An attempt to produce a complete nutritional product for bariatric surgery patients from probiotic fermented milk fortified with some natural additives

Fatema hanem Abd El Moneem Hassan Aly
Home Economics Department, Faculty of Specific Education, Zagazig University.
Hany Helmy Mohamed
Home Economics Department, Faculty of Specific Education, Zagazig University.
Mohamed Saleh Ismail
Home Economics Department, Faculty of Specific Education, Menoufia University.
Ahdab Abdo El Maadawy
Home Economics Department, Faculty of Specific Education, Zagazig University.
Abdelrahman Mohamed Amin Sarhan
General Surgery Department - Faculty of Medicine - Zagazig University.

المجلة العلمية المحكمة لدراسات وبحوث التربية النوعية

المجلد الحادى عشر– العدد الثاني– مسلسل العدد (٢٩)– أبريل ٢٠٢٥م

رقم الإيداع بدار الكتب ٢٤٢٧٤ لسنة ٢٠١٦

ISSN-Print: 2356-8690 ISSN-Online: 2974-4423

موقع المجلة عبر بنك المعرفة المصري https://jsezu.journals.ekb.eg

البريد الإلكتروني للمجلة E-mail JSROSE@foe.zu.edu.eg

An attempt to produce a complete nutritional product for bariatric surgery patients from probiotic fermented milk fortified with some natural additives

Hany Helmy Mohamed
Home Economics Department, Faculty of Specific Education, Zagazig University.

Mohamed Saleh Ismail
Home Economics Department, Faculty of Specific Education, Menoufia University.

Ahdab Abdo El Maadawy
Home Economics Department, Faculty of Specific Education, Zagazig University.

Abdelrahman Mohamed Amin Sarhan
General Surgery Department - Faculty of Medicine - Zagazig University.

Fatema hanem Abd El Moneem Hassan Aly
Home Economics Department, Faculty of Specific Education, Zagazig University.

تاريخ الرفع ٢٥-٢-٢٠٢٥م   تاريخ التحكيم ١٦-٣-٢٠٢٥م
تاريخ المراجعة ١٠-٣-٢٠٢٥م   تاريخ النشر ٧-٤-٢٠٢٥م

Abstract

Bariatric surgery leads to significant weight loss and improvement of obesity-related diseases. Despite the benefits of these operations, deficiency of vitamins and other micronutrients is common. Therefore, the aim of this research was to try to produce a nutritional product from fermented milk fortified with some natural additives to meet the nutritional needs of bariatric surgery patients. Three treatments of fermented cow's milk were manufactured, the first treatment was lactose-free fermented cow's milk fortified with vitamin D and sweetened with 10% date molasses (control treatment), the second treatment was the fermented milk in the first treatment but cow's milk was replaced with 25% barley milk, while the third treatment was the fermented milk in the first treatment but cow's milk was replaced with 50% barley milk. The chemical, sensory and bacteriological properties of the resulting bio-fermented milk treatments were estimated, as well as the contents of the most important nutritional elements that are deficient after bariatric surgery, such as vitamins A, D, K, E, B1, B12, iron, calcium, zinc, copper and selenium. As compared with the daily needs, and the amount that the prepared meal weighing 100 grams contributes to the management of common micronutrient deficiencies after bariatric surgery. The results showed that all the treatments of the resulting fermented milk were sensory acceptable to the judges and had a high nutritional value in terms of their content of total solids, protein, dietary fiber and carbohydrates, in addition to their high content of nutrients that are deficient after bariatric surgery such as vitamins A, D, K, E, B1, B12, iron, calcium, zinc, copper and selenium. The third treatment containing 50% barley milk gave the best results compared to the rest of the treatments. When compared to the daily nutritional needs recommended for healthy people, it was found that consuming 200 grams of it daily provides almost most of the nutritional needs necessary for healthy individuals. Therefore, this product may be suitable for feeding bariatric surgery patients after 12 months of surgery and that it meets most of their daily nutritional needs.

Keywords: bariatric surgery, fermented milk, nutritional value, bacteriological properties.

محاولة انتاج منتج غذائي متكامل لمرضي جراحة السمنة من اللبن المتخمر الحيوي المدعم ببعض الاضافات الطبيعية

الملخص

تؤدي جراحة السمنة إلى فقدان الوزن بشكل ملحوظ وتحسين الأمراض المصاحبة للسمنة. وعلى الرغم من الفوائد التي تتحقق من هذه العمليات، فإن نقص الفيتامينات والمغذيات الدقيقة الأخرى أمر شائع. لذا كان الهدف من هذا البحث هو محاولة انتاج منتج غذائي من اللبن المتخمر المدعم ببعض الاضافات الطبيعية ليلبي الاحتياجات الغذائية لمرضي جراحة السمنة . حيث تم تصنيع ثلاث معاملات من اللبن البقري المتخمر ، المعاملة الأولي تم فيها تصنيع اللبن البقري المتخمر المحلل اللاكتوز والمدعم بفيتامين د والمحلي ب ١٠ % دبس التمر (معاملة تحكم)، المعاملة الثانية هي عبارة عن اللبن المتخمر في المعاملة الاولي ولكن مستبدل فيه اللبن البقري ب ٢٥ % من لبن الشعير اما المعاملة الثالثة هي عبارة عن اللبن المتخمر في المعاملة الاولي ولكن مستبدل فيه اللبن البقري ب ٥٠ % من لبن الشعير.تم تقدير الخواص الكيميائية والحسية والبكتريولوجية لمعاملات اللبن المتخمر الحيوي الناتج ،كما تم تقدير محتويات أهم العناصر الغذائية التي يحدث بها نقص بعد عمليات جراحة السمنة مثل فيتامين أ ،د، ك ، هـ ، ب١ ، ب١٢ ، الحديد ، الكالسيوم ، الزنك ، النحاس والسلينيوم . ومقارنتها بالاحتياجات اليومية، والكمية التي تساهم بها الوجبة المحضرة التي تزن ١٠٠ جرام لإدارة نقص التغذية الدقيقة الشائعة بعد جراحة السمنة. ولقد اظهرت النتائج ان معاملات اللبن المتخمر الحيوي الناتج كانت جميعها مقبولة حسيا لدي المحكمين وذات قيمة عذائية عالية من حيث محتواها من الجوامد الصلبة الكلية والبروتين والالياف الغذائية والكربوهيدرات ، هذا بالاضافة الي محتواها المرتفع من العناصر الغذائية التي يحدث بها نقص بعد عمليات جراحة السمنة مثل فيتامين أ ،د، ك ، هـ ، ب١ ، ب١٢ ، الحديد ، الكالسيوم ، الزنك ، النحاس والسلينيوم واعطت المعاملة الثالثة المحتوية علي ٥٠ % لبن الشعير أفضل النتائج مقارنة بباقي المعاملات وبمقارنتها بالاحتياجات الغذائية اليومية الموصي بها للأصحاء وجد ان استهلاك ٢٠٠ جرام منها يوميا يوفر تقريبا معظم الاحتياجات الغذائية اللازمة للافراد الاصحاء. لذا قد يكون هذا المنتج ملائم لتغذية مرضي جراحة السمنة بعد مرور ١٢ شهر من اجراء الجراحة وانه يوفي معظم الاحتياجات الغذائية اليومية لهم.

Introduction

In developed nations, the prevalence of obesity is steadily rising (**NCD Risk Factor Collaboration, 2016**). A recent study by Webber et al. predicts that by 2030, Europe will be dealing with a massive obesity issue (**Webber *et al*., 2017**). According to **Upadhyay *et al*., (2018),** obesity is a chronic illness that increases the risk of numerous consequences, such as type 2 diabetes, cardiovascular disease, various malignancies, and cognitive impairment.

According to **Sjöström, (2013),** bariatric surgery is thought to be the most successful long-term treatment for morbid obesity. Various bariatric surgical techniques have been developed. The most popular procedures are the sleeve gastrectomy (SG), an irreversible restrictive treatment, the Roux-en-Y gastric bypass (RYGBP), a restrictive and malabsorptive reversible procedure, and adjustable gastric banding (AGA), a restrictive adjustable reversible procedure.

According to **Angrisani *et al*,. (2015),** the two latter procedures are currently the most common in both Europe and the USA. They can ameliorate comorbidities, particularly type 2 diabetes, and cause a large and long-lasting reduction in body weight (**Adams *et al*., 2017**). Because RYGBP is a malabsorptive and restrictive operation, it may result in shortages in some vitamins and micronutrients.

Thus, in the setting of vitamin shortages following bariatric surgery, particularly following RYGBP, major neurologic problems have been reported (**Zheng *et al*., 2016: Verger *et al*., 2016**). Despite the fact that SG is merely a restrictive treatment, recent research indicates that vitamin deficits may potentially develop following SG (**Coupaye *et al*., 2014**). Few studies have evaluated vitamin deficit following bariatric surgery based on the kind of procedure, such as RYGBP or SG (**Coupaye *et al*., 2014**). Additionally, there hasn't been much research done in tandem on the consumption of micro- and macronutrients and nutritional biological state.

Significant weight loss and alleviation of comorbidities related to obesity are the outcomes of bariatric surgery (BS). Vitamin and other micronutrient shortages are frequent, despite the benefits of these operations. If these inadequacies are not identified and treated in a timely manner, they could become clinically serious. Thus, in order to make BS a safer treatment, it is essential to do thorough screening and have effective preventive methods in place (**Steenackers *et al*., 2023: Gasmi *et al*., 2023**).

The primary components of milk include proteins, fats, water, lactose, and salts. These components also define the milk's nutritional and commercial worth. Its biological and technological qualities are determined by hundreds of additional ingredients, including vitamins, minerals, enzymes, dissolved gases, and other lipids, all of which are present in lower quantities than its primary constituents (**Chandan, 2009**). Catalase, phosphatase, and lipase are the enzymes that are present. Casein (αS1-Casein, αS2-Casein, β-Casein, κ-casein) is a kind of milk protein. A casein and gamma-lactoglobulin are examples of whey proteins. Proteins, lactose, minerals (calcium, magnesium, and potassium), vitamins (A, B1, B2, C, and D), and other substances and minerals are all found in milk, which is essentially a fat emulsion. According to **Fao, (2013),** solids make up 13% of milk, fat is 4%, protein is 3.5%, and lactose is 5%. Milk is not homogeneous. Some of these ingredients, such as fat, can be separated from the rest of the milk mechanically (**Malbon, 2007**). A diet rich in nutrients, cow milk satisfies nearly every requirement of the human body. Specifically, it is made up of calcium, phosphate, lipids, proteins, lactose, and vitamins (mostly D and B2). It has a lot of calcium and lysine, which is an amino acid that's frequently lacking in plant proteins. Calcium and phosphorus are the minerals' main constituents, which facilitate the body's absorption of them (**Mantis, 2018**).

Live bacteria, typically *Lactobacillus bulgaricus* and *Staphylococcus thermophilus*, acidify and ferment probiotic-fermented milks and yoghurts, producing a thicker product with an extended shelf life. They are a high-nutrient food that is an excellent source of potassium, calcium, phosphorus, and vitamins A, B2, and B12. They also supply vital fatty acids and proteins with significant biological significance. A growing body of research indicates that yoghurt and fermented milk consumption has several health benefits, such as promoting gut health and immune system modulation, as well as preventing osteoporosis, diabetes, and cardiovascular diseases (**Hadjimbei *et al*., 2022: Zhang *et al*., 2023**). Over time, prebiotics, probiotics, and synbiotics have drawn more and more attention due to their advantageous effects on the gut flora and their systemic anti-inflammatory properties. Also, it has been demonstrated that they enhance surgical results (**Trone *et al*., 2023**).

The fourth-biggest grain crop in the world is barley. It is mostly utilised for food production, feeding, and making beer. Scientists studying agriculture and food science are paying more attention to barley due to its unique chemical makeup and potential health benefits. Barley grains are higher in tocols and dietary fibre (such β-glucan) than other cereal crops like wheat, rice, and maize. These nutrients are good for human health. Diets high in such compounds have been shown to protect against diabetes, hypertension, and cardiovascular disease. It is commonly acknowledged that barley has a lot of promise for use as a nutritious or useful food (**Geng *et al*., 2021: Geng *et al*., 2022**). Thus, the aim of the study was attempting to produce an integrated food product that suits the nutrition of bariatric surgery patients.

Materials and Methods:

Materials

Fresh whole cow's milk was obtained from Dairy Technology Unit, Food Science Department, Faculty Agric., Zagazig Univ. Date syrup was obtained from local market in El-Sharkia Governorate. Grain barley (Hordeum vulgare) was obtained from the Agriculture Research Center's experimental farm in Giza, Egypt, and kept at 4ºC to prevent compositional changes.. An enzyme Ha-lactase® and starter cultures containing *Bifidobacterium bifidum* B-12 strains as probiotic strain and *Streptococcus salivaris* ssp *thermophillus* and *Lactobacillus bulgaricus* as a yoghurt starter were obtained from Hansen's Laboratories Copenhagen/ Denemark. Solvents of HPLC grade were employed in the analysis. Acetonitrile and methanol of analytical reagent quality were procured from Lab-Scan (Tedia Company, USA). Millipore, Molsheim, France, used a Millipore Simplicity device to prepare the water used for HPLC and sampling. All vitamin standards were obtained from Sigma Chemical Co. (Poole, Dorset) and were of chromatographic grade.

Methods:

Preparation of barley milks

The grains were heating at 100ºC for 30 min before grinding. The soaking was done in tap water 3x the weight of the grains. After soaking and after blanching, the grains were rinsed twice and drained. The grinding was done (Blender mill, Moulinex®, France) in tap water at differed ratios of grains to water, according to (**Salama *et al*., 2011**).

Manufacture of free lactose probiotic fermented milk:

Fresh bulk cow's milk was separated to skim-milk and cream. Cream used to standardize the percentage of milk fat. Low fat cow's milk having 1% fat was divided into 3 portions. The first portion was left without additive as a control (C), barley milk was added to the other two portions at the rate of 25 and 50 % (T1 and T2), and date syrup was added to all milk portions at the rate of 10% .All milk treatments were heated to 90 ˚C for 15 min., then, cooled to 42 ± 1 ˚C, To ensure that lactose hydrolysis had enough time to occur, 1000 IU of vitamin D3 and 4000 NLU/L of commercial Ha-lactase® were added to the milk for 30 minutes before the starter culture. Lactose hydrolysis occurs concurrently with fermentation until the pH falls to 5.5, at which point the enzyme is inactivated., inoculated with 2% of mixed (1 : 1) of yoghurt starter cultures and probiotic cultures, incubated at 42 ˚C until a uniform coagulation was obtained , the curd was refrigerated at 5±1°C overnight ,stirred with electrical mixer , filling in plastic bottles, stored at 5±1°C, and then analyzed for physicochemical, phytochemical , microbiological, and sensory properties.

Determination of Physicochemical:

Samples of probiotic fermented milk containing date syrup were analyzed for total solids, fat, total protein, fiber, and ash content following the standard methods **AOAC (2010).**

Determination of mineral content:

The content of minerals of probiotic fermented milk containing date syrup was determined according to the method described by **AOAC, (2010).** The flame atomic absorption with variant spectrophotometer (JENWAY PFP7) was used to determine the macro-elements, and micro-elements. Using atomic absorption (UNICAM 929 AA Spectrometer) using hollow cathode lamp differs according to each measured element.

Determination of Vitamins

The vitamin B group, Vitamin C, D, E, K, A, and β-Carotene was assessed by HPLC system according to (**Sami *et al*., 2014**)

Determination of total phenolic compounds (TPC):

With a few minor adjustments, total phenolic compounds (TPC) were calculated using the Folin-Cicalteau method (**Singleton *et al*., 1999**), with results expressed as mg Gallic acid (GAE) or as gallic acid equivalents in mg/g of extract. Gallic acid was used as a calibration curve..

Determination of antioxidant activity:

DPPH scavenging was used to assess the antioxidant activity of both free and bound phenolic extracts, as previously reported by (**Hung and Morita, 2009**). A mixture of 0.1 ml of the extracted solution and 3.9 ml of 0.075 mM DPPH was created. For precisely thirty minutes, the combination was kept at room temperature in the dark. Next, at 525 nm, the absorbance was measured with a spectrophotometer (6405 UV/VIS – Jenway – England). After adding 0.1 ml of methanol to the extracted solution, the blank was created and tested at T = 0.

The DPPH scavenging was calculated according to the following equation:

% DPPH scavenging= (Abs (T0) - Abs (T30) ×100)/Abs (T0)

Where: Abs. (T= 0) is absorbance of DPPH radical and methanol at T = 0 and Abs. (T=30) is absorbance of DPPH radical and extracts at T= 30.

Microbiological examinations

Total bacterial counts were measured in probiotic fermented camel milk samples that contained date syrup, in accordance with **APHA, (1992).** The International Dairy Federation's standard procedures for counting bifidobacterium on de Man-Rugosa- Sharpe agar (MRS+ 0.5 cestein; DIFCO, Heidelberg, Germany) were followed, and the experiment was conducted in anaerobic conditions for 3-5 **Laroia and Martin (1991).**

Sensory evaluation

Tamime and Robinson, (1999) reported an organoleptic examination of probiotic fermented milk. Samples received scores of 20 points for appearance, 30 points for consistency, and 50 points for flavour.

Statistical analysis:

One-way analysis of variance (ANOVA) was performed on all data using **SPSS v.20, 2012** software. Duncan's new multiple range tests were used to distinguish significant treatment means, and differences were deemed significant at ($P \leq 0.05$).

Results and discussion

Chemical composition minerals content and phytochemical properties of fresh Cow milk, Barley milk and date syrup

Table 1 shows the chemical composition, mineral content, antioxidant properties and vitamin content of the components of the fermented dairy product (cow's milk, barley milk and date syrup). The results and chemical composition showed that date syrup contained the highest percentage of total solids, ash and fibre compared to barley milk and cow's milk, while cow's milk contained the highest percentage of protein and fat compared to barley milk and date syrup. As for the mineral salt content, cow's milk showed the highest content of calcium only, while barley milk showed the highest content of phosphorus, zinc and copper, while date syrup showed the highest content of potassium, iron and selenium. In terms of vitamin C content, phenolic content and antioxidant activity, date syrup showed the highest vitamin C content, while barley milk showed the highest phenolic content and antioxidant activity, while cow's milk had the lowest vitamin C, phenolic content and antioxidant activity. Regarding vitamin content, barley milk showed the highest content of thiamine, riboflavin and niacin vitamins, while date syrup showed the highest content of pantothenic acid and vitamin B6, while in terms of vitamin D content, the highest content was in favor of cow's milk. These results are consistent with those observed by **Musa *et al.*,(2022)** for cow's milk, **Derouich *et al.*,(2020)** for date syrup and **Sorour *et al.*,(2020)** for barley milk when they studied the chemical composition and nutritional content of cow's milk, date syrup and barley milk, respectively.

Table 1. Chemical composition minerals content and phytochemical properties of fresh Cow milk, Barley milk and date syrup

Components (%)	Cow milk	Date syrup (Dips)	Barley milk
Total Solids	12.34±0.66c	80.60±1.72a	14.74±0.88b
Protein	3.82±0.5a	1.80±0.3c	3.02±0. 2b

Fat	**1.05±0.04a**	**0.96±0.02b**	**0.52±0.03c**
Ash	**0.80±0.4b**	**2.12±0.6a**	**0.84±0.5b**
Fiber	**0.0±0.0c**	**2.44±0.14a**	**1.2±0.04b**
Minerals (mg/100gm)			
Ca	**120.30±1.6a**	**72.30±1. 2b**	**50.20±1.4c**
P	**96.50±1.12a**	**55.70±1.66b**	**320.40±1.52c**
K	**120.30±1.9 c**	**268.20±2.4a**	**208.60±2. 2b**
Fe	**0.05±0.00c**	**4.82±0.12a**	**2.55±0.18b**
Zn	**0.33±0.02c**	**1.92±0.15b**	**2.62±0.16a**
Cu	**0.016±0.0c**	**0.38±0.02b**	**0.92±0.05a**
Se	**0.0018±0.0c**	**0.26±0.02a**	**0.01±0.0b**
Phytochemical properties			
Vitamin C (mg.L^{-1})	**2.22±0.18b**	**62.50±1.12a**	**0.00±0.0c**
Total phenolic (TP) mg/100g	**3.64±0.22c**	**460.20±24b**	**980.70±3. 2a**
Antioxidant activity (AO)%	**4.35±0.55c**	**71.80±1.2b**	**88.40±1.6a**
Vitamins (mg/100gm)			
Thiamine	**0.008±0.0c**	**0.08±0.0b**	**144.2±1. 2a**
Riboflavin	**0.22±0.02c**	**0.96±0.04b**	**112.5±1.4a**
Niacin	**0.11±0.01c**	**1.54±0.05b**	**4.2±0.08a**
Pantothenic acid	**0.42±0.02b**	**0.82±0.04a**	**0.22±0.02c**
Vitamin B6	**0.009±0.0c**	**0.245±0.02a**	**0.240±0.01b**
Vitamin B12 μg	**0.055±0.0a**	**0.0±0.0b**	**0.0±0.0b**
Vitamin D IU	**2.04±0.0a**	**0.0±0.0b**	**0.0±0.0ba**

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Changes in chemical composition and Minerals (mg/100gm) contents of probiotic fermented milk fortified with barley milk and date syrup

Table 2 shows the change in the chemical composition of the fermented milk fortified with barley milk and date syrup. The results showed an increase in the content of total solids, ash, fiber and carbohydrates with an increase in the percentage of replacing cow's milk with barley milk. This is due to the fact that barley contains higher percentages of total solids, ash and fiber compared to cow's milk (**Obadi *et al.*, 2021**), while the content of both protein and fat decreased with an increase in the percentage of replacement. Table 3 shows the change in the content of mineral salts in the fermented milk fortified with barley milk and date syrup. The results showed an increase in the content of phosphorus, potassium, iron, zinc, copper and selenium with an increase in the percentage of replacing cow's milk with barley milk. This is due to the fact that barley contains higher percentages of these salts compared to cow's milk (**Tilahun *et al.*, 2021**), while the calcium content decreased with an increase in the percentage of replacement. The results of the chemical composition and mineral salts content are consistent with the results approved by **Ismail *et al.*, (2018)** when they fortified fermented milk with barley flour.

Table 2: Changes in chemical composition of probiotic fermented milk fortified with barley milk and date syrup.

Treatments	**Total**	**Fat**	**Protein**	**Ash**	**Fiber**	**Car**

	solids%	%	%	%	%	%
C	20.60±0.66c	1.05±0.02a	3.94±0.34a	0.88±0. 2c	0.00±0.0c	14.73±0.92c
T1	21.14±0.78b	0.85±0.05b	3.90±0.52a	0.92±0.3b	0.55±0.02b	15.47±0.55b
T2	21.72±0.22a	0.70±0.12c	3.84±0.60a	0.98±0.2a	0.82±0.06a	16.20±0.32a

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

C: fermented milk made from cow milk as a control (C) .

T_1: fermented milk made from cow milk mixed with 25 % barley milk.

T_2: fermented milk made from cow milk mixed with 50 % barley milk .

Table 3: Minerals (mg/100gm) contents of probiotic fermented milk fortified with barley milk and date syrup

Treatments	Ca	P	K	Fe	Zn	Cu	Se
A	222.20± 1.4a	142.30± 2.3c	138.50 ±1.8c	2.46± 0.3c	0.48± 0.02c	0.04± 0.0c	0. 012±0.0c
A1	208.60± 1.9b	150.20± 2.5b	155.40 ±1.5b	3.92± 0. 2b	0.95± 0.04b	0.30± 0.02b	0. 016±0.0b
A2	194.80± 1.6c	188.60± 1.7a	172.90 ±1. 2a	4.36± 0.4a	1.40± 0.07a	0.64± 0.01a	0.028±0.0a

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

<u>Vitamins contents of probiotic fermented milk fortified with barley milk and date syrup</u>

Table 4 and 5 shows the vitamin content of the fermented milk fortified with barley milk and date syrup. The results showed an increase in the content of folic acid, thiamine, vitamin B6, vitamin B12, riboflavin, niacin, vitamin D, vitamin K and vitamin E with increasing the percentage of replacement of cow's milk with barley milk. This is due to the fact that barley contains higher levels of these vitamins compared to cow's milk (**Huang *et al*., 2020**), while the content of pantothenic acid and vitamin A decreased with increasing the percentage of replacement. It is noted that the vitamin content in the fortified fermented milk is higher than the raw materials used in its manufacture due to the ability of the starter bacteria to synthesize large amounts of vitamins during fermentation, especially the B vitamins group (**LeBlanc *et al*., 2015**).

Table 4: Vitamins B contents of probiotic fermented milk fortified with barley milk and date syrup

Treatments	Pantothenic acid mg/100g	Folate µg/ 100g	B6 mg/ 100g	B12 µg/100g	Thiamine mg/100g	Riboflavin m/100g	Niacin
A	0.68±0.02 a	170±1.2c	0.064±0.0 01c	0.86±0. 02c	0.52±0.3c	0.265±0.1c	0.214± 0. 2c
A1	0.65±0.04	184±1.5b	0.072±0.0	0.98±0.	3.20±0.6b	2.30±0.3b	1.35±0.

	b		02b	03b			1b
A2	0.62±0.02 c	200±1.8a	0.080±0.0 01a	1.06±0. 05a	6.40±0.4a	3.70±0.5a	2.60±0. 3a

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Table 5: Vitamins E, D, E, K contents of probiotic fermented milk fortified with barley milk and date syrup

Treatments	Vitamin D IU	Vitamin A IU	Vitamin K mg	Vitamin E mg
A	1000±0.6c	480±0.5a	0.04±0.002c	1.07±0.05c
A1	1004±0.8b	460±0.9b	0.06±0.001b	2.09±0.12b
A2	1012±0.7a	450±0.6c	0.09±0.002a	3.12±0.08a

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Total phenolic, Vitamin. C. contents and antioxidant activity of probiotic fermented milk fortified with barley milk and date syrup

Table 6 shows the vitamin C content, phenolic content and antioxidant activity of the fermented milk fortified with barley milk and date syrup. The vitamin C content, phenolic content and antioxidant activity increased with the increase in the percentage of replacement of cow's milk with barley milk, due to the fact that barley contains higher levels of vitamin C, phenolic content and antioxidant activity compared to cow's milk (**Wijekoon *et al*., 2022**), while the pantothenic acid and vitamin A content decreased with the increase in the percentage of replacement. The same results were observed when **Li *et al*.,(2023)** fortified fermented milk with barley flour. This significant increase in the vitamin C content, phenolic content and antioxidant activity of the fortified fermented milk compared to raw milk is due not only to the fortification with barley milk but also to the addition of date syrup, which is known to have a high content of vitamin C, phenolic content and antioxidant activity (**Shahein *et al*., 2022**).

Table 6: Total phenolic, Vitamin. C. contents and antioxidant activity of probiotic fermented milk fortified with barley milk and date syrup

Treatments	Total phenolic (TP) mg/100g	Antioxidant activity (AO) %	Vitamin. C. (mg/1000gm)
A	2.24±0.44c	8.40±0.9c	25.50±0.77c
A1	65.60±1.7b	14.60±0.87b	32.80±0.68b
A2	130.30±1.4a	22.50±0.92a	49.70±0.56a

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Total bacterial counts (Log10 cfu/ml)) of probiotic fermented milk fortified with barley milk and date syrup

Table 7 shows the total microbial content and probiotic content of the fermented milk enriched with barley milk and date syrup. An increase was observed in the total number of microbes and the number of probiotic bacteria with an increase in the percentage of replacing cow's milk with barley milk. This is due to the fact that barley milk contains substances that support the activity of probiotic bacteria, such as dietary fiber, which acts as a prebiotic (**Mio *et al*., 2021**), which increases the vitality of these probiotic microbes. Also, the date syrup contains dietary fiber and polysaccharides, which also act as a prebiotic, which can increase the number of probiotic microbes (**Shahein *et al.*, 2022**). It was observed that the number of probiotic microbes in all treatments was within the limits at which therapeutic bacteria perform their vital role, as it must be at a concentration of no less than 10^{7} / ml (**Khorshidian *et al.*, 2020**). There are many studies that have demonstrated the therapeutic importance of probiotic bacteria in terms of maintaining the microbial balance in the intestines and reducing or eliminating the risk of chronic non-communicable diseases and improving immunity and disease resistance (**Aponte *et al.*, 2020, Tegegne & Kebede,, 2022: Song *et al.*, 20223)**. This indicates the possibility of using fermented milk in feeding patients with chronic non-infectious diseases as well as patients with digestive system disorders. In the future, it is recommended to use it in feeding patients undergoing bariatric surgery (**Gasmi *et al*., 2023: Zhong *et al*., 2024**).

Table (7): Total bacterial counts (Log_{10} cfu/ml)) of probiotic fermented milk fortified with barley milk and date syrup

Treatments	Total bacterial counts (Log10 cfu/ml)	Bifidobacteria counts (Log10 cfu/ml))
A	8.123±0.02c	7.981±0.06c
A1	8.424±0.03b	8.275±0.05b
A2	8.630±0.04a	8.714±0.03a

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \le 0.05$).

Sensory properties of probiotic fermented milk fortified with barley milk and date syrup

Table 8 shows the sensory properties of the fermented milk fortified with barley milk and date syrup. A slight decrease was observed in the values of flavor, appearance and total value with increasing the percentage of cow's milk substitution with barley milk, while the texture values increased with increasing the percentage of substitution. In general, all treatments were sensory acceptable to the arbitrators and no significant differences were observed in the sensory arbitration values for all treatments. The addition of date syrup improved all the sensory properties of the fortified samples. The same results were observed by **Li *et al.*, (2023**) and **Shahein *et al.*, (2022)** when they fortified fermented milk with barley milk and date syrup, respectively.

Table (9): Sensory properties of probiotic fermented milk fortified with barley milk and date syrup

Treatments	Flavour (50)	Consistency (30)	Appearance (20)	Total (100)
A	48.0±0.52a	25.0±0.74c	18.0±0.46a	91±0.80a
A1	47.0±0.45b	27.0±0.82b	16.0±0.35b	90±0.74b
A2	46.0±0.60c	29.0±0.55a	15.0±0.42c	90±0.78b

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \le 0.05$).

Daily needs, the amount that probiotic fermented milk contributes and the necessary recommendations for management of common micro and micro nutritional deficiencies post bariatric surgery

When comparing the content of 100 grams of the probiotic fermented milk with the daily needs of a normal person and comparing it with a summary of the common micro- and micro-nutrient deficiencies in bariatric surgery patients (which is considered normal after one year of surgery), it was observed that 100 grams of the prepared product met the daily nutritional needs of both vitamin B1, folate, vitamin D and vitamin K. While if 200 grams of the prepared product were consumed, it would meet the daily nutritional needs of vitamin B1, folate, vitamin D, vitamin K, vitamin B12, vitamin A, vitamin D, iron, copper and selenium. These are among the most important elements that have common nutritional deficiencies in bariatric surgery patients (**Steenackers *et al*., 2023**). Thus, consuming 200 grams of this new product daily can meet most of the nutrients that a bariatric surgery patient needs one year after surgery (Table 10).

Table (10): Daily needs, the amount that probiotic fermented milk contributes and the necessary recommendations for management of common micro and micro nutritional deficiencies post bariatric surgery

Mico/micro deficiency	Daily needs	The amount that the 100 g prepared meal contributes	The amount that the 200 g prepared meal contributes
VitaminB1(Thiamin)	1.1-1.2 mg	6.4 mg	12.8 mg
Vitamin B12(Cobalamin)	2.4 µg	1.06 µg	2.12 µg
Folate	400 µg	1012 µg	2024 µg
Vitamin A	700-900 µg	450 µg	900 µg
Vitamin D	15.0 µg	25.3 µg	50.6 µg
Vitamin E	15 mg	3.12 mg	6.24 mg
Vitamin K	90 µg	90 µg	180 µg
Iron	8-18 mg	4.36 mg	8.72 mg
Calcium	1000 mg	194 mg	284 mg
Zinc	8.0-11 mg	1.40 mg	2.80 mg
Copper	900 µg	640 µg	1280 µg
Selenium	55 µg	28 µg	56 µg

Conclusions

In this research, an attempt was made to produce a new functional bio-fermented product from lactose-hydrolyzed cow's milk fortified with vitamin D, with barley milk added at rates of 25 and 50% and date syrup at rates of 10%. The results of the study showed that this new product has a high nutritional value and contains vital compounds that can enhance the health of the consumer. All parameters were sensory acceptable to the arbitrators. By analyzing the content of the new product in terms of nutritional elements and comparing them with the daily needs of the normal individual and with the necessary recommendations for managing of common micro and micro nutritional deficiencies post bariatric surgery, it was found that consuming 200 grams of the prepared product will meet the daily nutritional needs of both vitamin B1, folate, vitamin D, vitamin K, vitamin B12, vitamin A, vitamin D, iron, copper and selenium. These are among the most important elements that have common nutritional deficiencies in bariatric surgery patients.

References

Adams TD, Davidson LE, Litwin SE, et al. Weight and metabolic outcomes 12 years after gastric bypass. N Engl J Med. 2017;377(12):1143–55.

Angrisani L, Santonicola A, Iovino P, et al. Bariatric surgery worldwide 2013. Obes Surg. 2015;25(10):1822–32.

AOAC (2010): Associatiob of Official Analytical Chemists Official Methods of Analysis, 17th ed.,Gaithersburg, MD, USA.

APHA, AWWA, WPCE (1992) Standard Methods for examination of water and waste water, 18th ed., American Public Health Association, Washington DC.

Aponte, M., Murru, N., & Shoukat, M. (2020). Therapeutic, prophylactic, and functional use of probiotics: a current perspective. *Frontiers in microbiology*, *11*, 562048 .

Chandan, R. C. 2009. "Dairy Processing and Quality Assurance: An Overview." In *Dairy Processing and Quality Assurance*, 2nd ed., pp. 1-40.

Coupaye M, Rivière P, Breuil MC, et al. Comparison of nutritional status during the first year after sleeve gastrectomy and Roux-en-Y gastric bypass. Obes Surg. 2014;24(2):276–83.

Derouich, M., Meziani, R., Bourkhis, B., Filali-Zegzouti, Y., & Alem, C. (2020). Nutritional, mineral and organic acid composition of syrups produced from six Moroccan date fruit (Phoenix dactylifera L.) varieties. *Journal of food composition and analysis*, *93*, 103591. .

Fao. 2013. *Milk Human Nutrition Dairy Products.* www.fao.org/.

Farah Z (2011) Camel milk. In: Fuquay JW, Fox PF, McSweeney PLH, Encyclopedia of Dairy Sciences, 2nd Ed., London, UK: Academic Press, 512–517. https://doi.org/10.1016/B978-0-12-374407-4.00317-4

Gasmi , A., Bjørklund, G., Mujawdiya, P. K., Semenova, Y., Dosa, A., Piscopo, S., ... & Costea, D. O. (2023). Dietary supplements and bariatric surgery. *Critical reviews in food science and nutrition*, *63*(25), 7477-7488.

Gasmi, A., Bjørklund, G., Mujawdiya, P. K., Semenova, Y., Dosa, A., Piscopo, S., ... & Costea, D. O. (2023). Gut microbiota in bariatric surgery. *Critical Reviews in Food Science and Nutrition*, *63*(28), 9299-9314. .

Geng , L., Li, M. D., Xie, S. G., *et al*. (2021). Identification of genetic loci and candidate genes related to β-glucan content in barley grain by genome-wide association study in international barley core selected collection. *Molecular Breeding*, 41(1): 6.

Geng , L., Li, M., Zhang, G., & Ye, L. (2022). Barley: a potential cereal for producing healthy and functional foods. *Food Quality and Safety*, *6*, fyac012.

Hadjimbei, E., Botsaris, G., & Chrysostomou, S. (2022). Beneficial effects of yoghurts and probiotic fermented milks and their functional food potential. *Foods*, *11*(17), 2691.

Huang, H., Gao, X., Li, Y., Tian, P., Nima, Y., Laba, Z., ... & Liao, W. (2020). Content analysis of vitamins, dietary fibers and amino acids in a wide collection of barley (Hordeum vulgare L.) from Tibet, China. *Bioinformation*, *16*(4), 314.

Hung, P. V., and Morita, N. (2009). Distribution of phenolic compounds in the graded flours milled from whole buckwheat grains and their antioxidant capacities. Food chemistry, 109: 325-331.

Ismail, M. M., Hamad, M. F., & Elraghy, E. M. (2018). Using goat's milk, barley flour, honey, and probiotic to manufacture of functional dairy product. *Probiotics and antimicrobial proteins*, *10*, 677-691..

Khorshidian, N., Yousefi, M., & Mortazavian, A. M. (2020). Fermented milk: The most popular probiotic food carrier. In *Advances in food and nutrition research* (Vol. 94, pp. 91-114). Academic Press .

Laroia, S. and Martin, J.H. (1991): Effect of pH on survival of *Bifidobacterium bifidum* and *Lactobacillus acidophilus* in frozen fermented desserts. Cultured Dairy Products J. 26: 3-21.

LeBlanc, J. G., Laiño, J. E., del Valle, M. J., de Giori, G. S., Sesma, F., & Taranto, M. P. (2015). B-group vitamins production by probiotic lactic acid bacteria. *Biotechnology of lactic acid bacteria: Novel applications*, 279-296.

Li, K., Duan, Z., Zhang, J., & Cui, H. (2023). Growth kinetics, metabolomics changes, and antioxidant activity of probiotics in fermented highland barley-based yogurt. *LWT*, *173*, 114239 .

Malbon, K. 2007. "Neonatal Nutrition and Metabolism." *Arch Dis Child* 92 (4): F328. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2675448/.

Mantis, A., Papageorgiou, D., Fletouris, D., and Apostolos, A. 2018. *Hygiene and Technology of Milk and Its Products*, pp. 1-30.

Marco ML, Heeney D, Binda S, et al. Health benefits of fermented foods: microbiota and beyond. Curr Opin Biotechnol. 2017;44:94–102.

Mio, K., Otake, N., Nakashima, S., Matsuoka, T., & Aoe, S. (2021). Ingestion of high β-glucan barley flour enhances the intestinal immune system of diet-induced obese mice by prebiotic effects. *Nutrients*, *13*(3), 907 .

Musa, A., Bello, Z., Ibrahim, L., Musa, M., & Muhammad, I. B. (2022). Evaluation of nutrients composition, minerals, vitamins and bioactive components of camel and cow milk sold in Katsina Metropolis. *Journal of Biochemistry, Microbiology and Biotechnology*, *10*(1), 46-51.

NCD Risk Factor Collaboration (NCD-RisC). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. Lancet. 2016;387(10026):1377–96.

Obadi, M., Sun, J., & Xu, B. (2021). Highland barley: Chemical composition, bioactive compounds, health effects, and applications. *Food Research International*, *140*, 110065 .

Salama, F. M., Azzam, M. A., Abdl-Rahman, M. A., Naga, A. E., & Abdl-Hameed, M. S. (2011). Optimization of processing techniques for production of oat and barley milks. *Journal of Food and Dairy Sciences*, *2*(10), 577-591.

Sami, R., Li, Y., Qi, B., Wang, S., Zhang, Q., Han, F., ... & Jiang, L. (2014). HPLC analysis of water-soluble vitamins (B2, B3, B6, B12, and C) and fat-soluble vitamins (E, K, D, A, and β-carotene) of okra (Abelmoschus esculentus). *Journal of chemistry*, *2014*(1), 831357.

Savaiano, D.A.; Hutkins, R.W. Yogurt, cultured fermented milk, and health: A systematic review. Nutr. Rev. **2021**, 79, 599–614.

Shahein, M. R., Atwaa, E. S. H., Elkot, W. F., Hijazy, H. H. A., Kassab, R. B., Alblihed, M. A., & Elmahallawy, E. K. (2022). The impact of date syrup on the physicochemical, microbiological, and sensory properties, and antioxidant activity of bio-fermented camel milk. *Fermentation*, *8*(5), 192.

Singleton, V.L., Orthofer, R., and Lamuela-Raventós, R.S. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteau Reagent. Methods Enzymol., (299): 152–178.

Sjöström L. Review of the key results from the Swedish Obese Subjects (SOS) trial - a prospective controlled intervention study of bariatric surgery. J Intern Med. 2013;273(3):219–34.

Song, X., Liu, Y., Zhang, X., Weng, P., Zhang, R., & Wu, Z. (2023). Role of intestinal probiotics in the modulation of lipid metabolism: implications for therapeutic treatments. *Food Science and Human Wellness*, *12*(5), 1439-1449. .

Sorour, M. A., Ramadan, B. R., El Sayed MEHANNI, A. H., & Ahmed, W. K. (2020). Effect of Soaking and Malting Process on Chemical Compostion, Bioactive Compounds and Antioxidant Activity of some Egytian Barley Varities. *Journal of Food and Dairy Sciences*, *11*(11), 313-319.

SPSS package (SPSS v 20 2012): software package for Social Science for windows.

Steenackers , N., Van der Schueren, B., Augustijns, P., Vanuytsel, T., & Matthys, C. (2023). Development and complications of nutritional deficiencies after bariatric surgery. *Nutrition Research Reviews*, *36*(2), 512-525.

Tamime, A.Y. and Robinson, R.K. (1999). Yoghurt. Science and Technology.Cambridge, UK:Woodhead Publishing Limited England.

Tegegne, B. A., & Kebede, B. (2022). Probiotics, their prophylactic and therapeutic applications in human health development: A review of the literature. *Heliyon*, *8*(6) .

Tilahun, Z., Chandravanshi, B. S., & Abshiro, M. R. (2021). Mineral contents of barley grains and its processed foods (kolo, porridge, bread and injera) consumed in Ethiopia. *Bulletin of the Chemical Society of Ethiopia*, *35*(3), 471-484 .

Trone, K., Rahman, S., Green, C. H., Venegas, C., Martindale, R., & Stroud, A. (2023). Synbiotics and surgery: can prebiotics and probiotics affect inflammatory surgical outcomes?. *Current Nutrition Reports*, *12*(2), 238-246. .

Upadhyay J, Farr O, Perakakis N, et al. Obesity as a disease. Med Clin North Am. 2018;102(1):13–33.

Verger EO, Aron-Wisnewsky J, Dao MC, et al. Micronutrient and protein deficiencies after gastric bypass and sleeve gastrectomy: a 1-year follow-up. Obes Surg. 2016;26(4):785–96.

Webber L et al .The future burden of obesity-related diseases in the 53 WHO European-region countries and the impact of effective interventions: a modelling study. [cité 22 nov 2017]. Disponible sur: https://www.ncbi.nlm.nih.gov/pubmed/?term=(Webber+L%2C+BMJ+Open.+2014%3B4%3A+e004787).

Wijekoon, C., Netticadan, T., Sabra, A., Yu, L., Kodikara, C., & Badea, A. (2022). Analyses of fatty acids, proteins, ascorbic acid, bioactive phenolic compounds and antioxidant activity of Canadian barley cultivars and elite germplasm. *Molecules*, *27*(22), 7852. .

Zhang, T., Geng, S., Cheng, T., Mao, K., Chitrakar, B., Gao, J., & Sang, Y. (2023). From the past to the future: Fermented milks and their health effects against human diseases. *Food Frontiers*, *4*(4), 1747-1777.

Zheng L, Lu L, Jiang X, et al. Laparoscopy-assisted versus open distal gastrectomy for gastric cancer in elderly patients: a retrospective comparative study. Surg Endosc. 2016;30(9):4069–77.

Zhong, H., Wang, L., Jia, F., Yan, Y., Xiong, F., Hidayat, K., & Li, Y. (2024). Effect of Probiotic Fermented Milk Supplementation on Glucose and Lipid Metabolism Parameters and Inflammatory Markers in Patients with Type 2 Diabetes Mellitus: A Meta-Analysis of Randomized Controlled Trials. *Biology*, *13*(8), 641.