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USING OF JERUSALEM ARTICHOKE AND INULIN POWDER AS A FAT SUBSTITUTE FOR IMPROVING QUALITY OF BIFIDUM-ZABADY FERMENTED MILK

Elbaz, Azza M. * and Sahar R. Abd EL- Hady.**

*** Animal Production Res. Inst., Agric. Res. Center, Egypt**

**** Food Sci. and Technol. Dept., Fac. of Agric., Tanta Univ., Kafr EL-Sheikh, Egypt.**

ABSTRACT

The effects of different levels of Jerusalem artichoke tubers powder (JAP) and its extracted inulin on starter microorganism were investigated. Sensory and rheological properties of fat free zabady and fermented with a mixed culture of *Streptococcus thermophilus, Lactobacillus delbrueckii Subsp. bulgaricus and Bifidobacteria bifidum* during 12 days storage at 7±2°C were studied. The results obtained from the study revealed that: The pH diminished and the acidity augmented during the storage, both parameters were significantly affected by addition of Jerusalem artichoke and inulin powder. The addition of 6% inulin and control with fat had more acetaldehyde content than control without fat. Acetaldehyde content slightly increased during storage for about 4 days, then decreased thereafter. The use of 6% Jerusalem artichoke powder (JAP) or inulin in the preparation of Bifidum-Zabady fermented milk resulted in elevation of Total Volatile Fatty Acids (TVFA) in the fresh products. The TVFA gradually increased in bifidum-Zabady in different treatments with extended storage. Addition of JAP and inulin to fermented milk significantly increased the viability of *Lb. delbruekii spp. bulgricus* and *B. bifidum* bacteria. After 8 days of storage, the counts of *Lb. delbruekii spp. bulgricus* showed a sharp decline which was statistically significantly ($p<0.05$) from the initial counts. It should be noted that, addition of JAP and inulin powders to fermented milk, significantly increased the viability of *B. bifidum* bacteria. However, addition of inulin (3 and 6%) to the milk were more effective than the addition of JAP(3 and 6%) during the storage period. Fortification of Bifidum-Zabady with Jerusalem artichoke and inulin powders caused a significant ($p<0.05$) increase in curd tension. Syneresis phenomenon decreased with inulin addition, and it was higher in zabady without fat content. Regarding the organoleptic properties, no significant sensory differences were found between the control with fat and fermented milk added with 6% of JAP or inulin. The received data indicated that, using of Jerusalem artichoke or inulin powders at 6% level were good enough to compete with control with fat. So, it can be recommended to use such substances at the recorded levels in preparing synbiotic zabady. Accordingly, farmers should be encouraged to increase the cultivated area of Jerusalem artichoke for production such important products.

INTRODUCTION

One of the important categories of healthy food is low fat product, particularly low fat dairy products in order to combat obesity, heart disease and hypertension (NRC. 1989). Search for local sources to be used in low fat dairy products suggest that Jerusalem artichoke *(Helianthus tubersus)*, newly introduced vegetable crop in Egypt ,can be used for this purpose. Jerusalem artichoke is rich source of inulin which comprises 60-70% of its dry matter (Hui RU *et al.*, 2002). Inulin is used as food ingredient for a variety of reasons including for fat and sugar replacement as a low calorie-bulking agent and as a texturizing agent. It is also used for its physiological features of being

soluble dietary fiber and having prebiotic properties (Causey et al.2000). Abdel-Hady, *et al.* (2004) described the method used to manufacture diabetic bread. Jerusalem artichoke tubers powder was added as a source of inulin at the level ranged from 5-15% of the flour and found that, the structural and mechanical properties of the dough were improved. In addition, Salem, *et al.*, (2003) reported that, Jerusalem artichoke tubers have been used to replaced milk fat in ice cream.

Jerusalem artichoke is a plant that can serve as an alternative source of carbohydrate. The tubers contain 14-15 % inulin, 0.8-0.9 % minerals and 0.6-1.5 % raw fibre which can be concidered as basic components of healthy nutrition. Thus the Bifido promoting Jerusalem artichoke powder is a versatile food ingredient which combines beneficial effects on human health and technological aspects. It can be used for fibre enrichment and reduction in calories as well as for improving consistency or creating a new taste. Inulin is a polysaccharide, that consist of 80% fructose and 20 % glucose. Since it is hard to digest for humans, it functions as dietary fibre (Pátkai and Barta, 2002).

Inulin has a neutral taste, colourless and has minimal influence on the organoleptic characteristics of a product. Combining inulin with high intensity sweeteners significantly improves the taste of products giving a more sugar-like sweetness. Owing to the high solubility of this ingredient over `classical fibres' ; inulin can be used to fortify dairy products such as milk drinks, yoghurt, cheeses and desserts, which have been traditionally difficult to fortify (Niness, 1999). In consumer tests, plain unsweetened yogurt containing inulin was preferred over samples without inulin. Yogurt with inulin was identified as being creamier in appearance, having a less chalky and more creamy texture, and was sweeter with a less sour/fermented taste and aftertaste (Spiegel, *et al.*, 1994).

Zabady is the traditional type yoghurt manufactured in Egypt. The best is made from buffalo's, though it can be made from cow's milk or from a mixture of two milks. Yogurt is one of the dairy products, which should continue to increase in sales due to diversification in the range of yogurt-like products, including reduction in fat content yogurts, probiotic yogurts, yogurt shakes, drinkable yogurts, yogurt mousse, yogurt ice-cream, etc. (Fiszman *et al.*,1999; Giese, 1996; Shahani and Chandan,1979).

Since consumer concerns are related to both nutritional and sensory aspects, several authors studied texture characteristics of yogurts due to the addition of gelatin (Fiszman, *et al.*, 1999), pectin (Ramaswamy and Basak, 1992), k-carragenean (Xu, *et al.*,1992) oat, rice, soy and maize fibers Carboxy-methyl-cellulose (CMC) as hydrocolloids has exceptional water binding capacity and ability to enhance viscosity (Wang *et al.*, 1998) wheat, bamboo, inulin and apple (Dello- Staffoloa, *et al.*, 2004). Hassan *et al.*, (1999), reported that the utilization of stabilization mixture (inulin of dahlia tubers or galactomannan of leucena seeds) improved the organoleptic properties of resultant Zabady. El-Nagar and Brennan (2001) found that fat free zabady containing 2% inulin was superior to other fiber additions (Carbox-methyl cellulose and pen fiber), it has an acceptable consistency and smooth texture. Examples of probiotics are certain brands of yogurt and

acidophilus milk. An example of a prebiotic is a food containing inulin or oligofructose, which stimulate growth of bifidobacteria. An example of a synbiotic is a food containing both bifidobacteria and oligofructose or inulin. However, most of the studies on Jerusalem Artichoke are directed towards the extraction of inulin and its subsequent use in food products, and very little have been done on the direct use of Jerusalem Artichoke tubers in dairy products. Therefore, the present work has been undertaken to develop fat free zabady using Jerusalem artichoke powder (JAP) and its extraction inulin as fat replace. Conducted to determine the influence of fortification of fat free bifidum -zabady fermented milk with Jerusalem artichoke and its extracted inulin on microorganisms of starter and quality product.

MATERIALS AND METHODS

Materials:

Fresh skim milk prepared in Dairy Science Department, Faculty of Agriculture at Kafr El-Sheikh, Tanta University, Egypt. Starter culture of yoghurt *Streptococcus thermophilus*, St-36 and *Lactobacillus delbrueckii Subsp. bulgaricus, Lb-12* and *B. bifidum* (Bb-11) were obtained from Chr. Hansen'Lab. Copenhangen, Denmark.

Jerusalem artichoke tubers (*Helianthus tuberosus*) which were harvested in October 2004 were provided from the Experimental Station, Agricultural Research Center, El-Kanater El-Khayria, Egypt.

Inulin: Inulin was isolated from the tubers of Jerusalem artichoke (*Helianthus tuberosus*) in the Laboratory of Food Science and Technology Department, Faculty of Agriculture at Kafr El-Sheikh, Tanta University, Egypt.

Preparation of Jerusalem artichoke tubers powder (JAP):

Raw Jerusalem artichoke tubers were cleaned with tap water to remove dust and other undesirable materials. The cleaned tubers were cut into small pieces, warmed in water 85°C for 30 min and blended, then dried freezing in a freeze- drier.. The recovered powder was kept in polyethylene bags and stored at 7±2°C in a refrigerator until used. The composition of Jerusalem artichoke tubers powder (JAP)were: Moisture 6.50, total carbohydrates 86.21, inulin 71.78, crude protein 7.40, Ether extract 0.70, crude fiber7.52 and ash 5.30%. Percentages were as on dry weight basis.

Extraction inulin:

Inulin was extracted from the tubers of Jerusalem artichoke (*Helianthus tuberosus*) according to the method of El-Farra (1989). The inulin paste obtained by centrifugation was freeze dried in a freeze- drier. Inulin powder was placed in polyethylene bags and stored in a refrigerator at 7±2°C until used. The composition of inulin: Moisture3.82, inulin 97.76, crude protein 0.58, Ether extract 0.50, crude fiber was 1.52 and ash 0.69 %. Percentages were as on dry weight basis.

Preparation of fermented milk :

The milk was divided into 6 portions: first two protions were supplemented with Jerusalem artichoke powder(3, 6%), and secend two with inulin powder (3,6%)added, one portion used as a control without fat and without additives. The last portion used as a control with fat 3% and without additive. Every portion was inoculated with (3% w/v) mixed culture (1:1:1) of

Streptococcus thermophilus, St-36 and *Lactobacillus delbrueckii Subsp. bulgaricus, Lb-12* and *B. bifidum* (Bb-11), divided in plastic cups (50 gm each) and incubated at 40±2°C until complete coagulation. The produced fat free Zabady-bifidum fermented milk was stored at 7±2°C and analyzed when fresh (after over night cold storage) and after 4,8 and 12 days of storage for some chemical, microbiological, rheological properties and sensory evaluation.

Chemical analysis:

Protein, total solids, titratable acidity, ash, pH value were determined according to Ling (1963). Total volatile fatty acid (TVFA) in fermented milk products was determined by according to Kosikowski (1978), and the result were expressed as ml 0.1N NaOH/100gm sample. Acetaldehyde content in the fermented milk products was estimated according to the conway micro diffusion semicarbazed method as described by Lees and Jago(1969).

Rheological properties:

Curd tensions was determined at room temperature (25-30°C) as described by Chandrasekhara, *et al.*(1957), whereas curd syneresis was measured at the same room temperature as described by Rashed (1982). 100g portions of the milk inoculated with the starter cultures were put in a deep bowel equipped with a semi-sphere net with a hand. After coagulation at 32°C, the net was carefully removed from the bowel and put in funnel over a 100-ml cylinder. The rest of the curd in the bowel was determined in order to estimate the weight of curd on the net. The whey drained from the curd into the cylinder was measured at appropriate times and calculated as ml whey per 100g curd.

Microbilogical analysis:

One gram of each yoghurt sample was diluted with 9 mL of sterile 0.15% (w/v) peptone water (Oxoid, Hampshire, UK) and mixed uniformly with a vortex mixer. Subsequent serial dilutions were made and viable yoghurt and bifidobacteria numbers were counted using the pour plate technique. The counts of *S. thermophilus* were enumerated on ST agar after incubating the plates aerobically at 37°C for 24h. MRS agar adjusted to pH 5.2, and incubated at 40°C for 72 h were used for the enumeration of *L. delbrueckii ssp. bulgaricus*. The viable numbers of bifidobacteria were enumerated according to the method of Tharmaraji and Shah (2003) using MRS-L (lithium chloride and L-cystein chloride) agar. The inoculated plates were incubated anaerobically at 37°C for 72 h. Plates containing 25 to 250 colonies were enumerated and recorded as colony forming units (CFU) per gram of sample.

Sensory evaluation:

The sensory evaluation of Zabady was assessed according to El-Shibiny, *et al.* (1979) using the following points for different properties: Appearance(10 points), body &texture (30 points), and flavor (60 points).

Statistical analyses:

Data analysis was carried out with SPSS Inc. software (version 10.0; SPSS Inc., Chicago, IL). and statistically different groups were determined by the DUNCAN's Multiple Rage test (Steel and Torrie, 1980). *All data are presented as average ± standard error.*

RESULTS AND DISCUSSIONS

Chemical Composition of resultant fresh Zabady

The changes in the chemical composition of resultant fresh Zabady with added different levels of Jerusalem artichoke tubers powder (JAP) and its extracted inulin are recorded in table (1). The total solids of fresh Zabady with JAP (6%) or inulin (6%) were the highest which can be attributed to protein content in JAP(protein content 7.40%). Salem, *et al.*, (2003) indicated that JAP contained 8.50% curd protein in agreement with present finding. Also, there was slightly increase in ash content for fresh synbiotic-zabady, due to high proportions of protein, fiber and minerals in Jerusalem artichoke tubers powder (JAP).

Table (1): Chemical composition of fresh Bifidum-zabady manufactured from fat free milk containing different levels of Jerusalem Artichoke powder and extracted inulin.

Product	Total solid (%)	Protein (%)	Ash (%)
C F	13.63^{B}±0.16	3.38^{A}±0.01	0.76^{A}±0.01
CNF	10.88^{A}±0.10	3.53^{AB}±0.05	0.84^{B}±0.02
JAP 3%	13.52^{B} ±0.33	3.56^{AB}±0.05	0.91^{C}±0.01
JAP 6%	16.31^{D}±0.14	3.66^{C}±0.09	0.98^{D}±0.01
Inulin 3%	14.45^{C}±0.32	3.93^{D} ±0.04	0.85^{B} ±0.01
Inulin 6%	19.45^{E}±0.10	4.25^{E}±0.01	0.87^{B}±0.01

C F: fermented milk made by milk with 3% fat as control, whereas CNF: fermented milk made by milk non fat as control and JAP: Jerusalem artichoke powder. Data are means ± SE for 3 replicates. Means with different superscript capital letters are significantly different at $p<0.05$.

Changes in pH and Titratable acidity(TA)

Changes in pH and TA during the refrigerated storage of resultant Zabady are shown in Table2. The addition JAP and inulin increase pH values of fresh Zabady with supplemented JAP (6%) or inulin (6%)compared with the control without fat (CNF). The pH values decreased during storage period in all resultant Zabady (Table2). An opposite trend of results was observed with respect to titratable acidity. Differences in pH values and TA were significant between treatment but with less significance between storage intervals for each individual treatment. However, titratable acidity of samples containing JAP(3% and 6%), and those containing inulin (3% and 6%) reached >0.8 after about 8days. While the control without fat reached 0.9% after about 4days. Addition JAP(3%) and inulin (3%) showed the lowest acidity while the addition JAP(6%) and inulin (6%) showed the highest acidity for fresh of products. Titratable acidity increased during storage period in all treatments and this may be due to the starter culture activity. Increase in acidity level during storage of yoghurt was also reported by El-Shibiny, *et al*., (1979). The addition of fibers did not affect the development of acidity during storage of yoghurt as apparent from the close acidity of the different treatments (El-Nagar and Brennan, 2001).

Table (2): Changes in pH and Titratable acidity (TA) Bifidum-zabady manufactured from fat free milk containing different levels of Jerusalem Artichoke powder and extracted inulin during storage period.

Product	Storage period (days)			
	Fresh*	4	8	12
		pH		
CF	4.25^{Aa} ±0.05	4.17^{Aa} ±0.10	4.14^{Aa} ±0.01	4.13^{Aba} ±0.01
CNF	4.19^{Ab} ±0.00	4.23^{Ac} ±0.01	4.18^{ABb} ±0.01	4.15^{ABCa} ±0.01
JAP 3%	4.25^{Aa} ±0.05	4.18^{Aa} ±0.08	4.18^{ABa} ±0.01	4.16^{BCa} ±0.01
JAP 6%	4.27^{Aa} ±0.08	4.16^{Aa} ±0.07	4.23^{Ba} ±0.03	4.18^{Ca} ±0.02
Inulin 3%	4.61^{Bc} ±0.02	4.53^{Bbc} ±0.06	4.41^{Cb} ±0.03	4.23^{Da} ±0.02
Inulin 6%	4.83^{Cc} ±0.03	4.63^{Bb} ±0.04	4.19^{ABa} ±0.02	4.11^{Aa} ±0.01
		Acidity (%)		
CF	0.81^{ABa} ±0.08	0.92^{ABab} ±0.09	1.06^{BCb} ±0.01	1.09^{BCb} ±0.00
CNF	0.73^{Aa} ±0.06	0.85^{Aab} ±0.06	0.93^{Abc} ±0.02	1.01^{Ac} ±0.01
JAP 3%	0.87^{ABa} ±0.04	1.04^{Bb} ±0.04	1.07^{BCb} ±0.02	1.06^{ABCab} ±0.05
JAP 6%	0.92^{Ba} ±0.05	1.04^{Bab} ±0.01	1.12^{Cb} ±0.02	1.12^{BCb} ±0.02
Inulin 3%	0.84^{ABa} ±0.04	0.99^{ABb} ±0.02	1.03^{Bb} ±0.03	1.04^{ABb} ±0.01
Inulin 6%	0.93^{Ba} ±0.03	0.98^{ABb} ±0.04	1.09^{BCb} ±0.01	1.13^{Cb} ±0.01

***After overnight cooling. C F: fermented milk made by milk with 3% fat as control, whereas CNF: fermented milk made by milk non fat as control and JAP: Jerusalem artichoke powder. Data are means ± SE for 3 replicates. Means with different superscript capital letters (between groups at the same storage period "column") and small letters (within group at different storage period "row") are significantly different at $p<0.05$.**

Changes in total volatile fatty acids(TVFA) and acetaldehyde content

The change in the TVFA during storage period are showed in Table(3). The data shows pronounced gradual increase in the total volatile fatty acids(TVFA) in all fermented milk during 12days of cold storage. The use JAP(6%) and inulin (6%) in the preparation of synbiotic-Zabady fermented milk resulted in elevation of TVFA in the fresh products. The TVFA gradually increased in synbiotic-Zabady of different treatment with extended storage. The rate of increase in TVFA was much higher in treatments with 6% of JAP or inulin as compared with other treatments. There was a gradual increases in the TVFA, which could be attributed to the fact that bifidobacteria fermentation is unique in that it produces 1.5 moles of acetic acid as well as 1 mol of lactic acid as the end product of the fermentation process of 1 mol of glucose (Tamime, *et al.*, 1995). Data illustrated in Table (3) also revealed that, The addition of Jerusalem artichoke powder at different levels (3 and 6%) and inulin powder at the levels of (3 and 6 %) to synbiotic Zabady fermented milk significantly increased the acetaldehyde content during the first days of storage period. After 4days of cold storage all samples showed a gradual reduction of its acetaldehyde content till the end of the storage period.

The addition of inulin (6%) and control with fat had more acetaldehyde content than treatments with turn and higher than control without fat. Acetaldehyde content slightly increased during storage for about 4 days, then decreased there after. However, this may be due to the ability of numerous

lactic acid bacteria to reduce acetaldehyde to ethanol (Amer, *et al.*,1991 and Salama, 1993).

Table(3): Changes in total volatile fatty acids (TVFA) and acetaldehyde content of Bifidum-zabady manufactured from fat free milk containing different levels of Jerusalem Artichoke powder and extracted inulin during storage period.

Product	Storage period (days)			
	Fresh*	4	8	12
Total volatile fatty acids (ml 0.1N NaOH/100g)				
CF	6.75^{Aa} ±0.25	8.25^{Ab} ±0.25	10.50^{Ac} ±0.50	13.58^{Ad} ±0.42
CNF	7.80^{Ba} ±0.20	9.75^{Bb} ±0.25	12.45^{ABc} ±0.35	14.30^{ABd} ±0.30
JAP 3%	8.00^{BCa} ±0.00	10.25^{Bb} ±0.25	13.68^{Cc} ±0.10	15.05^{Bd} ±0.15
JAP 6%	8.65^{Ca} ±0.25	9.80^{Ba} ± 0.20	13.50^{Cb} ±0.50	15.20^{Bc} ±0.20
Inulin 3%	8.20^{BCa} ±0.20	10.25^{Bb} ± 0.25	12.00^{Bc} ±0.00	15.00^{Bd} ±0.00
Inulin 6%	8.75^{Ca} ±0.25	10.25^{Bb} ±0.25	12.50^{ABc} ±0.50	14.40^{ABd} ±0.40
Acetaldehyde (µmol/100g)				
CF	64.06^{Ab} ±2.60	85.60^{Bb} ±2.04	48.93^{Aa} ±1.78	46.34^{Aa} ±1.14
CNF	61.84^{Ab} ±2.48	68.93^{Ab} ±3.58	54.91^{ABa} ±2.24	54.55^{Ba} ±1.22
JAP 3%	64.54^{Aab} ±3.09	62.13^{Ab} ±3.69	51.02^{Aa} ±1.02	55.92^{BCab} ±0.97
JAP 6%	72.46^{Bc} ±1.90	66.18^{Ab} ±3.58	59.83^{BCb} ±2.28	49.03^{Aa} ±0.58
Inulin 3%	63.59^{Cab} ±1.03	69.44^{Ab} ±2.98	64.46^{Cab} ±2.36	58.20^{BCa} ±0.65
Inulin 6%	76.57^{Bb} ±2.06	90.74^{Bc} ±2.29	71.37^{Db} ±1.79	59.18^{Ca} ±1.63

*After overnight cooling. C F: fermented milk made by milk with 3% fat as control, whereas CNF: fermented milk made by milk non fat as control and JAP: Jerusalem artichoke powder. Data are means ± SE for 3 replicates. Means with different superscript capital letters (between groups at the same storage period "column") and small letters (within group at different storage period "row") are significantly different at $p<0.05$.

Changes in the starter cultures activity

The changes in the viable count of *Str. thermophilus*, *Lb. delbruekii spp. bulgricus* and *B. bifidum* for produced synbiotic-zabady with JAP and inulin (3 and 6%) during refrigerated storage are presented in Table (4). It was observed from the presented data that, addition of Jerusalem artichoke tubers powder (JAP) and inulin to fermented milk significantly increased the viability of *Lb. delbruekii spp. bulgricus* and *B. bifidum* bacteria. However, *Lb. delbruekii spp.bulgricus* showed a more marked decrease than *Str. thermophilus* during refrigerated storage (Table.4). After 8days of storage, the counts of *Lb. delbruekii spp. bulgricus* showed a sharp decline which was statistically significantly different ($p<0.05$) from the initial counts.

The counts of *Lb. delbruekii spp. bulgricus* had decreased by 2 log in all samples at the end of storage. Similarly, *Str. thermophilus* counts were higher by at least 2 log order than those for *Lb. delbruekii spp. bulgricus* in yoghurt containing probiotic bacteria (Vinderola, *et al.*, 2000). On average, the survival rate of *Str. thermophilus* was better than that of both *Lb. delbruekii spp.bulgricus* and bifidobacteria. These observation are in line with those of Kim, *et al.*, 1993; Medina and Jordano (1994), Lim, *et al.*, 1995 and Dave and Shah (1997). As given in Table (4), it should be noted that, addition of Jerusalem artichoke and inulin powder to fermented milk

significantly increased the viability of *B. bifidum* bacteria. However, addition inulin (3 and 6%) to the milk were more effective than the addition of JAP(3%) through the storage period. All resultant Zabady showed a steady decline in the numbers *B. bifidum* .The decrease was more rapid for the control with fat (CF)and control without fat (CNF). The viability of bacteria in Bifidum–zabady during the storage was higher when they were grown in presence of Jerusalem artichoke and inulin powder as compared with control samples containing no prebiotic (Table4). Although a significant decrease ($P<0.05$) was observed after 8 days in Jerusalem artichoke and inulin powder, the viable counts of *B. bifidum* recommended were above the recommended limit of cells per gram of fermented milk up to 8days of storage period. These results are consistent with previous reports on ability of Fructo-oliogsaccharide (FOS) to stimulate the viability of bifidobacteria in reconstituted non fat dried milk during 4weeks of refrigerated at 4°C. FOS was the most effective prebiotic among the carbohydrate sources tested and the effect of FOS increased carbohydrate concentration (maxinmal at 5%) (Shin, *et al.*, 2000.

Table (4): Effect of different concentration of Jerusalem Artichoke powder and extracted inulin on the starter culture strains of Bifidum–zabady fermented milk during storage period.

Product	Storage period (days)			
	Fresh*	4	8	12
Str. thermophilus (log CFU/gm)				
CF	$10.63^{Cb} \pm 0.07$	$10.37^{Db} \pm 0.01$	$10.37^{Db} \pm 0.04$	$9.13^{A} \pm 0.38$
CNF	$10.40^{BCc} \pm 0.13$	$10.18^{CDbc} \pm 0.17$	$9.36^{Cb} \pm 0.22$	$6.50^{A} \pm 0.33$
JAP 3%	$10.13^{Ad} \pm 0.07$	$8.73^{Bc} \pm 0.13$	$7.41^{Ab} \pm 0.11$	$7.74^{A} \pm 0.22$
JAP 6%	$10.54^{BCd} \pm 0.06$	$9.49^{BCDc} \pm 0.11$	$7.98^{Bb} \pm 0.11$	$6.20^{A} \pm 0.25$
Inulin 3%	$10.26^{ABb} \pm 0.08$	$10.01^{Db} \pm 0.13$	$7.28^{Aa} \pm 0.62$	$6.51^{A} \pm 0.31$
Inulin 6%	$10.24^{ABc} \pm 0.08$	$9.23^{BCb} \pm 0.23$	$7.20^{Aa} \pm 0.14$	$7.00^{A} \pm 0.29$
L.delbruckii ssp. bulgaricus (log cfu /gm)				
CF	$7.60^{Bc} \pm 0.10$	$6.49^{Ab} \pm 0.09$	$5.30^{Aa} \pm 0.00$	$5.03^{Aa} \pm 0.13$
CNF	$7.02^{Ac} \pm 0.02$	$6.90^{Bc} \pm 0.05$	$6.15^{Bb} \pm 0.15$	$5.12^{ABa} \pm 0.12$
JAP 3%	$7.93^{Cc} \pm 0.03$	$6.36^{Ab} \pm 0.06$	$6.15^{Bb} \pm 0.15$	$5.13^{ABa} \pm 0.18$
JAP 6%	$8.06^{Cd} \pm 0.06$	$7.00^{Bc} \pm 0.00$	$6.30^{Bb} \pm 0.12$	$5.49^{ABa} \pm 0.13$
Inulin 3%	$7.43^{Bc} \pm 0.05$	$7.26^{Cc} \pm 0.00$	$6.75^{Cb} \pm 0.16$	$5.57^{Ba} \pm 0.16$
Inulin 6%	$8.33^{Dd} \pm 0.07$	$7.93^{Dc} \pm 0.03$	$7.30^{Db} \pm 0.04$	$6.06^{Ca} \pm 0.12$
B. bifidum (log cfu/gm)				
CF	$7.33^{Ac} \pm 0.07$	$6.05^{Ab} \pm 0.02$	$5.85^{Bb} \pm 0.13$	$5.05^{ABa} \pm 0.15$
CNF	$7.25^{Ac} \pm 0.05$	$6.41^{Bb} \pm 0.09$	$5.00^{Aa} \pm 0.00$	$4.83^{Aa} \pm 0.13$
JAP 3%	$8.22^{Bd} \pm 0.06$	$6.95^{Cc} \pm 0.05$	$6.15^{Bb} \pm 0.15$	$5.33^{BCa} \pm 0.14$
JAP 6%	$8.07^{Bd} \pm 0.01$	$7.08^{Dc} \pm 0.08$	$6.44^{BCb} \pm 0.19$	$5.50^{Ca} \pm 0.09$
Inulin 3%	$8.17^{Bc} \pm 0.06$	$7.19^{Eb} \pm 0.01$	$6.90^{Ca} \pm 0.12$	$6.63^{Da} \pm 0.04$
Inulin 6%	$8.72^{Cc} \pm 0.11$	$7.76^{Fb} \pm 0.06$	$7.73^{Db} \pm 0.09$	$6.88^{Da} \pm 0.10$

***After overnight cooling. C F: fermented milk made by milk with 3% fat as control, whereas CNF: fermented milk made by milk non fat as control and JAP: Jerusalem artichoke powder. Data are means ± SE for 3 replicates. Means with different superscript capital letters (between groups at the same storage period "column") and small letters (within group at different storage period "row") are significantly different at $p<0.05$.**

Similarly, the viability of bifidobacteria strains in reconstituted skimmed milk 4 weeks of storage was significantly higher ($p<0.05$), when they were inoculated in the presence of prebiotics as compared with controls without any prebiotic. Stimulation of bifidobacteria in the human colon by FOS has also been demonstrated in human feed trails (Gibson, *et al.*, 1995; Roberfroid, *et al.*, 1998). The degradation of FOS by Fructofuronasidases of bifidobacteria can increase growth and short-chain FOS are fermented more quickly by Bifidobacteria (Perrin, *et al.*, 2002).

Effect of Fortified with different levels of Jerusalem artichoke and inulin powders on some rheological properties

The effect of fortification with Jerusalem artichoke (JAP) or inulin powders at different levels (3 and 6%) curd tension and syneresis curd for fermented milk manufactured from free fat milk are presented in Table (5). The given data indicated that, the curd tension of addition JAP(6%) was higher than the control without fat treatment. On the other hand, control with fat treatment was higher than control without fat. Adapa and Schmidt (1998) reported that, fat content greatly affects rheological and sensory properties. Fortification of zabady with Jerusalem artichoke and inulin powder caused a significant ($p<0.05$) increase in curd tension (Table 5). The increase can be due to the Jerusalem artichoke contain inulin which being highly soluble appears to enhance gel matrices. Blomsma (1997), found that, the fat-substituting property of inulin is based on the products' ability to stabilize water into a creamy structure. Marshall and Rawson (1999) suggested that it may not be the amount of polysaccharide which is important in affecting the rheological properties, but the type of exopolysaccharide (EPS) and consequently the interaction of the polymer with the milk proteins during fermentation. Schaller-povolny and Smith (1999) indicated that half of the amount of inulin may have the same desired effect as adding 100%inulin. The syneresis of Zabady was affect by the addition Jerusalem artichoke and inulin powder used as shown in Table(5). Increase separation of whey from the resultant Zabady was observed in the control without fat , which may be to low total solids.

Table (5): Rheological properties of fresh bifidum-zabady manufactured from fat free milk containing different levels of Jerusalem Artichoke powder and extracted inulin.

Product*	Curd Tension (gm)	Curd Syneresis (ml/100gm)			
		30 minutes	60 minutes	90 minutes	120 minutes
CF	$38.90^{B}\pm0.84$	$15.00^{C}\pm0.00$	$17.00^{E}\pm0.00$	$20.00^{D}\pm0.00$	$22.00^{D}\pm0.00$
CNF	$30.68^{A}\pm0.80$	$17.50^{D}\pm0.50$	$21.50^{F}\pm0.50$	$23.50^{E}\pm0.50$	$23.50^{E}\pm0.50$
JAP 3%	$54.27^{E}\pm0.45$	$10.00^{B}\pm0.00$	$14.50^{D}\pm0.50$	$19.50^{D}\pm0.50$	$19.50^{C}\pm0.50$
JAP 6%	$57.27^{F}\pm0.55$	$10.00^{B}\pm0.00$	$11.50^{C}\pm0.50$	$14.00^{C}\pm0.00$	$14.50^{B}\pm0.50$
Inulin 3%	$47.98^{C}\pm0.16$	$9.50^{B}\pm0.50$	$10.00^{B}\pm0.00$	$11.00^{B}\pm0.00$	$10.50^{A}\pm0.50$
Inulin 6%	$51.52^{C}\pm0.30$	$7.50^{A}\pm0.50$	$8.50^{A}\pm0.50$	$9.00^{A}\pm0.00$	$10.00^{A}\pm0.00$

C F: fermented milk made by milk with 3% fat as control, whereas CNF: fermented milk made by milk non fat as control and JAP: Jerusalem artichoke powder. Data are means ± SE for 3 replicates. Means with different superscript capital letters are significantly different at $p<0.05$.

In all treatments (Table 5), increased levels of Jerusalem artichoke and inulin powder caused to increase curd syneresis at both 30 and 120 minutes of holding time and their curd syneresis values were lower than those of the control samples. Similar results were reported by Kalab *et al*, 1983 and Cerning *et al.*, (1990), they found that the exopolysaccharides reduced syneresis when used in yoghurt. Also, the syneresis decreased by increasing the fibers level (El-Nagar and Brennan, 2001). These results might be due to addition of JAP and inulin which lead to mechanism for shear-induced disruption of the network prevented by expolysaccharides associated with the casein matrix (Hess, *et al.*, 1997). Addition of inulin (6%) was superior, then inulin3% followed by Jerusalem artichoke powder (6%) in reducing whey exudates of resultant fresh zabady. The obtained results are in harmony with Terry, *et al.*,1999, who reported that yogurt made with 10% inulin with a degree of polymerization (DP) of 12-16 was found to increase firmness and decrease synthesis compared to yogurt made with shorter chained inulin (DP 5-8) and controls with no inulin. Due to the unique functional properties, inulin has to manage water effectively, affect rheology and improve texture in foods and act synergistically with high water binding hydrocolloids has allowed inulin to be used across all food product application areas, particularly in low and no fat and low and no sugar systems.

The influence of Jerusalem artichoke and inulin powder on the organoleptic properties of Bifidum-zabady fermented milk

Organoleptic properties of resultant fresh zabady with different levels of Jerusalem artichoke and inulin powder(3 and 6%) are shown in table (6). The control with fat scored higher for flavour and body& texture than those with control without fat. Results emphasized the importance of fat as a flavour modifier (Ohmes, *et al.*,1998). The bifidum-zabady with inulin 6% and JAP 6% followed the control with fat in the total scores.

Table (6): Organoleptic properties of fresh synbiotic-zabady manufactured from fat free milk containing different levels of Jerusalem Artichoke powder and its extracted inulin.

Product*	Flavor(60)	body& texture (30)	Appearance(10)	Total (100)
CF	54.09^{B} ±.07	25.82^{B} ±0.71	8.36^{B} ±0.15	88.27^{B} ±1.51
CNF	48.45^{A} ±.56	23.27^{A} ±0.57	7.45^{A} ±0.16	79.18^{B} ±0.70
JAP 3%	52.00^{B} ±1.37	24.91^{AB} ±0.90	7.68^{A} ±0.14	84.59^{B} ±1.86
JAP 6%	52.73^{B} ±0.69	26.27^{B} ±0.75	8.45^{B} ±0.16	87.45^{B} ±1.12
Inulin 3%	52.27^{B} ±0.60	24.64^{AB} ±0.89	7.50^{A} ±0.20	84.41^{B} ±1.18
Inulin 6%	51.45^{B} ±1.15	26.64^{B} ±0.56	8.27^{B} ±0.14	86.36^{B} ±1.11

C F: fermented milk made by milk with 3% fat as control, whereas CNF: fermented milk made by milk non fat as control and JAP: Jerusalem artichoke powder. Data are means ± SE for 3 replicates. Means with different superscript capital letters are significantly different at $p<0.05$.

As given in Table (6), it should be noted that, no significant sensory differences were found between the control with fat and fermented milk with 6% of JAP or inulin. The fat –substituting property of Jerusalem artichoke and inulin powder is based on the products ability stabilize water into a creamy

structure, which has an excellent fat like mouth feel and is almost taste free (Blomsma, 1997 and Adapa and Schmidt, 1998). However, El-Nagar and Brennan, (2001) indicated that fat –free yoghurt containing 2 % inulin superior to other treatments it has an acceptable consistency and smooth texture. The samples with inulin 6% came at first, followed by Jerusalem artichoke 6%, then samples of 3% Jerusalem artichoke or inulin as it had the lowest scores. These results agree with those of Blomsma, 1997 and Tungland (2000) who reported that inulin had functional properties to act as a fat or sugar replacer without adversely affecting flavour. In conclusion, the above mentioned results indicated that addition of Jerusalem artichoke or inulin powder (especially addition of 6%) had a beneficial effect and improved the quality, the safety and the acceptability of the manufactured fat free zabady. So, it can be strongly recommended to use such materials (Jerusalem artichoke and inulin) for preparing different types of synbiotic fermented milk for human consumption, especially for healthy' effects.

REFERENCES

Abd EL- Hady, S.; Salem, M.; Metwalli, S.; Miligi, A. and Ghazi, A.(2005). Utilization of inulin extracted from Jerusalem artichoke in preparing some foods for diabetics. The 2ND Arab Monsora Conf. On Food and Dairy Sci. & Technol, 22-24, March2005, Mansoura, Egypt.

Adapa, S. and Schmidt, K. A. (1998). Physical properties of low- fat sour cream containing exopolysaccharide-producing lactic acid. J. Food Sci., 63: 901.

Amer, S.N.; Moussa, A. E; Anis, S.M. K and Salama, F. M. (1991). Comparative study between Biograde as a new product and Zabady. Egyptian J. Appl. Sci. 6:667.

Blomsma, C. A. (1997). A review of commercial applications. International food ingredient. March/April pp22-23.

Causey, J.L., Xin-chua Y., Tungland, B.C., Feirtag, J.M., Gallaher, D.G., and Slavin J.L(2000). Effect of dietary inulin on serum lipids, blood glucose and the gasatrointestinal environment in hypercholesterolemic men. Nutr. Res. 20(2):191-201.

Cerning, J.; Bouillanne, C.; Demasead, M.J. and Landon, M. (1990). Exocellular polysaccharides produced by lactic acid bacteria. FEMS Microbiology Reviews, 87:113-130.

Chandan, R. C., and K. M. Shahani. 1995. Other fermented dairy products. Pages 386–418 in Biotechnology. 2nd ed. Vol. 9. G. Reed and T. W. Nagodawithana, ed. VCH Publ., Weinheim, Germany.

Chandrasekhara, M. R.; Bhagawan, R. K.; Swaminathan, M. and Subrahomanyan, V. (1957). The use of mammalian milk and processed milk foods in the foods in the feeding of infants. Indan J. Child. Health, 6:0701

Dave, R. I., and N. P. Shah. (1997). Viability of yoghurt and probiotic bacteria in yoghurts made from commercial starter cultures. Int. Dairy J. 7:31.

Dello-Staffoloa, M.B.; Bertolaa, b, M.; Martinoa, b. and Bevilacquaa, A.Y. (2004). Influence of dietary fiber addition on sensory and rheological properties of yogurt . International Dairy Journal 14: 263.

El-Farra, S.A. (1989). Studies on Production of Diabetic Drinks. Ph.D. Thesis, Food Technol. Dept., Fac. Agric., Cairo Univ., Cairo, Egypt.

El-Nagar, C.F. and Brennan, C. S .(2001). The influence of fiber addition on the texture and quality of stirred yoghurt. Proc. 8Th Egyptian Conf. Dairy Sci.&Techn.505-523.

El-shibiny, S.; El-Dein, H. and Hofi, A. A. (1979). Effect of storage on the chemical composition of Zabady. Egyptian J. Dairy Sci. 7:1.

Fiszman, S. M., Lluch, M. A., and Salvador, A. (1999). Effect of addition of gelatin on microstructure of acidic milk gels and yoghurt and on their rheological properties. International Dairy Journal, 9: 895.

Gibson, G. R.; Beatly, E.R.; Wang, X. and Cummings, J. H. (1995). Selective stimulation of bifidobacteria in the human colon by oligofructose and inulin. Gastroenterology, 108: 975.

Giese, J. (1996). Fats, oils and fats replacers. Food Technol., 51: 60

Hassan, F. A. M.; Helmy, W. A. and Enab, A. E.(1999). Utilization of some local polysaccharide in manufacture of yoghurt. Egyptian J. Dairy Sci. 27:281

Hess,S.J.; Roberts, R. F. and Zeigler, G.R. (1997). Rheological properties of nonfat yoghurt stabilized using *Lactobacillus delbrueckii subspp. bulgaricus*. J. Dairy Sci., 80: 252.

Hui-Ru, Y. ; Shaoh ua, H. and Yingli,Y. (2002). The extraction and purification of inulin. Natural product Research and development. 14: 65.

Kalab, M., Allan-Wojtas, P and Phipps-Todd, B.E. (1983). Development of microstructure in set-Styl nonfat yoghurt- A review. Food Microstructure 2:51-66.

Kim, E.R., Lee, K.W., Park, Y.H. and Kwak, H.S. (1993). The study of lactic acid bacteria in yoghurt during delivery and storage. Korean Journal of Dairy Science, 14, 260–263.

Kosikowski, F. V. (1978). Cheese and Fermented Milk Food. 2nd Ed., Published by the author, Cornell Univ., Ithaca, New York, USA.

Lees, G.J and Jago, G. R. (1969). Methods for the estimation of acetaldehyde in cultured dairy products. Australian J. Dairy Techno., 24: 181.

Lim, K.S., Huh, C.S., Baek, Y.J. and Kim, H.U. (1995). A selective enumeration medium for bifidobacteria in fermented dairy products. Journal of Dairy Science, 78: 2108.

Ling, E.R. (1963). A Text Book of Dairy Chemistry. Vol. 11, Practical. 3rd Ed. Chapman and Hall, London., UK.

Marshall, V. M. and Rawson, H. L. (1999). Effects of exopolysaccharide-producing strains of thermophilic lactic acid bacteria on the texture of stirred yoghurt. International Journal of Food Science and Technology, 34: 137.

Medina, L.M. and Jordano, R. (1994). Survival of constitutive micro flora in commercially fermented milk containing bifidobacteria during refrigerated storage. Journal of Food Protection, 56: 731.

Niness, KR (1999). Inulin and oligofructose: what are they? Journal of Nutrition 129: S1402.

NRC (National Research Council)(1989). Diet and health implication for reducing chronic disease risk. Common diet and health, food and Nutr. Board, commission on life sciences Nat., Res., Council National Academy Press. Washington, D.C. U. S. A.

Ohmes, R.L. ; Marshall, R. T. and Heymann, H. (1998). Sensory and physical properties of ice creams containing milk fat or fat replacers. J. Dairy Sci., 81: 1222.

Pátkai, Gy. and Barta, J. (2002). Nutritive value of different Jerusalem artichoke varieties.9Th Seminar on Inulin, 18-19 April2002, Budapest/Hungary.

Perrin, S., Fougnies, C., Grill, J.P., Jacobs, H. and Schneider, F. (2002). Fermentation of chicory fructo-oligosaccharides in mixtures of different degrees of polymerization by three strains of bifidobacteria. Canadian Journal of Microbiology, 48: 759.

Ramaswamy, H. S., and Basak, S. (1992). Pectin and raspberry concentrate effects on the rheology of stirred commercial yogurt. Journal of Food Science, 57, 357–360.

Rashed, M. A. (1982). The influence of storage time and temperature on the characteristics of the raw milk. Ph.D. Thesis, Univ. of Agric. Sci. Godollo, Hungary.

Roberfroid, M.B., Van Loo, J.A E. and Gibson, G.R. (1998). The bifidogenic nature of chicory inulin and its hydrolysis products. J. of Nutrition, 128: 11.

Salama, F. M. (1993). Chemical and organoleptical properties of biogarde from lactose-hyrolysed milk. Egyptian J. Dairy Sci. 21:273.

Salem, A.S.; Abdel-Salam, A. M and El- shibiny, S. (2003). Preparation and properties of low fat and low sugar functional ice cream varieties. Egyptian J. Dairy Sci. 31:399.

Schaller-povolny, L. and Smith, D.(1999). Sensory attributes and storage life of reduced fat ice cream as related to inulin content. J. Food Sci. 64: 555.

Schorr-Galindo, S.; Fontana, A. and Guiraud, J.P. (1995). Fructose syrups and ethanol production by selective fermentation of inulin. Current Microbiology, 30: 325.

Shahani, K. M., and R. C. Chandan. (1979). Nutritional and health-ful aspects of cultured and culture-containing dairy foods. J. Dairy Sci. 62:1685.

Shin, H.S., Lee, J.H., Pestka, J.J. and Ustunol, Z. (2000).Growth and viability of commercial Bifidobacterium spp. in skim milk containing oligosaccharides and inulin. Journal of Food Science, 65: 884.

Spiegel, J., Rose, R., Karabell, P., Frankos, V. and Schmitt D. 1994. Safety and Benefits of fiuctooligosaccharides as food ingredients. Food Technol. 48(1):85.

Steel, R.G. and Torrie, J.H. (1980). Principles and procedures of statistics. Abiometrical approach. 2nd Ed. (pp. 120) McGraw-Hill Book Co., New York, USA.

Tamime, A. Y; Marshall, V. M. and Robinson, R. K. (1995). Microbiological and technology aspects of milks fermented by bifidobacteria. J. Dairy Res., 62: 151.

Terry, H., Rupnow, J., Boeckner, L. and Schnepf, M. (1999). Influence of long - and short - chained inulin on the firmness and sclerosis of nonfat yogurt. IFT Annual Meeting Technical Program Abstracts. 658-23, 178.

Tharmaraji, N. and Shah, N.P. (2003). Selective enumeration of *Lactobacillus bulgaricu, Streptococcus thermophilus*, Bifidobacteria, *Lactobacillus casei* and Propionibacteria. J. Dairy Sci., 86: 2288.

Tungland, B. (2000). A call for dietary fiber status for inulin. Cereal foods World. 45: 413.

Vinderola, C.G., Bailo, N. and Reinheimer, J.A. (2000). Survival of probiotic microflora in Argentinean yoghurts during refrigerated storage. Food Research International, 33: 97.

Wang, S.T.;Barringer, S.A. and Hansen, P.M.T. (1998). Effects of carboxy-methyl-cellulose and guargum on ice crystal propagation in a sucrose-lactose solution. Published by El-Sevier Science Ltd. Food Hydrocollloids 12: 211.

Xu, S. Y.; Stanley, D. W.; Goff, H. D.; Davison, V. J. and Le Marguer, M. (1992). Hydrocolloid/milk gel formation and properties. Journal of Food Science, 57: 96.

استخدام مسحوق الطرطوفة و الانيولين كبديل لدهن اللبن لتحسين جودة الزبادي- bifidium (الحيوي)

عزة البازº و سحر عبد الهادي°°

ºمعهد بحوث الإنتاج الحيواني- مركز البحوث الزراعية - مصر

°° قسم الصناعات الغذائية، كلية الزراعة بكفر الشيخ، جامعة طنطا

تهتم الدراسة الحالية بالأغذية الوظيفية لمالها من أهمية غذائية و صحية وحيث تم تدعيم الزبادي المصنع من لبن خالى من الدهن باستخدام *B.bifidum* مع بادئ الزبادي بإضافة مسحوق الطرطوفة (خرشوفة القدس) والأنيولين المستخلص منها بنسب ٣% ، ٦% وقد أوضحت النتائج أن استخدام الطرطوفة و الانيولين بالنسب المختلفة أدى إلى زيادة البروتين و الجوامد الصلبة و الرماد للزبادي الناتج الطازج أما بالنسبة للحموضة و الـ pH فزادت معنويا مع إضافة الطرطوفة و الانيولين بنسبة ٦%. أدى استخدام الطرطوفة و الانيولين إلى زيادة محتوي الزبادي الناتج من الاستالدهيد و الأحماض الدهنية الطيارة الكلية بالمقارنة بالزبادي المقارنة أما خلال التخزين انخفض محتوى الاستالدهيد بعد ٤ أيام من التخزين والعكس بالنسبة الأحماض الدهنية الطيارة الكلية فكانت تزيد خلال فترات التخزين المختلفة. أما بالنسبة لحبوبة بكتريا *B.bifidum* *Lb. bulgaricus, فكانت تزيد بإضافة الانيولين* بنسب ٣% ، ٦% لاستخدامه كـ prebiotic مقارنة بالمعاملة بدون إضافة ولكن انخفضت قليلا خلال فترات التخزين المختلفة إلا أنها احتفظت بالمستوى الحيوي المؤثر صحيا(١٠ ٧). أدى التدعيم بمسحوق الطرطوفة و الانيولين بنسبة ٦% الى زيادة قوة جذب الخثرة و إنخفاض معدلات انفصال الشرس في الزبادي الناتج الطازج. و قد أظهرت نتائج التحكيم الحسى و التى اشتملت على القوام و المظهر بالإضافة إلى الصفات الريولوجية ان استخدام مسحوق الطرطوفة والانيولين بنسبة ٦% حسنت من النكهة و القوام والتركيب لدرجة أنها تقاربت مع زبادي المقارنة المصنع من لبن ٣%دهن.