural properties Moreover, adding fibers did not impact cheese flavor. On contrary [28] reported that the addition of high molecular-weight inulins (DP ≥ 23) at 1, 2 and 3% negatively affect the quality of set-type low-fat yoghurt. Also, more than 1% inulin negatively affected tyrosine and volatile fatty acid levels, appearance, color, taste, consistency and aroma of the yoghurt. [44] stated that a complete replacement of milk fat 4% inulin in both refrigerated and frozen mousse provided similar textural properties as the control, which is consistent with the findings of [28].

Moreover [44] stated that the addition of inulin regardless of chain length provided positive sensory qualities: Flavor, color consistency, appearance, texture and taste in synbiotic cheeses. Soft white cheese containing 2.5% (w/w) inulin (DP ≥ 23) received the highest texture score. Also [60] worked on Low fat labneh cheese fortified with 1% short chain inulin and probiotic Lactobacillus reuteri (*L. reuteri)* was the most preferred when consumed fresh and after a 10-day storage as it provided the most desirable flavor and a smoother consistency than other samples .

Furthermore [18] stated that the increased body and texture scores of maltodextrin containing mistidahi could be due to the water binding capacity of low molecular weight polymers (dextrins) present in maltodextrin.

Also, [27] stated that the addition of inulin or polydextrose significantly (p 0.05) affected positively appearance, color, texture and overall preference, but no such effect was found for odor or flavor. Also, polydextrose seemed to yield the product with better sensory properties, especially when added at higher levels (2- 3 g/100 mL).

4. CONCLUSION

Maltodextrin showed the best results in increasing bifidobactrial count with a mean 8.53 cfu/g, viscosity was increased by 18% comparing to the inulin treatment which increased it by 7.9% as well. Maltodextrin treatment lowered the synersis by 34% comparing to inulin which lowered the syneresis by 18% also enhancing the organoleptic properties of full fat and skimmed fermented milk compared with inulin, and that is recommended by our study to use it in industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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