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PREPARATION AND PROPERTIES OF BIFIDUM-ZABADY FERMENTED MILK USING JERUSALEM ARTICHOKE AND INULIN POWDER AS A FAT SUBSTITUTE

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ABSTRACT: *The objective of this work is to study the effects of different levels of Jerusalem artichoke tubers powder (JAP) and its extracted inulin on starter microorganism. Sensory and rheological properties of fat free zabady and zabady fermented with a mixed culture of S. thermophilus, Lb. delbruckii subsp bulgaricus and B. bifidum during 12 days storage at 7±2°C were studied. The results obtained from the study revealed that: The pH diminishing and the acidity augmention during the storage, 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 treatments with control without fat. Acetaldehyde content slightly increased during storage for about 4 days, then decreased there after. The use of 6% Jerusalem artichoke powder (JAP) or inulin in the preparation of bifidum-Zabady fermented milk resulted in the elevation of Total Volatile fatty acid (TVFA) in the fresh products. The TVFA gradually increased in bifidum-Zabady from different treatment 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 different ($p<0.05$) from the initial counts. It should be noted that, the addition of JAP and inulin powders to fermented milk, significantly increased the viability of B. bifidum bacteria. However,the addition of inulin (3 and 6%) to milk who more effective than the addition of JAP (3 and 6%) through 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. In relation to 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 the production of such important foods.*

Key words: *Bifido bscteriumm bifidum, irulin, jerusalen artichoice.*

INTRODUCTION

One of the important categories of functional food is low fat products, particularly low fat dairy products in order to combat obesity, heart disease and hypertension (NRC. 1989). The 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 a rich source of inulin which comprises 60-70% of its dry matter (Hui RU *et al.,* 2002). Inulin is used as a food ingredient for a variety of reasons including 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 a 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 replace 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 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 consists of 80% fructose and 20 % glucose. Since it is hard to digest for humans, it functions as a dietary fibre.

Inulin has a neutral taste, is 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 fibers, 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. Yoghurt 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 of yoghurt manufactured in Egypt. The best is made from buffalo's,the though it can be made from cow's milk or from a mixture of two milks. Yoghurt is one of the dairy products, which should continue to increase in sales due to diversification in the range of yoghurt-like products, including reduction in fat content yoghurts, probiotic yoghurts, yogurt shakes, drinkable yoghurts, yogurt mousse, yoghurt 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. Wafaa *et al.,* (2010) Found that, addition of inulin caused asignificat decrease in lactose, tittratable acidity, and syneriss while total solids, ash and viscosity were increased..Furthermore, tittratable acidity, synerissand penetration were decreased during storage of the yoghurt.

El-Nagar and Brennan (2001) found that fat free zabady containing 2% inulin was superior to other fiber addition (Carbox-methyl cellulose and pen fiber), it has an acceptable consistency and smooth texture. Examples of probiotics are certain brands of yoghurt and acidophilus milk. An example of a prebiotic is a food containing inulin or oligofructose, which stimulate the 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 have 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 the extraction inulin it as fat replace and 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 from Dairy Science Department, Faculty of Agriculture at Kafr El-Sheikh, 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*) that harvested in October 2012 were provided from the Laboratory of *Food Technology Research Institute* Sakha Agric. Res. Station.

Inulin: Inulin was isolated from the tubers of Jerusalem artichoke (*Helianthus tuberosus*) in the Laboratory of *Food Technology Research Institute* Sakha Agric. Res. Station.

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 85ºC for 30 min and blended, then dried freezing in a freeze- drier.. The recovered powder was kept in polyethylene bags and stored at 7±2ºC in a refrigerator until used. The composition of Jerusalem artichoke tubers powder (JAP)were: Moisture 6.53, total carbohydrates 86.33, inulin 71.58, curd protein 7.51, Ether extract 0.63, Curd fiber7.34 and ash 5.11%. Percentages were as on dry weight basis

Extraction of 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 dried freezing in a freeze- drier. Inulin powder was placed in polyethylene bags and stored in a refrigerator at 7±2ºC until used. The composition of inulin: Moisture3.70, inulin 97.55, curd protein 0.50, Ether extract 0.40, Curd fiber 1.40 and ash 0.70 %. Percentages were as on dry weight basis

Preparation of fermented milk: The milk was divided into 6 portions: Jerusalem artichoke powder (3 and 6%), inulin powder (3 and 6%)added, one portion used as a control without fat and without additive. 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 were 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 were determined at room temperature (25-30ºC) 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 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 enumerated using the pour plate technique. The counts of *S. thermophilus* were enumerated on ST agar after incubating the plates aerobically at 37ºC for 24h. MRS agar adjusted to pH 5.2, and incubation at 40ºC 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 37ºC 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 & 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	13.41^{B}	3.19^{A}	0.64^{A}
CNF	10.69^{A}	3.32^{AB}	0.78^{B}
JAP 3%	13.50^{B}	3.33^{AB}	0.80^{C}
JAP 6%	16.21^{D}	3.43^{C}	0.88^{D}
Inulin 3%	14.22^{C}	3.72^{D}	0.74^{B}
Inulin 6%	19.36^{E}	4.14^{E}	0.77^{B}

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 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 of 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 with storage in all resultant Zabady (Table 2). The 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 qf JAP(3%) and inulin (3%) showed the lowest acidity while the addition JAP(6%) and inulin (6%) showed the highest acidity for fresh products. Titratable acidity increased during storage period in all treatments and this may be due to the starter culture activity. The increase in acidity content 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 the 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 (days).

Product	Storage period (days)			
	Fresh*	4	8	12
pH				
CF	4.14^{Aa}	4.08^{Aa}	4.04^{Aa}	4.02^{Aba}
CNF	4.09^{Ab}	4.12^{Ac}	4.09^{ABb}	4.05^{ABCa}
JAP 3%	4.14^{Aa}	4.06^{Aa}	4.08^{ABa}	4.06^{BCa}
JAP 6%	4.16^{Aa}	4.04^{Aa}	4.13^{Ba}	4.07^{Ca}
Inulin 3%	4.50^{Bc}	4.42^{Bbc}	4.30^{Cb}	4.12^{Da}
Inulin 6%	4.72^{Cc}	4.52^{Bb}	4.10^{ABa}	4.01^{Aa}
Acidity (%)				
CF	0.71^{ABa}	0.81^{ABab}	0.96^{BCb}	1.00^{BCb}
CNF	0.63^{Aa}	0.75^{Aab}	0.83^{Abc}	0.91^{Ac}
JAP 3%	0.77^{Aba}	0.94^{Bb}	1.00^{Bcb}	0.96^{ABCab}
JAP 6%	0.91^{a}	0.94^{Bab}	1.08^{Cb}	1.02^{BCb}
Inulin 3%	0.82^{ABa}	0.89^{ABb}	0.93^{Bb}	0.94^{ABb}
Inulin 6%	0.91^{Ba}	0.88^{ABb}	1.00^{BCb}	1.03^{Cb}

*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 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 changes in the TVFA during storage period are showen 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 of JAP(6%) and inulin (6%) in the preparation of synbiotic-Zabady fermented milk resulted in the 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 to other treatments. There was a gradual increased 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 products 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.

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 (days).

Product	Storage period (days)			
	Fresh*	4	8	12
Total volatile fatty acids (ml 0.1N NaOH/100g)				
CF	6.55^{Aa}	8.05^{Ab}	10.31^{Ac}	13.37^{Ad}
CNF	7.61^{Ba}	9.54^{Bb}	12.23^{ABc}	14.19^{ABd}
JAP 3%	7.89^{BCs}	10.05^{Bb}	13.46^{Cc}	15.00^{Bd}
JAP 6%	8.44^{Ca}	9.61^{Ba}	13.31^{Cb}	15.02^{Bc}
Inulin 3%	8.01^{BCa}	10.04^{Bb}	11.90^{Bc}	14.90^{Bd}
Inulin 6%	8.54^{Ca}	10.05^{Bb}	12.31^{ABc}	14.20^{ABd}
Acetaldehyde (µmol/100g)				
CF	63.95^{Ab}	85.40^{Bb}	48.72^{Aa}	46.15^{Aa}
CNF	61.65^{Ab}	68.72^{Ab}	54.70^{ABa}	54.33^{Ba}
JAP 3%	64.33^{Aab}	62.00^{b}	50.92^{Aa}	55.71^{BCab}
JAP 6%	72.25^{Bc}	66.01^{Ab}	59.62^{BCb}	48.80^{Aa}
Inulin 3%	63.38^{Cab}	69.23^{Ab}	64.24^{Cab}	58.00^{BCa}
Inulin 6%	76.35^{Bb}	90.53^{Bc}	71.16^{Db}	59.01^{Ca}

*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 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 $p<0.05$.

The addition of inulin (6%) and the control with fat had more acetaldehyde content than treatments with turn were 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).

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 present in Table (4). It was observed from the presented data that, the 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 decreased 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 observations were 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, the addition of inulin (3 and 6%) to the milk was 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 control with fat (CF)and control without fat (CNF). The viability of bacteria in Bifidum–zabady during storage was higher when it was grown in the 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 well above the recommended limit of cells per gram of fermented milk up to 8 days of storage period. These results were consistent with previous reports on the ability of Frucooliogsaccharide (FOS) to stimulate the viability of bifidobacteria in the reconstituted non fat dried milk during 4 weeks of refrigerated at 4^{o}C. FOS was the most effective prebiotic among the carbohydrate sources tested and the effect of FOS increased the carbohydrate concentration (maxinmal at 5%) (Shin *et al.,* 2000). 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).

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

Product	Storage period (days)			
	Fresh*	4	8	12
Str. thermophilus (log CFU/gm)				
CF	10.52^{Cb}	10.37^{Db}	10.37^{Db}	9.13^{A}
CNF	10.30^{BCc}	10.18^{CDbc}	9.36^{Cb}	6.50^{A}
JAP 3%	10.02^{Ad}	8.73^{Bc}	7.41^{Ab}	7.74^{A}
JAP 6%	10.42^{BCd}	9.49^{BCDc}	7.98^{Bb}	6.20^{A}
Inulin 3%	10.16^{ABb}	10.01^{Db}	7.28^{Aa}	6.51^{A}
Inulin 6%	10.14^{ABc}	9.23^{BCb}	7.20^{Aa}	7.00^{A}
L.delbruckii ssp. bulgaricus (log cfu /gm)				
CF	7.50^{Bc}	6.24	5.10^{Aa}	4.80^{Aa}
CNF	5.92^{Ac}	6.71^{Bc}	6.00^{Bb}	4.92^{ABa}
JAP 3%	7.82^{Cc}	6.16^{Ab}	6.00^{Bb}	4.13^{ABa}
JAP 6%	8.00^{Cd}	6.80^{Bc}	6.10^{Bb}	5.29^{ABa}
Inulin 3%	7.32^{Bc}	7.06^{Cc}	6.54^{Cb}	5.37^{Ba}
Inulin 6%	8.22^{Dd}	7.71^{Dc}	7.10^{Db}	5.86^{Ca}
B. bifidum (log cfu/gm)				
CF	7.22^{Ac}	5.85^{Ab}	5.64^{Bb}	4.85^{Aba}
CNF	7.15^{Ac}	6.21^{Bb}	4.80^{Aa}	4.62^{Aa}
JAP 3%	8.20^{Bd}	6.75^{Cc}	6.00^{Bb}	5.12^{BCa}
JAP 6%	8.00^{Bd}	6.88^{Dc}	6.24^{BCb}	5.31^{Ca}
Inulin 3%	8.16^{Bc}	7.00^{Eb}	6.70^{Ca}	6.42^{Da}
Inulin 6%	8.61^{Cc}	7.56^{Fb}	7.53^{Db}	6.69^{Da}

*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 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 $p<0.05$.

Effect of Fortification 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 Schmictt (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 Rawoson (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. Schalllerpvonly 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). Increased separation of whey from the resultant Zabady was observed in the control without fat , which may be to low total solids. In all treatments (Table 5) increased levels of Jerusalem artichoke and inulin powder increased 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) that the exopolysaccharides reduced syneresis when used in yoghurt. Also, the syneresis decreased by increasing the fibers level (El-Nagar and Brennen, 2001).

These results might be due to the 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). The 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 were 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.

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	38.80^{B}	14.90^{C}	16.90^{E}	19.90^{D}	21.90^{D}
CNF	30.58^{A}	17.40^{D}	21.40^{F}	23.40^{E}	23.40^{E}
JAP 3%	54.16^{E}	9.90^{B}	14.40^{D}	19.40^{D}	19.40^{C}
JAP 6%	57.18^{F}	9.90^{B}	11.40^{C}	13.90^{C}	14.40^{B}
Inulin 3%	47.87^{C}	9.40^{B}	9.90^{B}	10.90^{B}	10.40^{A}
Inulin 6%	51.41^{C}	7.40^{A}	8.40^{A}	8.90^{A}	9.90^{A}

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 for 3 replicates. Means with different superscript capital letters are significantly different at p<0.05.

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.

As given in Table (6), it should be noted that, no significant sensory differences were found between the control with fat and fermented milk added with 6% of JAP and 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 (Blomsna, 1997and Adapa and Schmictt, 1998). However, El-Nagar and Brennen, (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. This 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'.

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	53.08^{B}	24.74^{B}	8.25^{B}	88.27^{B}
CNF	47.40^{A}	22.23^{A}	7.34^{A}	76.97^{B}
JAP 3%	51.00^{B}	23.89^{AB}	7.57^{A}	82.46^{B}
JAP 6%	51.69^{B}	25.25^{B}	8.35^{B}	85.29^{B}
Inulin 3%	51.20^{B}	23.60^{AB}	7.40^{A}	82.20^{B}
Inulin 6%	50.40^{B}	25.60^{B}	8.16^{B}	84.16^{B}

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 for 3 replicates. Means with different superscript capital letters are significantly different at $p<0.05$.

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اعداد و خصائص الزبادى الحيوى باستخدام مسحوق الطرطوفة والانيولين كبديل للدهن

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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 معنوياً مع إضافة الطرطوفة و الانيولين بنسبة ٦%، أدى استخدام الطرطوفة و الانيولين إلى زيادة محتوي الزبادي الناتج من الاستالدهيد والأحماض 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. بالنسب لحيوية بكتريا *Lb. bulgaricus, B.bifidum* *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 صحياً (١٠ ^{٧}). أدى التدعيم بمسحوق الطرطوفة و الانيولين بنسبة ٦% الى زيادة قوة جذب الخثرة وإنخفاض معدلات انفصال الشرس في الزبادي الناتج الطازج. و قد أظهرت النتائج لتحكيم الحسى و التى اشتملت على القوام و المظهر بالإضافة إلى الصفات الريولوجية ان استخدام مسحوق الطرطوفة والانيولين بنسبة ٦% حسنت من النكهة والقوام والتركيب لدرجة أنها تقاربت مع زبادي المقارنة المصنع من لبن ٤% دهن.