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EFFECT OF FORTIFICATION INGREDIENTS ON THE QUALITY OF YOGHURT MADE FROM COW'S MILK

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ABSTRACT: ***Effect of replacing non-fat dry milk that used to fortify cow's milk in making yoghurt with either milk protein concentrate or whey protein concentrate or inulin were studied. Control yoghurt treatment was made from 3.0% fat cow's milk that was fortified with 3.0% non-fat dry milk. Another 12 yoghurt treatments were made by replacing 25, 50, 75 and 100% of non-fat dry with either milk protein concentrate or whey protein concentrate or inulin respectively. Replacement of non-fat dry milk with other ingredients did not affect significantly (0.05) the total solids and fat contents of yoghurt treatments. Protein and ash content increased by replacing non-fat dry milk with milk protein concentrates, while using inulin to replace non-fat dry milk caused a significant decrease in total protein and this increase or decrease was proportional to the rate of replacement. Replacing of non-fat dry milk with milk protein concentrate caused a significant increase in titratable acidity of yoghurt treatments, while replacing of non-fat dry milk with inulin up to 50% increased yoghurt acidity. Increasing the rate of replacing non-fat dry milk with inulin up to 50% increased total volatile fatty acids, while treatments those made using milk protein contrite and whey protein concentrate were not significantly different from control yoghurt treatments. Replacement of non-fat dry milk with either inulin or whey protein concentrate caused a significant reduction in whey syneresis. On the other hand, curd tension of yoghurt increased by replacing non-fat dry milk with either milk protein concentrate or inulin. Yoghurt treatment that made by replacing 50% of non-fat dry milk was the most acceptable yoghurt treatments and were not significantly different from yoghurt treatments those made by replacing 25 and 50% of non-fat dry milk with milk protein concentrate.***

Key words: ***Inulin, non-fat dry milk, milk protein concentrate, whey syneresis, prebiotic.***

INTRODUCTION

Yoghurt is the most popular fermented milk produced in Egypt and worldwide. It has a sharp refreshing acid taste and the typical flavour described as being similar to walnuts. Its consumption in Egypt and the world has been increased tremendously because of using the pure culture applying of modern equipment which resulted in continuous processes

introducing wide range of flavoured yoghurt supplementing the yoghurt flora with probiotics and prebiotics for the purpose of increasing the dietetic value. The value of yoghurt in human nutrition is based not only on the nutritive value of the milk from which it is made and the chemical changes of milk constituents occurring during lactic acid fermentation and increased digestibility, but also the beneficial effect of intestinal microflora particularly in certain conditions, prophylactic and healing effects. Yoghurt has positive healing effect when antibiotic and radiation therapy applied and for people suffering from chronic constipation, diarrhea, colitis, intestinal intoxication, liver and bile disorders. The reduced content of lactose in yoghurt is an important factor for better tolerating yoghurt than ordinary milk by lactose deficient people and persons suffering from galactosaemia formation of the fine cured particles of yoghurt is more easily digested by enzymes than large casein particles of ordinary milk being formed by gastric juice also the presence of lactic acid and culture microflora results in a significant hydrolysis of proteins. Fat in yoghurt is easier to digest than fat in the ordinary milk (Rasic and Kurmam, 1978; Marshall, 1984; Agrebaek *et al*., 1995; Buttress, 1997; Hussein and Kebary, 1999).

Inulin is a linear non-digestible poly saccharide of β-(2-1) linked fructose residues with a terminal glucose residue unit (Tarrega and Costell, 2006). It has been used as fat or sugar replacer, a low caloric bulking agent and a textureising and water binding agent (Tungland and Meyer, 2002 and Kip *et al.,* 2006). Inulin has been shown to induce crucial physiological and nutritional effects such as hyperdiglyceridemia, hypoinsulinemia, improved mineral absorption and stimulation of immune function and reducing colon cancer (Flamm *et al.,* 2001; Bosscher *et al.,* 2006; Huebner *et al.,* 2007; Villegas and Costell, 2007 and Guggisberg *et al.,* 2009). Also, inulin increased the number and activity of probiotic bacteria such as bifidobacteria (Gibson and Roberfroid, 1995; Kebary *et al.,* 2005 and Badawi *et al.,* 2006).

Milk protein concentrate is one of the most used materials for improving firmness, viscosity, solubility and structure of a lot of products specially dairy products (Damin *et al.,* 2010). Milk protein concentrate is made by separating milk into cream and skim milk. The skim milk is fractionated using ultrafiltration to make lactose-reduced skim-concentrate. The skim concentrate can be concerned further by evaporation and spray dried to form a powder. The resultant concentrate contains 40 – 90% milk protein. New Zealand considered the major exporter of milk protein concentrate and totaling about 250 million $ worth of milk protein concentrate imported worldwide.

There is a large amount of whey produced during cheese making in Egypt. Most of them is discharged directly into the sewage system without any treatments. According to the Egyptian environmental law issued recently, dairy effluents should be treated before its drainage into sewage system.

Therefore, recovery of whey proteins can be very important for cheese plant. Whey protein products are considered as important and valuable protein ingredients due to their high nutritional value (Blecker *et al*., 1997) and their unique functional properties including solubility, water binding capacity, gelation, emulsifying and foaming capacity. Whey protein products have been used in the manufacture of cheese, cheese analog, yoghurt, ice cream and beverages (Kebary *et al.,* 1998 and Hussein, 2000). Whey proteins concentrate is used to fortify the cow's milk to produce a good quality yoghurt firmer and less syneresis (Greig and Kan, 1984; Guirguis *et al.,* 1984; Hofi *et al.,* 1995 and Antunes *et al.,* 2004).

It is well known that making yoghurt from cow's milk has a weak body and texture. Therefore, it has been recommended to fortify cow's milk with non-fat dry milk and some stabilizers.

In view of the aforementioned the objectives of these study were to investigate the possibility of partial replacement of non-fat dry milk that used to fortify cow's milk with either milk protein concentrate or inulin or whey protein concentrates during manufacture of yoghurt and to monitor the changes during storage period.

MATERIALS AND METHODS

Bacterial strains and propagation:

Active *Streptococcus salivarius* subsp. *thermophilus* (EMCC 1043) and *Lactobacillus delbrueckii* subsp. *bulgaricus* (EMCC 1102) were obtained from Cairo Mircen, Ain Shams University, Egypt. *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus* were activated individually by three successive transfers in sterile 10% reconstituted non-fat dry milk.

Manufacture of yoghurt:

Fresh cow's milk was obtained from Toch Tanbisha Farm, Faculty of Agriculture, Minoufiya University, Shibin El-Kom, Egypt. Milk was standerized to 3.0% fat. Thirteen yoghurt treatments were made standerized to 3.0% fat content. Preliminary experiment showed that the best yoghurt quality was made by supplementing cow's milk with 3.0% non-fat dry milk. Control treatment (C) was made from 3.0% fat cow's milk supplemented with 3.0% non-fat dry milk (Fresno, California, USA). Four yoghurt treatments were made by replacing 25, 50, 75 and 100% of non-fat dry milk with milk protein concentrate powder (P_1, P_2, P_3 and P_4, respectively) (Dana Foods, USA). Another four yoghurt treatments were made from the same cow's milk but by replacing 25, 50, 75 and 100% of non-fat dry milk with inulin (N_1, N_2, N_3 and N_4, respectively) (Orafti, Tienen, Belgium). The other four yoghurt treatments were made as described previously except that whey protein concentrate powder was used to replace the non-fat dry milk at the rate of 25,

50, 75 and 100% (W_1, W_2, W_3 and W_4, respectively) (Proteint, Mountain Labe, MN, USA). Non-fat dry milk, milk protein concentrate powder, inulin and whey protein concentrate powder were added to milk and stirred thoroughly during heat treatment, then filtered through cheese cloth. All milk treatments were heated to 85°C for 20 min., then cooled to 42°C and inoculated with 1.5% *Streptococcus thermophilus* and 1.5% *Lactobacillus delbuerkii* subsp. *bulgaricus*. The inoculated batches were packed in plastic cups and incubated at 42°C for 3.0 – 3.5 hrs. until complete coagulation. All yoghurt treatments were stored in the refrigerator (6°C $\pm$ 1) for 12 days and were sampled when fresh and at 3, 6, 9 and 12 days for chemical, rheological analysis and sensory evaluation. The whole experiment was triplicated.

Chemical analysis:

pH values, titratable acidity and fat content were determined according to Ling (1963), while total solids, ash and total protein were determined according to the methods described by AOAC (2000). The method of Kosikowski (1966) was used to determine the total volatile fatty acids.

Rheological properties:

Whey syneresis was determined according to the method of Dannenberg and Kessler (1988) with slight modification. Hundred grams of yoghurt in plastic cups were cut into four sections and transferred into a funnel fitted with 120 mesh metal screen. The amount of whey drained into graduated cycinder was measured after 120 min. at room temperature (20 $\pm$ 1°C) for all yoghurt samples stored for 1, 3, 6, 9 and 12 days.

Curd tension of yoghurt was assessed using non destructive Effagi firmness measurements (Effagi, Albonsine, Italy). The penetration depth was 50 mm using a stainless steel plunger flat ended with diameter of 5 mm. Five readings were taken for each yoghurt treatment.

Sensory evaluation:

Yoghurt samples were judged by panelists from the staff members of Dairy Science and Technology Department, Faculty of Agriculture, Minoufiya University. Results were recorded in a score sheet described by (Kebary and Hussein, 1999).

Statistical analysis:

Data were analyzed using completely randomized block design and 2 × 3 factorial design. Newman Keul's test was used to make the multiple comparisons (Steel and Torrie, 1980) using Costat program. Significant differences were determined at $p \leq 0.05$.

RESULTS AND DISCUSSION

Change in titratable acidity of yoghurt are shown in Table (1). Titratable acidity of all yoghurt treatments increased gradually ($p \leq 0.05$) as storage at low temperature period progressed (Table 1). These results are in agreement with those of Harby and El-Sabie (2001), Badawi *et al.* (2004), Kebary *et al.* (2009), Farag *et al.* (2010), Hamed *et al.* (2010) and Kebary *et al.* (2010).Replacement of non-fat dry milk with milk protein concentrate caused a significant increase ($p \leq 0.05$) in titratable acidity (Table 1). These results might be due to the high buffering capacity (acidic effect) of milk protein. This increase was proportional to the rate of replacing non-fat dry milk with milk protein concentrate. On the other hand, yoghurt treatments made with adding whey proteins concentrate were not significantly ($p > 0.05$) different from control yoghurt, which means that replacement of non-fat dry milk with whey proteins concentrate did not have significant effect on titratable acidity of yoghurt (Table 1). Similar trends were reported by Kebary *et al.* (2008) and Kebary *et al.* (2009).

pH values of all yoghurt treatments as affected by replacing non fat dry milk with milk protein concentrate, inulin, whey protein concentrate and storage period followed contradictory trends to that of acidity (Table 1).

Table (2) shows the changes in total solids content of yoghurt treatments during low temperature storage period. All yoghurt treatments were not significantly ($p > 0.05$) different from each other, which means that neither the type nor the concentration of ingredient used to replace the non-fat dry milk in making yoghurt affected significantly the total solids content of the resultant yoghurt (Table 3). Similar results were obtained by Abd El-Baky *et al.* (1981), El-Neshawy and El-Shafie (1988) and Hofi *et al.* (1995). Total solids content of all yoghurt treatments did not change significantly ($p > 0.05$) during low temperature storage period (Table 2). These results are in agreement with those reported by Farag *et al.* (2010), Hamed *et al.* (2010) and Kebary *et al.* (2010).

There were no significant ($p > 0.05$) differences among yoghurt treatments in fat content(Table 2) these results suggested that replacement of non-fat dry milk with either milk protein concentrate or inulin or whey proteins concentrate did not exhibit significant effect ($p > 0.05$) on fat content of the resultant yoghurt treatments. These results are in accordance with those reported by Badawi *et al.* (2008) and Kebary *et al.* (2008). On the other hand, fat content of all yoghurt treatments did not change significantly ($p > 0.05$) as storage period progressed (Table 2). These results are in agreement with those reported by Farag *et al.* (2010), Hamed *et al.* (2010) and Kebary *et al.* (2010).

TABLE 1

TABLE 2

Replacement of non-fat dry milk with milk protein concentrate caused a significant ($p \leq 0.05$) increase in total protein content of the resultant yoghurt. this increase was proportional to the rate of replacement (Table 2). Yoghurt treatment P_4 contained the highest total protein content. These results could be attributed to the higher protein content of milk protein concentrate compared with non-fat dry milk. Similar trends were reported by Kebary *et al.* (2009). On the other hand, replacement of non-fat dry milk with inulin caused a significant ($p \leq 0.05$) reduction in total protein content (Table 2). This decrease was proportional to the rate of replacement. Treatment N_4 contained the lowest protein content. These results could be attributed to the difference of protein content in non-fat dry milk and inulin (Table 2). Yoghurt treatments those made with adding whey proteins concentrate were not significantly ($p > 0.05$) different from each other and control yoghurt, which means that replacement of non-fat dry milk with whey proteins concentrate did not affect significantly the total protein content of the resultant yoghurt treatments (Table 2). These results could be attributed to the similar protein content of both non-fat dry milk and whey proteins concentrate.Total protein content of all yoghurt treatments did not change significantly ($p > 0.05$) as storage period advanced (Table 2). Similar results were reported by Kebary *et al.* (2009) and Kebary *et al.* (2010).

Replacement of non-fat dry milk with milk protein concentrate caused a significant ($p \leq 0.05$) increase in ash content for p3, p4 and control (Table 3), while replacement of non-fat dry milk with either inulin or whey proteins concentrate did not affect significantly ($p > 0.05$) the ash content of the resultant yoghurt treatments (Table 3). Ash content of all yoghurt treatments did not change significantly ($p > 0.05$) as storage period progressed (Table 3). These results are in agreement with those of Kebary and Hussein (1999) and Ibrahim *et al.* (2001).

Total volatile fatty acids content increased significantly ($p \leq 0.05$) in all yoghurt treatments as cold storage progressed (Table 3). Similar results were reported by Kebary *et al.* (2007), Badawi *et al.* (2008) and El-Sonbaty *et al.* (2008). TVFA of all yoghurt treatments increased slightly during the first nine days of storage period, while they increased significantly ($p < 0.05$) during the last three days of storage period. This could be attributed to the lipase activity of lactic acid bacteria. These results are in accordance with those reported by Rasic and Karman (1978) and Guven *et al.* (2005). Replacement of non-fat dry milk with inulin up to 50% increased ($p \leq 0.05$) the TVFA content of the resultant yoghurt treatments (Table 3). These results might be due to the simulation effect of inulin on the growth of lactic acid bacteria and subsequently increasing the lipase activity. Increasing the rate of replacement above 50% did not affect the TVFA content of the resultant yoghurt treatments.

TABLE 3

These results might be due to the increasing of water holding capacity, while affect the water activity and subsequently suppress the growth of yoghurt microflora (Banwart, 1981). There were no significant ($p > 0.05$) differences among treatments those made with adding either milk protein concentrate or whey proteins concentrate and control, which means that neither milk protein concentrate nor whey proteins concentrate affected significantly the TVFA content of the resultant yoghurt treatments (Table 3).

Syneresis from all yoghurt treatments decreased gradually ($p \leq 0.05$) as storage period progressed and reached their minimum values at the 6th day of storage period, then increased up to the end of storage period (Table 4). These results were in agreement with those reported by Farooq and Haque (1992), Kebary and Hussein (1999) and Kebary *et al.* (2009). Replacement of non-fat dry milk with either inulin or whey proteins concentrate caused a significant ($p \leq 0.05$) reduction of whey syneresis (Table 4). There was negative correlation between the rate of replacement and whey syneresis. Similar results were reported by Kebary and Hussein (1999), Guggisberg *et al.* (2009) and Hamed *et al.* (2010). These results might be due to the possible addition of either inulin or WPC leads to form a complex with casein micelles and prevent them from excessive fussion and form a fine meshed gel network which is less susceptible to whey separation and / or increasing the water holding capacity (Danneberg and Kessler, 1988). Yoghurt treatments those made with adding inulin exhibited the least whey separation compared with corresponding yoghurt treatment made with either milk protein concentrate or whey proteins concentrate (Table 4). These results might be probably due to the highest water holding capacity of inulin compared with those of milk protein concentrate and whey proteins concentrate. On the other hand, replacing of non-fat dry milk with milk protein concentrate up to 50% decreased the whey syneresis, while increasing the rate of replacement above that caused a significant ($p \leq 0.05$) increase in whey separation (Table 4). The reduction of whey separation might be due to the higher water holding capacity of milk protein concentrate compared to non-fat dry milk, while the increase of whey syneresis as a result of increasing the rate of replacement above 50% could be attributed to the higher protein content that might form a strong curd which leads to excessive fussion and / or increasing the titratable acidity, those help to contract the curd and subsequently expel the whey from the curd.

Replacement of non-fat dry milk with either milk protein concentrate or inulin increased the curd tension of the resultant yoghurt treatments. Curd tension increased by increasing the rate of replacement (Table 4) yoghurt treatments made with replacing non-fat dry milk with milk protein concentrate exhibited higher curd tension than corresponding yoghurt treatments those made by adding inulin.

TABLE 4

These results might be due to the higher protein content of milk protein concentrate that might trend the form strong curd. On the other hand, replacing non-fat dry milk with whey proteins concentrate caused a significant reduction in curd tension. This reduction was proportional to the rate of replacement (Table 4). These results might be due to the interfere of whey proteins concentrate with casein, which hinder the formation of curd tension.

Scores of organoleptic properties (flavor, body & texture, appearance and acidity) of yoghurt treatments are presented in Table (5). There were no significant ($p > 0.05$) differences among yoghurt treatments in acidity scores, while there were slight differences in both appearance and body & texture (Table 5). Scores of flavor and total scores followed almost similar trends. Replacement of non-fat dry milk with milk protein concentrate up to 50% increased the scores of organoleptic properties, while increasing the rate of replacement above that decreased the organoleptic scores, and conversely related to whey seneresis and curd tension. On the other hand, replacement of non-fat dry milk up to 50% with inulin increased the organoleptic scores of the resultant yoghurt treatments, while increasing the replacement rate more than 50% caused a significant reduction in organoleptic scores (Table 5).. Yoghurt treatments these made with adding whey proteins concentrate were not significantly different from control yoghurt. Yoghurt treatments P_1, P_2 and N_2 which made by replacing non-fat dry milk with 25 and 50% milk protein concentrate and 50% inulin respectively gained the highest score of organoleptic properties. On the other hand, organoleptic scores of all yoghurt treatments did not change significantly ($p > 0.05$) up to the sixth day of storage, then decreased as storage period progressed (Zedan *et al.,* 2001; Kebary *et al.,* 2004; Kebary *et al.,* 2008 and Kebary *et al.,* 2010).

It could be concluded that replacement of non-fat dry milk with milk protein concentrate, inulin, whey proteins concentrate did not affect significantly total solids, fat and ash content of yoghurt treatments. Replacement of non-fat dry milk with inulin decreased whey syneresis. Yoghurt treatments P_1 and P_2 those made by replacing 25 and 50% of non-fat dry milk with milk protein concentrate and N_2 that made by replacing 50% non-fat dry milk with inulin were the most acceptable yoghurt treatment and were not significantly different from each other. N_2 will be used as a control yoghurt in the next part (Part II), not only because it is one of the most acceptable yoghurt treatments, but also because yoghurt treatments which made by adding inulin have lower lactose content and this is very important for lactose intolerant people, also inulin has many beneficial health roles and it considered as prebiotic ingredients.

TABLE 5

REFERENCES

Abdel-Baky, A. A., M. M. Ashour, M. M. Omar and A. A. El-Neshway (1981). Quality of zabadi made from milk fortified with protein concentrate. Research-Bulletin, Fac. of Agric., Ain-Shams Univ., 50: 15.

Agrebaek, M., L. V. Gerdes and B. Richelsen (1995). Hypocholestrol-aemic effect of new fermented milk products in healthy middle-agedmen. Europ. S. Clinical Nutr., 49: 346.

Antunes, A. E. C., A. J. Antunes and H. M. Cardello (2004). Chemical, physical, microstructural and sensory properties of set fat-free yogurts stabilized with whey protein concentrate. Milchwissenschaft, 59 (3/4): 161 – 165. [C.F Dairy Sci. Abst., 2004, 66 (8): 709].

A.O.A.C. (2000). Official Method of the Association of Analytical Chemists. 17th ed. Published by the Association of Official Agriculture Chemists, Washington, D.C.

Badawi, R. M., A. I. Hamed, K. M. K. Kebary and Hweda, A. El-Sayed (2008). Effect of replacing milk fat with fat replacers on the quality of stirred yoghurt. Egyptian, J. Diary Science, 36 (2): 197 – 206.

Badawi, R. M., K. M. K. Kebary and I. I. Badran (2006). Growth and bioactivity of bifidobacteria in camel's milk supplemented with some nutrients. Minufiya J. Agric. Res., 31 (4): 853 – 863.

Badawi, R. M., K. M. K. Kebary and S. A. Hussein (2004). Impact of substituting non-fat dry milk with pictin on cow's milk yoghurt quality. Proc. The 9 th Egyptian Conf. For Dairy Sci. and Techn. pp. 133-151.

Banwart, G. J. (1981). Basic food microbiology, AVI Publishing Company INC., Westport. Connecticut, USA.

Blecker, B. C., J. A. Culbertson, J. A. Partridge and D. M. Smith (1997). Improved emulsifying and foaming of whey proteins after enzymic fat hydrolysis. J. Food Sci., 62 (1): 48 – 52.

Bosscher, D., J. VanLoo and A. Frank (2006). Inulin and oligofructose as functional ingredients to improve bone mineralization. Intr. Dairy J., 16: 1092 – 1079.

Buttress, J. (1997). Nutritional properties of fermented milk products. Int. J. Dairy Technol., 50: 21.

Damin, M.R., M.R. Alcantara, A.P. Nunes and M. N. Oliveira (2010). Effects of milk supplementation with skim milk powder, whey protein concentrate and sodium caseinate on acidification kinetics, rheological properties and structure of nonfat stirred yogurt. Food Sci. and Technol.; 42: 1744 – 1750.

Danneberg, F. and H. G. Kessler (1988). Effect of denaturation of B-lactoglobulin on texture properties of set-type non-fat yoghurt. I. Synersis. Milchwissens Chaft, 43: 632.

El-Neshawy, A. A. and N. M. El-Shafie (1988). Quality of zabadi made from cow's milk fortified with whey and soy protein. Nahrung, 32 (10): 939 – 943. [C.F. Dairy Sci. Abs., 51: 2909].

El-Sonbaty, A. H., K. M. K. Kebary, R. M. Badawi and Hweda, A. El-Sayed (2008). Effect of stabilizers on the quality of stirred yoghurt. Egyptian J. Dairy Sci., 36 (2): 185 – 195.

Farag, Seham, I., K. M. K. Kebary, R. M. Badawi, I. I. Badran and Afaf, Said (2010). Manufacture of probiotic yoghurt from cow's milk fortified with butter milk. Proc. 11th Egyptian Conf. Dairy Sci. & Technol., pp. 447 – 461.

Farooq, K. and Z. U. Haque (1992). Effect of sugar esters on the textural properties of non-fat low calorie yoghurt. J. Dairy Sci., 75: 2676 – 2680.

Flamm, G., W. Glinsmann, D. Kritchevsky, L. Prosky and M. Roberfroid (2001). Inulin and oligofructose as a dietary fiber: A review of the evidence. Critical Rev. Food Sci. and Nut., 41 (5): 353 – 362.

Gibson, G. R. and M. B. Roberfroid (1995). Dietary modulation of the human colonic microbiota: Introducing the concept of prebiotics, J. of Nut., 125: 1401 – 1412.

Greig, R.I.W. and J. Kan (1984). Effect of whey protein concentrate on fermentation of yogurt. Dairy Industries Int., 49 (10): 28 – 29.

Guggisberg, D., J. Cuthbert-Steven, P. Piccinali, U. Bütikofer and P. Eberhard (2009). Rheological, microstructural and sensory characterization of low-fat and whole milk set yoghurt as influenced by inulin addition. Int. Dairy J., 19 (2): 107 – 115.

Guirguis, N., M.C. Broome and M.W. Hickey (1984). The effect of partial replacement of skim milk powder with whey protein concentrate on the viscosity and syneresis of yoghurt. Australian J. Dairy Technol., 39 (1): 33 – 35.

Guven, M., K. Yasar, O. B. Karaca and A. A. Hayaloglu (2005). The effect of inulin as fat replacer on the quality of set-type low-fat yoghurt manufacture. Int. J. of Dairy Technol., 58 (3): 180 – 184.

Hamed, A., K. M. Kebary, R. M. Badawi and Nevein S. Omar (2010). Manufacture of low fat prebiotic yoghurt. Minufiya J. Agric. Res., 35 (1): 157 – 174.

Harby, S. and W. El-Sabie (2001). Studies on skim milk yoghurt using some stabilizers. Proc. 8th Egyptian. Conf. Dairy Sci. and Technol., p. 537.

Hofi, M., MA. Khorshid, SA. Khalil and AA. Ismail (1995). The use of ultrafiltered whey-protein concentrate in the manufacture of zabadi. Egyptian J. Food Sci., 22 (2): 189-200.

Huebner, J., R. L. Wehling and R. W. Hutkins (2007). Functional activity of commercial prebiotics. Int. Dairy J., 17 (7): 770-775.

Hussein, S. A. (2000). Ripening acceleration of low fat Ras cheese made by adding fat replacers. Minufiya J. Agric. Res., 25 (8): 427 – 444.

Hussein, S. A. and K. M. K. Kebary (1999). Improving viability of bifidobacteria by microentrapment and their effect on some pathogenic bacteria in stirred yoghurt. J. Dairy Sci. & Technol., 28 (2) 113 – 131.

Ibrahim, M. K. E., M. A. El-Assar, Sh. G. Osman and W. M. Salama (2001). Manufacture of low fat soft cheese enriched with whey protein concentrate. Egyptian J. Dairy Sci., 29: 107 – 117.

Kebary, K. M. K. and S. A. Hussein (1999). Manufacture of low fat Zabady using different fat substitutes. Acta Alimentaria 28: 1 – 14.

Kebary, K. M. K., R. M. Badawi, I. I. Badran and S. A. Hussein (2005). Influence of some nutrients and bile salt on the production of antimicrobial agents by bifidobacteria. Egyptian J. Dairy Sci., 33: 157 – 170.

Kebary, K. M. K., R. M. Badawi, A. I. Hamed and Nevein S. Omar (2010). Preparation and properties of novel functional yoghurt from buffalo milk. Proc. 11th Egyptian Conf. Dairy Sci. and Technol., pp. 463 – 478.

Kebary, K. M. K., A. H. El-Sonbaty, A. N. Zedan and Hweda, A. El-Sayed (2008). Impact of bifidobacteria on flavoured low fat stirred yoghurt quality. Proc. Of the 3rd Int. Conference on Food Sci. and Nutrition, Cairo, Egypt, November 3 – 5, 2008, pp. 160 – 179.

Kebary, K. M. K., A. I. Hamed, I. I. Badran, S. A. Hussein and A. M. Gaber (2009). Manufacture of yoghurt from cow's milk fortified with trypsin modified whey proteins. Minufiya J. Agric. Res., 34: 1525 – 1537.

Kebary, K. M. K., S. A. Hussein and R. M. Badawi (2004). Impact of fortification of cow's milk with a modified starch on yoghurt quality. Egypt. J. Dairy Sci., 32 (1): 111 – 124.

Kebary, K. M. K., S. A. Hussein, R. M. Badawi and I. I. Badran (2007). Incorporation of bifidobacteria in low fat Labneh. Proc. 10th Egyptian Conf. Dairy Sci. and Technol., pp. 359 – 375.

Kebary, K. M. K., S. Hussein and R. M. Badawi (1998). Improving viabilitty of bifidobacteria and their effect on frozen ice milk. Egyptian J. Dairy Sci. 26: 319-337.

Kip, P., D. Meyer and R. H. Jellema (2006). Inulins improve sensoric and textural properties of low-fat yoghurts. Int. Dairy J., 16 (9): 1098 – 1103.

Kosikowski, F. V. (1966). Cheese and fermented milk foods. 2nd printing. Edward Brothers, Inc., Ann. Arbor., Mi., U.S.A.

Ling, E. R. (1963). A Text Book of dairy Chemistry, Vol. 2 Practical 3rd ed. Chapman & Hall, Ltd., London.

Marshall, V. M. E. (1984). Flavour development in fermented milks. In Advances in the Microbiology and Biochemistry of cheese and fermented

milk, eds. F. L. Davis and B. A. Law. Elsevier Applied Sci. Publisher, London.

Rasic, J. L. and J. A. Kurmann (1978). Yoghurts Scientific Grounds, Technology, Manufacture and Preparations. Technical Dairy Publishing House, Copenhagen, Denmark, pp. 99 – 137.

Steel, R. G. D. and J. H. Torrie (1980). Principles and Procedures of Statistics. A biometrical approach. 2nd Ed. McGraw-Hill Book Co., New York.

Tárrega, A. and E. Costell (2006). Effect of inulin addition on rheological and sensory properties of fat-free starch-based dairy desserts. Int. Dairy J., 16 (9): 1104 – 1112.

Tungland, B. C. and D. Meyer (2002). Nondigestible oligo- and polysaccharides (dietary fiber): Their physiology and role in human health and food Comprehensive Reviews in Food Science and Food Safety, 1: 73 – 92.

Villegas, B. and E. Costell (2007). Flow behaviour of inulin-milk beverages. Influence of inulin average chain length and of milk fat content. Int. Dairy J., 17 (7): 776 – 781.

Zedan, M. A., A. N. Zedan, K. M. K. Kebary and S. F. Mahmoud (2001). Effects of fortification of cow's milk with acetylated whey protein concentrates on the quality of set yoghurt. Egyptian J. Dairy Sci., 29: 285 .

تأثير مواد تدعيم اللبن البقري المستخدم في صناعة اليوجورت على جودته

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الملخص العربي :

يهدف هذا البحث لدراسة إمكانية استبدال اللبن الفرز المجفف المستخدم في تدعيم اللبن البقري أثناء صناعة اليوجورت بواسطة مركزات بروتينات اللبن ، مركزات بروتينات الشرش والإنيولين وتأثير ذلك على صفات اليوجورت الناتج ولذلك فقد تم تصنيع ١٣ معاملة حيث صنعت المعاملة الكنترول القياسية من اللبن البقري المحتوى على ٣% دهن والمدعم بإضافة ٣% من اللبن الفرز المجفف أما ١٢ معاملة الأخرى فقد صنعت باستبدال ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠% من اللبن الفرز المضاف للبن البقري إما بواسطة مركزات بروتينات اللبن أو مركزات بروتينات الشرش أو الإنيولين .

ولقد أوضحت النتائج المتحصل عليها بعد تحليلها إحصائياً ما يلي :

- **لم يُؤثر استبدال اللبن الفرز المجفف بواسطة المواد السابق ذكرها على نسب كل من الجوامد الصلبة الكلية والدهن لليوجورت .**
- **ازدادت نسب كل من البروتين الكلى والرماد عند استبدال اللبن الفرز المجفف بواسطة مركزات بروتينات اللبن فى حين انخفضت نسبة البروتين عند استبدال اللبن الفرز المجفف بواسطة الإنيولين وازداد هذا التأثير بزيادة معدل الاستبدال .**
- **ازدادت حموضة اليوجورت عند استبدال اللبن الفرز المجفف بواسطة مركزات بروتينات اللبن فى حين ازدادت الحموضة عند استخدام الإنيولين حتى ٥٠% استبدال.**
- **أدى استبدال اللبن الفرز المجفف بواسطة الإنيولين حتى نسبة استبدال ٥٠% إلى زيادة كمية الأحماض الدهنية الطيارة الكلية ولم تختلف المعاملات المصنعة باستبدال اللبن الفرز المجفف**

سواء بمركزات بروتينات اللبن أو مركزات بروتينات الشرش عن بعضها البعض وعن المعاملة الكنترول .

- أدى استبدال اللبن الفرز المجفف سواء بمركزات بروتينات اللبن أو بروتينات الشرش إلى انخفاض نسبة انفصال الشرش فى حين ازدادت قوة الخثرة عند استبدال اللبن الفرز المجفف بمركزات بروتينات الشرش .
- حصلت العينة المصنعة باستبدال ٥٠% من اللبن الفرز المجفف بالإنيولين على أعلى الدرجات وكانت أكثر العينات قبولاً ولم تختلف عن المعاملات المصنعة باستبدال ٢٥ ، ٥٠% من اللبن الفرز المجفف بواسطة مركزات بروتينات اللبن .

تأثير مواد تدعيم اللبن البقري المستخدم في صناعة اليوجورت على جودته

كمال محمد كمالي – خميس محمد كامل كعباري – على حسن السنباطى – خديجة رجب محمد بدوى

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ولقد أوضحت النتائج المتحصل عليها بعد تحليلها إحصائياً ما يلي :

- لم يُؤثر استبدال اللبن الفرز المجفف بواسطة المواد السابق ذكرها على نسب كل من الجوامد الصلبة الكلية والدهن لليوجورت .
- ازدادت نسب كل من البروتين الكلى والرماد عند استبدال اللبن الفرز المجفف بواسطة مركزات بروتينات اللبن فى حين انخفضت نسبة البروتين عند استبدال اللبن الفرز المجفف بواسطة الإنيولين وازداد هذا التأثير بزيادة معدل الاستبدال .
- ازدادت حموضة اليوجورت عند استبدال اللبن الفرز المجفف بواسطة مركزات بروتينات اللبن فى حين ازدادت الحموضة عند استخدام الإنيولين حتى ٥٠% استبدال.
- أدى استبدال اللبن الفرز المجفف بواسطة الإنيولين حتى نسبة استبدال ٥٠% إلى زيادة كمية الأحماض الدهنية الطيارة الكلية ولم تختلف المعاملات المصنعة باستبدال اللبن الفرز المجفف سواء بمركزات بروتينات اللبن أو مركزات بروتينات الشرش عن بعضها البعض وعن المعاملة الكنترول .
- أدى استبدال اللبن الفرز المجفف سواء بمركزات بروتينات اللبن أو بروتينات الشرش إلى انخفاض نسبة انفصال الشرش فى حين ازدادت قوة الخثرة عند استبدال اللبن الفرز المجفف بمركزات بروتينات الشرش .
- حصلت العينة المصنعة باستبدال ٥٠% من اللبن الفرز المجفف بالإنيولين على أعلى الدرجات وكانت أكثر العينات قبولاً ولم تختلف عن المعاملات المصنعة باستبدال ٢٥ ، ٥٠% من اللبن الفرز المجفف بواسطة مركزات بروتينات اللبن .

Table (1): Effect of replacing non-fat dry milk with milk protein concentrate, whey proteins concentrate and inulin on titratable acidity and pH values of yoghurt treatments during refrigerated storage (6°C + 1).

Yoghurt treatments	Titratable acidity (%)					pH values				
	Storage period (days)					Storage period (days)				
	0	3	6	9	12	0	3	6	9	12
C*	$0.91^{Ce\bullet}$	0.97^{Cd}	1.00^{Cc}	1.08^{Cb}	1.21^{Ca}	4.69^{Ba}	4.57^{Bb}	4.49^{Bc}	4.41^{Bd}	4.33^{Be}
P_1	0.92^{Ce}	1.00^{Cd}	1.08^{Cc}	1.16^{Cb}	1.23^{Ca}	4.64^{Ca}	4.53^{Cb}	4.45^{Cc}	4.36^{Cd}	4.27^{Ce}
P_2	0.93^{BCe}	1.01^{BCd}	1.07^{BCc}	1.18^{BCb}	1.27^{BCa}	4.63^{Ca}	4.57^{Cb}	4.51^{Cc}	4.42^{Cd}	4.32^{Ce}
P_3	0.95^{Be}	1.00^{Bd}	1.08^{Bc}	1.16^{Bb}	1.29^{Ba}	4.62^{Ca}	4.50^{Cb}	4.43^{Cc}	4.34^{Cd}	4.35^{Ce}
P_4	0.96^{Ae}	0.99^{Ad}	1.05^{Ac}	1.18^{Ab}	1.30^{Aa}	4.63^{Ca}	4.59^{Cb}	4.53^{Cc}	4.44^{Cd}	4.36^{Ce}
N_1	0.94^{BCe}	1.03^{BCd}	1.14^{BCc}	1.29^{BCb}	1.31^{BCa}	4.63^{Ca}	4.51^{Cb}	4.45^{Cc}	4.37^{Cd}	4.28^{Ce}
N_2	0.96^{Ae}	1.09^{Ad}	1.18^{Ac}	1.28^{Ab}	1.31^{Aa}	4.61^{Da}	4.48^{Db}	4.51^{Dc}	4.43^{Dd}	4.31^{De}
N_3	0.94^{BCe}	1.00^{BCd}	1.06^{BCc}	1.14^{BCb}	1.28^{BCa}	4.66^{BCa}	4.54^{BCb}	4.49^{BCc}	4.40^{BCd}	4.29^{BCe}
N_4	0.88^{CDe}	0.92^{CDe}	0.98^{CDc}	1.06^{CDb}	1.23^{CDa}	4.71^{Aa}	4.62^{Ab}	4.57^{Ac}	4.49^{Ad}	4.40^{Ae}
W_1	0.90^{Ce}	0.95^{Cd}	1.04^{Cc}	1.15^{Cb}	1.18^{Ca}	4.67^{BCa}	4.63^{BCb}	4.55^{BCc}	4.46^{BCd}	4.38^{BCe}
W_2	0.91^{Ce}	1.01^{Cd}	1.04^{Cc}	1.15^{Cb}	1.23^{Ca}	4.68^{BCa}	4.59^{BCb}	4.52^{BCc}	4.43^{BCd}	4.31^{Bce}
W_3	0.91^{Ce}	0.92^{Cd}	1.03^{Cc}	1.13^{Cb}	1.21^{Ca}	4.67^{BCa}	4.62^{BCb}	4.58^{BCc}	4.50^{BCd}	4.40^{Bce}
W_4	0.91^{Ce}	1.00^{Cd}	1.05^{Cc}	1.13^{Cb}	1.25^{Ca}	4.69^{BCa}	4.56^{BCb}	4.50^{BCc}	4.42^{BCd}	4.33^{Bce}

*C: Yoghurt treatment made with adding 3.0% non-fat dry milk.

P_1, P_2, P_3 and P_4: Yoghurt treatments made with replacing 25, 50, 75 and 100% of non-fat dry milk with milk protein concentrate, respectively.

N_1, N_2, N_3 and N_4: Yoghurt treatments made with replacing 25, 50, 75 and 100% of non-fat dry milk with inulin, respectively.

W_1, W_2, W_3 and W_4: Yoghurt treatments made with replacing 25, 50, 75 and 100% of non-fat dry milk with whey protein, respectively.

• A, B, …: The means with the different capital letters within the same column are significantly different ($p \leq 0.05$) unhile the different small (a,b) letters within the same row are significantly different ($p > 0.05$).

Table (2): Effect of replacing non-fat dry milk with milk protein concentrate, whey proteins concentrate and inulin on total solids, fat and total protein contents of yoghurt treatments during refrigerated storage (6°C + 1).

Yoghurt treatments	Total solids content (%)					Fat content (%)					Total protein content (%)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
C*	12.76$^{Aa\bullet}$	12.72^{Aa}	12.79^{Aa}	12.75^{Aa}	12.78^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.2^{Aa}	3.1^{Aa}	3.85^{Ea}	3.82^{Ea}	3.86^{Ea}	3.88^{Ea}	3.90^{Ea}
P_1	12.93^{Aa}	12.96^{Aa}	12.92^{Aa}	12.92^{Aa}	12.93^{Aa}	3.1^{Aa}	3.1^{Aa}	3.0^{Aa}	3.0^{Aa}	3.0^{Aa}	4.15^{Da}	4.13^{Da}	4.14^{Da}	4.17^{Da}	4.15^{Da}
P_2	12.91^{Aa}	12.96^{Aa}	12.98^{Aa}	12.96^{Aa}	12.92^{Aa}	3.0^{Aa}	3.0^{Aa}	3.1^{Aa}	3.1^{Aa}	3.1^{Aa}	4.45^{Ca}	4.47^{Ca}	4.47^{Ca}	4.46^{Ca}	4.45^{Ca}
P_3	12.86^{Aa}	12.81^{Aa}	12.88^{Aa}	12.91^{Aa}	12.89^{Aa}	3.0^{Aa}	3.1^{Aa}	3.1^{Aa}	3.0^{Aa}	3.1^{Aa}	4.75^{Ba}	4.77^{Ba}	4.76^{Ba}	4.78^{Ba}	4.75^{Ba}
P_4	12.62^{Aa}	12.60^{Aa}	12.58^{Aa}	12.53^{Aa}	12.59^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.1^{Aa}	3.1^{Aa}	5.05^{Aa}	5.04^{Aa}	5.04^{Aa}	5.05^{Aa}	5.07^{Aa}
N_1	12.97^{Aa}	12.94^{Aa}	12.99^{Aa}	12.98^{Aa}	12.96^{Aa}	3.1^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.2^{Aa}	3.65^{EFa}	3.65^{EFa}	3.67^{EFa}	3.68^{EFa}	3.67^{EFa}
N_2	13.01^{Aa}	12.97^{Aa}	12.98^{Aa}	13.02^{Aa}	13.02^{Aa}	3.0^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.2^{Aa}	3.40^{Fa}	3.45^{Fa}	3.41^{Fa}	3.44^{Fa}	3.48^{Fa}
N_3	12.96^{Aa}	12.92^{Aa}	12.94^{Aa}	12.97^{Aa}	12.95^{Aa}	2.9^{Aa}	3.0^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.15^{Ga}	3.17^{Ga}	3.19^{Ga}	3.14^{Ga}	3.15^{Ga}
N_4	12.82^{Aa}	12.86^{Aa}	12.87^{Aa}	12.85^{Aa}	12.87^{Aa}	3.1^{Aa}	3.1^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.05^{Ha}	3.08^{Ha}	3.98^{Ha}	3.06^{Ha}	3.00^{Ha}
W_1	12.72^{Aa}	12.75^{Aa}	12.71^{Aa}	12.79^{Aa}	12.75^{Aa}	3.1^{Aa}	3.2^{Aa}	3.2^{Aa}	3.1^{Aa}	3.0^{Aa}	3.82^{Ea}	3.81^{Ea}	3.84^{Ea}	3.82^{Ea}	3.79^{Ea}
W_2	12.87^{Aa}	12.83^{Aa}	12.89^{Aa}	12.90^{Aa}	12.90^{Aa}	3.0^{Aa}	3.1^{Aa}	3.1^{Aa}	3.0^{Aa}	2.9^{Aa}	3.80^{Ea}	3.81^{Ea}	3.80^{Ea}	3.76^{Ea}	3.76^{Ea}
W_3	12.93^{Aa}	12.98^{Aa}	12.99^{Aa}	12.95^{Aa}	12.92^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.1^{Aa}	3.0^{Aa}	3.90^{Ea}	3.92^{Ea}	3.89^{Ea}	3.92^{Ea}	3.91^{Ea}
W_4	12.75^{Aa}	12.72^{Aa}	12.71^{Aa}	12.78^{Aa}	12.75^{Aa}	3.0^{Aa}	3.1^{Aa}	3.1^{Aa}	3.2^{Aa}	3.1^{Aa}	3.94^{Ea}	3.93^{Ea}	3.93^{Ea}	3.96^{Ea}	3.95^{Ea}

***, ● See Table (1).**

Table (3): Effect of replacing non-fat dry milk with milk protein concentrate, whey proteins concentrate and inulin on ash content and total volatile fatty acids (TVFA) of yoghurt treatments during refrigerated storage (6°C + 1).

Yoghurt treatments	Ash content (%)					Total volatile fatty acids (ml NaOH 0.1 N/100 gm)				
	Storage period (days)					Storage period (days)				
	0	3	6	9	12	0	3	6	9	12
C*	0.97$^{Ba\bullet}$	0.99^{Ba}	1.01^{Ba}	0.99^{Ba}	1.01^{Ba}	13.30^{Cd}	13.90^{Ccd}	14.00^{Cbc}	14.60^{Cb}	15.50^{Ca}
P_1	0.98^{Ba}	1.00^{Ba}	1.02^{Ba}	1.01^{Ba}	0.99^{Ba}	13.20^{Cd}	13.80^{Ccd}	14.10^{Cbc}	14.40^{Cb}	14.50^{Ca}
P_2	0.99^{Ba}	1.01^{Ba}	1.02^{Ba}	0.99^{Ba}	1.01^{Ba}	13.20^{Cd}	13.70^{Ccd}	13.90^{Cbc}	14.30^{Cb}	14.30^{Ca}
P_3	1.04^{Aa}	1.05^{Aa}	1.07^{Aa}	1.09^{Aa}	1.07^{Aa}	13.30^{Cd}	13.80^{Ccd}	13.90^{Cbc}	14.50^{Cb}	14.80^{Ca}
P_4	1.06^{Aa}	1.07^{Aa}	1.09^{Aa}	1.07^{Aa}	1.10^{Aa}	13.10^{Cd}	13.70^{Ccd}	13.80^{Cbc}	14.60^{Cb}	14.80^{Ca}
N_1	0.99^{Ba}	1.02^{Ba}	1.03^{Ba}	1.01^{Ba}	1.02^{Ba}	13.30^{ABd}	14.20^{ABcd}	14.90^{ABbc}	15.60^{ABb}	16.90^{ABa}
N_2	0.98^{Ba}	0.98^{Ba}	1.00^{Ba}	1.02^{Ba}	1.02^{Ba}	13.20^{Ad}	14.50^{Acd}	14.60^{Abc}	14.90^{Ab}	16.00^{Aa}
N_3	0.97^{Ba}	0.98^{Ba}	0.97^{Ba}	0.99^{Ba}	1.02^{Ba}	13.40^{BCd}	14.00^{BCcd}	14.30^{BCbc}	14.70^{BCb}	15.01^{BCb}
N_4	0.95^{Ba}	0.97^{Ba}	0.99^{Ba}	0.96^{Ba}	0.94^{Ba}	13.30^{Cd}	13.90^{Ccd}	14.10^{Cbc}	14.60^{Cb}	15.00^{Ca}
W_1	0.97^{Ba}	0.99^{Ba}	0.98^{Ba}	1.01^{Ba}	1.01^{Ba}	13.10^{Cd}	13.70^{Ccd}	13.80^{Cbc}	14.40^{Cb}	14.80^{Ca}
W_2	0.99^{Ba}	1.01^{Ba}	1.01^{Ba}	1.02^{Ba}	1.01^{Ba}	13.30^{Cd}	13.70^{Ccd}	13.80^{Cbc}	14.50^{Cb}	14.70^{Ca}
W_3	0.99^{Ba}	1.02^{Ba}	1.02^{Ba}	1.01^{Ba}	1.03^{Ba}	13.20^{Cd}	13.80^{Ccd}	13.90^{Cbc}	14.40^{Cb}	14.60^{Ca}
W_4	0.99^{Ba}	0.98^{Ba}	0.98^{Ba}	0.99^{Ba}	1.01^{Ba}	13.30^{Cd}	13.90^{Ccd}	14.10^{Cbc}	14.30^{Cb}	14.60^{Ca}

*, ● See Table (1).

Table (4): Effect of replacing non-fat dry milk with milk protein concentrate, whey proteins concentrate and inulin on whey syneresis and curd tension of yoghurt treatments during refrigerated storage (6°C + 1).

Yoghurt treatments	Syneresis (ml whey / 100 gm)					Curd tension (gm)
	Storage period (days)					
	0	3	6	9	12	
C^{*}	$37^{Ba\bullet}$	34^{Bb}	29^{Be}	31^{Bc}	32^{Bd}	85^{F}
P_1	35^{Ca}	32^{Cb}	28^{Ce}	30^{Cc}	32^{Cd}	90^{E}
P_2	34^{CDa}	31^{CDb}	27^{CDe}	28^{CDc}	30^{CDd}	95^{D}
P_3	39^{ABa}	37^{ABb}	33^{ABe}	37^{ABc}	41^{ABd}	105^{B}
P_4	41^{Aa}	39^{Ab}	35^{Ae}	38^{Ac}	43^{Ad}	110^{A}
N_1	34^{CDa}	31^{CDb}	26^{CDe}	27^{CDc}	29^{CDd}	85^{F}
N_2	32^{Ea}	31^{Eb}	26^{Ee}	28^{Ec}	30^{Ed}	90^{E}
N_3	31^{Ga}	28^{Gb}	20^{Ge}	22^{Gc}	25^{Gd}	100^{C}
N_4	29^{Ha}	27^{Hb}	20^{He}	21^{Hc}	23^{Hd}	105^{B}
W_1	35^{Ca}	33^{Cb}	27^{Ce}	31^{Cc}	32^{Cd}	75^{G}
W_2	33^{CDa}	30^{CDb}	24^{CDe}	27^{CDc}	30^{CDd}	75^{G}
W_3	31^{Fa}	27^{Fb}	25^{Fe}	27^{Fc}	29^{Fd}	70^{H}
W_4	30^{Ga}	28^{Gb}	21^{Ge}	22^{Gc}	25^{Gd}	70^{H}

*, ● See Table (1).

Table (5): Effect of replacing non-fat dry milk with milk protein, concentrate, whey proteins concentrate and inulin on organoleptic properties of yoghurt treatments during refrigerated storage (6°C + 1).

Yoghurt treatments	Flavour (45)					Body and texture (35)					Appearance (10)					Acidity(10)					Total score (100)				
	of yoghurt samples (days)																								
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
C*	$39^{Ba\bullet}$	38^{Ba}	37^{Bab}	36^{Bb}	34^{Bc}	28^{BCa}	28^{BCa}	27^{BCab}	26^{BCb}	25^{BCc}	7^{Ba}	7^{Ba}	7^{Ba}	6^{Bb}	5^{Bc}	9^{Aa}	8^{Aab}	8^{Abc}	7^{Ac}	7^{Ad}	83^{Ba}	81^{Ba}	79^{Bab}	75^{Bb}	71^{Bc}
P_1	40^{Aa}	40^{Aa}	39^{Aab}	38^{Ab}	33^{Ac}	30^{Ba}	30^{Ba}	29^{Bab}	27^{Bb}	26^{Bc}	9^{Aa}	9^{Aa}	8^{Aa}	7^{Ab}	7^{Ac}	9^{Aa}	7^{Aab}	8^{Abc}	7^{Ac}	6^{Ad}	88^{Aa}	86^{Aa}	84^{Aab}	79^{Ab}	72^{Ac}
P_2	43^{Aa}	42^{Aa}	41^{Aab}	40^{Ab}	35^{Ac}	33^{Aa}	32^{Aa}	31^{Aab}	30^{Ab}	28^{Ac}	9^{Aa}	9^{Aa}	9^{Aa}	7^{Ab}	6^{Ac}	9^{Aa}	9^{Aab}	7^{Abc}	7^{Ac}	6^{Ad}	94^{Aa}	92^{Aa}	88^{Aab}	84^{Ab}	79^{Ac}
P_3	38^{Ba}	37^{Ba}	36^{Bab}	34^{Bb}	32^{Bc}	30^{Ba}	30^{Ba}	28^{Bab}	27^{Bb}	26^{Bc}	7^{Ba}	7^{Ba}	6^{Ba}	6^{Bb}	5^{Bc}	8^{Aa}	8^{Aab}	6^{Abc}	7^{Ac}	6^{Ad}	83^{Ba}	82^{Ba}	76^{Bab}	74^{Bb}	69^{Bc}
P_4	37^{BCa}	37^{BCa}	36^{BCab}	35^{BCb}	33^{BCc}	29^{BCa}	29^{BCa}	28^{BCab}	27^{BCb}	25^{BCc}	6^{BCa}	6^{BCa}	6^{BCa}	5^{BCb}	4^{BCc}	9^{Aa}	9^{Aab}	8^{Abc}	8^{Ac}	6^{Ad}	81^{Ba}	81^{Ba}	78^{Bab}	75^{Bb}	68^{Bc}
N_1	41^{Aa}	40^{Aa}	40^{Aab}	38^{Ab}	35^{Ac}	30^{Ba}	30^{Ba}	29^{Bab}	28^{Bb}	26^{Bc}	9^{Aa}	8^{Aa}	8^{Aa}	6^{Ab}	5^{Ac}	9^{Aa}	8^{Aab}	7^{Abc}	6^{Ac}	6^{Ad}	89^{Ba}	86^{Ba}	84^{Bab}	78^{Bb}	72^{Bc}
N_2	43^{Aa}	43^{Aa}	42^{Aab}	40^{Ab}	37^{Ac}	32^{Aa}	32^{Aa}	31^{Aab}	29^{Ab}	27^{Ac}	9^{Aa}	9^{Aa}	9^{Aa}	8^{Ab}	7^{Ac}	9^{Aa}	9^{Aab}	8^{Abc}	7^{Ac}	7^{Ad}	93^{Aa}	93^{Aa}	90^{Aab}	84^{Ab}	78^{Ac}
N_3	39^{Ba}	38^{Ba}	38^{Bab}	36^{Bb}	34^{Bc}	32^{ABa}	31^{ABa}	30^{ABab}	28^{ABb}	26^{ABc}	9^{Aa}	8^{Aa}	9^{Aa}	7^{Ab}	6^{Ac}	9^{Aa}	8^{Aab}	6^{Abc}	7^{Ac}	5^{Ad}	89^{Ba}	85^{Ba}	83^{Bab}	78^{Bb}	71^{Bc}
N_4	38^{BCa}	38^{BCa}	36^{BCab}	34^{BCb}	32^{BCc}	31^{ABa}	30^{ABa}	30^{ABab}	29^{ABb}	27^{ABc}	9^{Aa}	7^{Aa}	8^{Aa}	6^{Ab}	5^{Ac}	8^{Aa}	7^{Aab}	7^{Abc}	6^{Ac}	5^{Ad}	86^{Ba}	82^{Ba}	81^{Bab}	75^{Bb}	69^{Bc}
W_1	37^{Ba}	36^{Ba}	35^{Bab}	34^{Bb}	32^{Bc}	30^{Ba}	30^{Ba}	29^{Bab}	28^{Bb}	26^{Bc}	7^{Ba}	6^{Ba}	6^{Ba}	5^{Bb}	4^{Bc}	8^{Aa}	8^{Aab}	8^{Abc}	7^{Ac}	5^{Ad}	82^{Ba}	80^{Ba}	78^{Bab}	74^{Bb}	67^{Bc}
W_2	38^{Ba}	37^{Ba}	35^{Bab}	33^{Bb}	31^{Bc}	28^{Ba}	27^{Ba}	27^{Bab}	26^{Bb}	26^{Bc}	8^{ABa}	7^{ABa}	8^{ABa}	8^{ABb}	6^{ABc}	8^{Aa}	8^{Aab}	7^{Abc}	6^{Ac}	5^{Ad}	82^{Ba}	79^{Ba}	76^{Bab}	73^{Bb}	68^{Bc}
W_3	36^{BCa}	35^{BCa}	32^{BCab}	31^{BCb}	29^{BCc}	28^{BCa}	28^{BCa}	27^{BCab}	26^{BCb}	24^{BCc}	7^{Ba}	7^{Ba}	6^{Ba}	6^{Bb}	5^{Bc}	9^{Aa}	7^{Aab}	8^{Abc}	7^{Ac}	7^{Ad}	80^{BCa}	77^{BCa}	73^{BCab}	70^{BCb}	65^{BCc}
W_4	36^{Ca}	35^{Ca}	35^{Cab}	32^{Cb}	29^{Cc}	27^{Ca}	28^{Ca}	26^{Cab}	27Cb	26Cc	6^{Ca}	5^{Ca}	5^{Ca}	4^{Cb}	4^{Cc}	8^{Aa}	8^{Aab}	7^{Abc}	6^{Ac}	6^{Ad}	77^{Ca}	76^{Ca}	73^{Cab}	69^{Cb}	65^{Cc}

*, $^{\bullet}$ See Table (1).