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A new approach in the production of a novel gluten-free probiotic beverage using broken white beans, broken rice, and whey

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Abstract

This study investigates the use of probiotic-rich beverages using cooked soaked broken white beans, broken rice, and whey by fermentation with a probiotic (*Lactobacillus acidophilus* and *Bifidobacterium bifidum)* starter culture. Four treatments of broken white beans were prepared (raw dry, soaked, cooked, and cooked soaked beans) for proposed beverages with different percentages of broken white beans milk, and whey. Three beverages without probiotic bacteria and nine probiotic beverages were prepared using other ingredients and commercial control. The physiochemical, microbiological, and sensory qualities of raw materials and proposed beverages were studied at zero time and after 15 days of storage. Then beverages with the highest sensory scores were evaluated chemically and physically. Results showed significant changes in the chemical composition of raw materials after different treatments. The levels of phytochemicals in raw broken beans (RBB) were significantly higher ($P<0.05$) than in other treatments. The loss in total phenols, flavonoids, tannins, phytic acid, and DPPH in cooked soaked broken beans was 52.82 %, 44.05%, 65.43%, 68.17, and 34.37%, respectively. The raw broken beans showed the greatest value of L* (Brightness). Similarly, cooked non-soaked broken beans had the greatest values of a* (+: red, -: green), and b* (+: yellow, -: blue). Cooked soaked broken beans showed the highest value of water absorption capacity (WAC) and the lowest value of oil absorption capacity (OAC). Results of the preliminary study of 12 treatments of beverage and compared with commercial control of fermented beverage, the samples containing 40% broken white bean milk and 30% whey with and without starter culture and commercial control (C, C1, L1, B1 and L1+B1) scored higher in overall acceptability at zero time and after storage for 15 days at 5 °C. The microbiological results indicated that molds, yeast, and coliform were undetected in refrigerated samples of fermented white bean beverages. Making beverages was a profitable endeavor. The beverages have fairly acceptable storage quality. In conclusion, Overall, this study highlights the potential of the production of probiotic-enriched beverages by fermented cooked soaked broken white beans milk, broken rice, and whey to combine the established benefits of probiotics for gut health with the enjoyment of consuming non-dairy probiotic-rich beverages for suffer from lactose intolerance.

Keywords: Broken *phaseolus vulgaris L*, Broken rice, Functional properties, probiotics, Beverage.

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1. Introduction

Commonly known as white beans (Phaseolus vulgaris L.), are considered a near-perfect diet due to its high protein, fiber, probiotic, and vitamin B contents in addition to other micronutrient makeup. This legume is a great functional food because it also contains high levels of chemically diverse components (phenols, resistance starch, vitamins, fructo oligosaccharides) that have been shown to protect against conditions like oxidative stress, cardiovascular disease, diabetes, metabolic syndrome, and many types of cancer [1]. Pulse losses in Egypt increased by 122.22% from an estimated 127,000 tons in 2014 to 60,000 tons in 2018 [2]. Broken (6–13%) products are underutilized, sold at poor prices, and have low economic value as byproducts [3].

One of the waste products of removing bean seeds from their dry horns is shattered white beans, a type of legume byproduct. It is well-known for its traditional medicinal benefits in weight control and health maintenance as well as being gluten free. [4]. Conventional methods including soaking, cooking, germination, and fermentation have been applied to increase the flavor, nutritional content, and acceptability of the legumes and dry beans by consumers. As cooking improves digestibility, inactivates or antinutrients, boosts nutrient biological value, and provides the sensory quality that consumers need to improve acceptability, cooking is known to be essential for bean consumption [5].

Live lactic acid bacteria and bifidobacteria contribute nutritional value, acid tolerance, and sensory benefits to fermented beverages like yogurt. As more people adopt vegan diets and study sources of protein, scientists are looking into using vegetable sources, such bean seeds, to make nutrient-dense beverages. Modern diet-promoting technologies make it possible to consume fermented plant-based foods devoid of dairy [6]. Foods other than dairy products have the potential to ferment [7]. Even though a large number of people have lactose intolerance or allergies to milk proteins. The long-standing trend of reducing or giving up animal consumption has led to the availability of a wide variety of plant-based foods on the market [8]. Probiotic microorganisms found in fermented foods aid in better digestion, create vitamins and nutrients, prevent diarrhea, and slow down rotting [9]. Several studies have demonstrated the efficacy of probiotics in combating entero-pathogenic infections [10]. These experiments have provided evidence for probiotic functional foods [11], but selection of the appropriate food system is essential for survivability, sensory attributes, and bio-

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efficacy. There is a correlation between gut microbiota and plant phenolics [12]. The function that lactic acid bacteria (LAB) play in food preservation, gastrointestinal tract immunomodulation, and health benefits [13]. Because the bacteria in probiotics generate a wide variety of bioactive substances, adding them to fruit juices might be regarded as a unique category of functional products. Combining probiotics with fruit juices can increase the nutritional value of fruit juices and produce health advantages that are linked to them, as both have similar effects [14].

A byproduct of milling and polishing rice is broken rice. It is an excellent source of carbohydrates and low in fat. Broken rice can play a significant role in the production of numerous low-cost, low-lactose, and low-fat goods. Starch, with trace levels of sugars, hemicelluloses, and pentosan, is the primary carbohydrate found in rice. Because rice protein has a high lysine level, it has one of the highest nutritive values among grain proteins. The total protein digestibility of rice protein is rather high [15]. Egypt's rice losses ranged from 8.16 to 28.50%, with the breakage rate rising with longer storage times. Furthermore, if the functionality of certain items is appropriate for food manufacturing, their low economic value—such as broken and chalky grains—could be greatly enhanced [16].

Whey is produced in large quantities by the dairy sector, which presents serious environmental hazards. However, because it is rich in minerals and items with health advantages, using it or adding value could be advantageous for the environment and a sustainable economy [17]. Whey in food production provides attractive approaches of valorization with unique products such as whey-based beverages with fruit inclusion for greater flavor and nutritional value [18]. As a byproduct of producing cheese, whey has a high organic load and is biodegradable [19]. It influences body composition, energy balance, and satiety [20], and it can substitute fat in processed foods. Whey is perfect for use in specialist formulations. For small firms, however, the substantial amount of whey presents a hurdle [21]. Important bioactive components that improve product functionality and offer nutritional quality are whey protein concentrates and isolates [22]. They are incorporated into medicinal and functional food compositions [23]. Whey also affects the texture, flavor, and color of products [24].

Mixed beverages are getting more and more popular; fruits and vegetables provide a greater variety of nutrients and more bioactive compounds than pure beverages [25]. Fermented beverages with unique tastes and health benefits are being introduced by the food sector in response to consumer demand and the increasing popularity of plant-based diets [26].

The objective of the present study was to produce functional beverage blends through also incorporating starter cultures of Lactobacillus acidophilus and *Bifidobacterium bifidum* by using non-dairy probiotic-rich beverages cooked soaked broken white beans, broken rice, and whey, to combine the established benefits of probiotics for gut health with the enjoyment of consuming probiotic-rich beverages for lactose intolerance patients.

2. Materials and methods

2.1. Materials

Raw materials

Broken white beans (*Phaseolus vulgaris L.*) variety Nebraska was obtained from Horticulture Research Institute, Vegetables Department, Agricultural Research Center, Giza, Egypt.

Broken rice (*Oryza sativa*) variety Sakha 104 (*Japonica genotype*) was obtained after the milling and polishing process of brown rice at a local milling processing unit, in Kafer EL-Sheikh governorate, Egypt. The percentage of broken rice grain is 25%.

Whey was obtained from the unit of milk processing, Animal Production Research Institute, Agricultural Research Center, Giza, Egypt.

Mango (*Mangifera Indica*) and cane sugar (sucrose) were purchased from a local market in Giza, Egypt.

Probiotic starter culture freeze-dried ABT-2 starter culture containing *Lactobacillus acidophilus*, *Bifidobacterium bifidum*, and *Streptococcus thermophilus* was obtained from Chr. Hansen laboratories (Denmark). Both *Lactobacillus* and *Bifidobacterium* were used alone as starter culture in this study with *Streptococcus thermophilus.*

Chemicals:

Sigma Aldrich Co. Ltd. provided all of the chemicals and solvents (Dorset, UK).

2.2. Methods

2.2.1. Preparation of raw materials:

Broken white beans were prepared using four different treatments as follows:

1- Grinding: The dry broken beans were ground for 3 min in a laboratory mill (Qudrumat Senior Laboratory Mill) to prepare a broken white beans (RBB) sample.
2- Soaking: 300 ml of water was added to 100 g of broken bean seeds; soaking took place for 18 hrs at 20°C; the soaked seeds were drained and dried in an electric oven at 50°C for 12 hours then ground for 3 min in a laboratory mill to prepare soaked broken white beans sample (SBB).
3- Cooking without soaking: broken beans without soaking were cooked (volume ratio beans to water is 1:9) in a covered pot until they became ready for consumption (which took approximately 1 h); the cooked broken seeds were drained, and dried in an electric oven at 50°C for 12 hours then ground for 3 min in a laboratory mill to prepare cooked non-soaked broken white beans sample (CNSBB).
4- Cooking after soaking: cooked beans were soaked the same method for SBB, and then were (volume ratio beans to water are 1:6) in a covered pot until they became ready for consumption (which took approximately 40 min; the cooked seeds were drained, and dried in an electric oven at 50°C for 12 hours then ground for 3 min in a laboratory mill to prepare cooked soaked broken white beans sample (CSBB).

The beans prepared using different methods were stored in polyethylene bags for chemical and physical analysis.

Preparation of broken rice: grains were cleaned, washed, and cooked with water (1:3) for 25 min. then, drained in to obtain the cooked rice.

Fresh mango preparation: fresh mango was waged, peeled, blended, and filtrated then kept frozen in a glass jar until used.

Whey was pasteurized at 70°C /10 min. in bath water and then was suddenly cooled.

Preparation of broken white beans for the proposed probiotic beverage.

The proposed probiotic beverage was prepared as illustrated in Fig. 1.

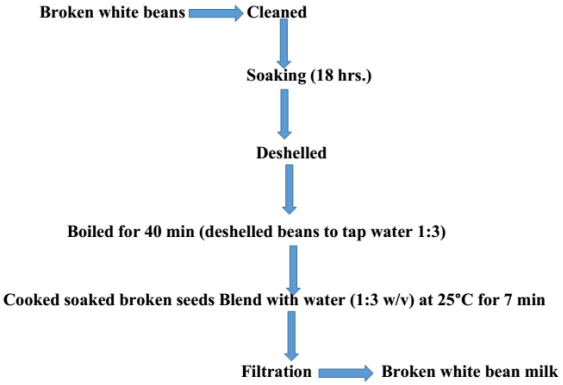

Fig. 1: Preparation of broken white bean-based beverage

The proposed beverages based on broken white beans were prepared as follows (Fig. 2).

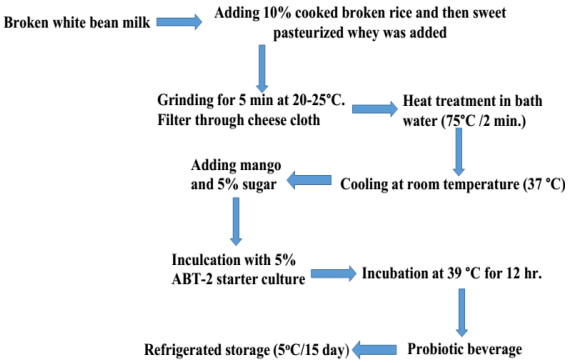

Fig. 2: Preparation of probiotic beverage

2.2.2. Formulation of the proposed beverages:

Nine proposed beverages were prepared using different percentages of broken white bean milk (40%) and whey (30%) were used for preparing samples 1,4 and 7. The percentages of broken white bean milk and whey accounted for 50% and 20% respectively for preparing samples 2,5 and 8. While for the remaining samples (3,6 and 9) 60% of broken white bean milk and 10 % of whey were utilized. For each sample, 10% of cooked broken rice, 10% mango, and 5% sugar were added. Samples 1,2 and 3 (L) were inoculated with 5% *Lactobacillus acidophilus* La-5. Samples 4, 5, and 6 (B) were inoculated with 5% *Bifidobacterium lactis* Bb-12. Samples 7, 8, and 9 (L+B) were inoculated with 2.5 % *Lactobacillus acidophilus* La-5 and 2.5% *Bifidobacterium lactis* Bb-12. C1, C2, and C3 control beverages were prepared using percentages of broken white bean extract (40, 50, and 60%) and whey (30, 20, and 10 %) without additional starter culture shown in the following Table 1.

Table 1. Different formulas for the proposed beverages

Formula	Commodities %							
	Broken white bean	Whey	Broken rice	Mango	Sugar	Starter		Total
						L	B	
T1 (L1)	40	30	10	10	5	5	-	100
T2 (L2)	50	20	10	10	5	5	-	100
T3 (L3)	60	10	10	10	5	5	-	100
T4 (B1)	40	30	10	10	5	-	5	100
T5 (B2)	50	20	10	10	5	-	5	100
T6 (B3)	60	10	10	10	5	-	5	100
T7 (L+ B1)	40	30	10	10	5	2.5	2.5	100
T8 (L+ B2)	50	20	10	10	5	2.5	2.5	100
T9 (L +B3)	60	10	10	10	5	2.5	2.5	100

L: *Lactobacillus acidophilius* La-5. B: *Bifidobacterium lactis* Bb-12

2.2.3. Physicochemical properties of raw materials and beverages:

2.2.3.1. Water and oil Absorption Capacity:

The weight of oil or water absorbed by 1g of flour of protein was calculated and expressed as oil or water absorption capacity according to Zhu, *et al.* [27].

2.2.3.2. Color measurements:

The color was measured using a Hunter Lab colorimeter (Color Quest XE, Hunter Association Lab. Inc., Reston V.A. USA) (Hunter Lab, CQ X3397) according to Guzel and Sayar [28].

2.2.4. Physical analysis of the beverages fermented samples

2.2.4.1. Measurement of pH, Acidity, and Viscosity during Fermentation:

The pH of the fermented samples was monitored during fermentation by measures of pH meter. The viscosity was measured by a dynamic viscometer (Brookfield Model RVDI, USA). Titratable acidity was determined as a lactic acid percentage by titrating with 0.1 NaOH, using phenolphthalein as an indicator A.O.A.C [29].

2.2.5. Chemical Analysis of treated broken white beans and beverages:

2.2.5.1. Chemical Analysis: Moisture, protein, ash, fat, fiber and minerals content were determined

according to A.O.A.C [29] for dry weight. Total carbohydrates were calculated by difference. Total calories were calculated according to the following equation:

Total calories = 4 (Protein + Carbohydrates) + 9 (Fat).

2.2.5.2. In Vitro Protein Digestibility:

The protein digestibility of beverage samples was determined according to the method of Manus *et al.* [30]. The percentage of protein in the supernatant to protein in the sample was used to compute the percentage of protein digestibility, as shown by the following equation:

$$\text{Protein digestibility (\%)} = \frac{N \text{ in supernatant} - \text{N in Blank}}{\text{N in sample}} \times 100$$

N= Nitrogen

2.2.5.3. Bioactive components total flavonoids, phenol, and %DPPH antioxidants activity:

Total phenolic compounds were measured by spectrophotometric (GENESYS 10S UV–Vis, Thermo Scientific, USA) using the Folin–Ciocalteu method at 765 nm using gallic acid solutions for calibration, with concentrations ranging from zero to 1000 µg/ml. Total flavonoids were measured spectrophotometric using an AlCl3 colorimetric assay at 510 nm using quercetin solutions for calibration, with concentrations ranging from zero to 1000 µg/ml [31].

The antioxidants were analyzed according to El Ouadi, *et al.* [32] DPPH (2, 2-diphenyl-1 picrylhydrazyl) radical-scavenging activity determined at 515 nm. Following that, Equation (1) determined the inhibition percentage of the DPPH free radical.

$$I (\%) = (a - b) / a \times 100$$

Where I = inhibition, a = absorbance of the control, and b = absorbance of the sample.

Tannins of broken bean seed treatments were determined as described by Bressani *et al.* [33]. Phytic acid was determined as described by A.O.A.C [29].

2.2.6. Microbiological Analysis:

Total bacterial count (on standard plate count agar), Mold &Yeast, and Coliform were enumerated at room temperature (25±1°C) according to the American Public Health Association Methods Da Silva, *et al.* [34].

The viable count of ABT cultures (*Bifidobacterium bifidum*, *Lactobacillus acidophilus*, and Stre*ptococc*us *thermophiles*) was enumerated according to the methods described by Samona, and Robison [35].

2.2.7. Percent daily values of probiotic beverages

The percentages of protein, fat, and carbohydrates in probiotic beverages relative to a child's recommended daily allowance [36], of 2000 kcal were calculated using the following formula:

$$\text{Nutrient adequacy of probiotic beverage} = \frac{\text{Nutrient in probiotic beverage}}{\text{Nutrient requirements}} \times 100$$

The calorie contribution of probiotic beverages to the energy requirement of 2000 kcal, as stated in RDA, [36], was calculated by the following formula.

$$\text{Calorie adequacy of probiotic beverages} = \frac{\text{Calories in custard sample}}{\text{Recommended Calories}} \times 100$$

2.2.8. Production costs of the probiotic beverages:

The production costs of the 1L probiotic beverage of the selected samples were estimated based on some economic indicators and the value added. Variable costs were calculated based on the quantities and the average unit prices of the broken, electrical energy, wages, and other expenses. All the costs and returns were calculated considering the average prices practiced in the market in Egyptian pounds (EGP). The following formulae were used to calculate the economic indicators:

$$TR = P \times Q$$

$$NR = TR - VC$$

$$AV = TR - IC$$

$$RVA = VA/TR$$

Where TR is the total return, P is the commodity price, Q is the quantity of the commodity, NR is the net return, VC is the variable costs, IC is the intermediate costs, value added (VA), and the ratio of value added to production value (RVA).

2.2.9. Sensory evaluation:

The Food Technology Research Institute uses ten trained tasters to assess the samples and score for color, taste, flavor, texture, and overall acceptability [37].

2.2.10. Estimation of Shelf-Life:

The shelf-life of the fermented broken white bean beverages was defined as the refrigerated storage period (4°C) for 15 days with periodic observation of pH, total acidity, and viability of starter culture.

2.2.11. Statistical analysis:

Analysis were made in triplicate and the mentioned values were the average ± standard deviation (SD). These experimental data were subjected to Analysis of Variance (ANOVA) and Duncan's multiple range test for mean separation at $p<0.05$ in STATISTICA software SPSS version 25.0.

3. Results and discussion

3.1. Chemical composition of broken white bean treatments

The contents of crude protein, fat, ash, crude fiber, total carbohydrates, and total calories in RBB, SBB, CNSBB, and CSBB are presented in Table 2.

All treatments were significantly increased in protein contents compared to raw broken beans. Where it the protein content in all treatments ranged from 25.86 to 27.98%. CNSBB and CSBB treatments had insignificant differences in protein content and the highest protein, and fiber content were found in CSBB. The increase in protein content in cooked soaked white beans may be due to the loss of soluble solids during cooking, increasing protein availability.

The results also show that ash and fats had the lowest value in CSBB compared with other treatments. This may be due to the loss of total solids and leaching into discarded water. Results in the same table show that total calorie content ranged from 395.85 to 400.36 Kcal/100gm.

Clawson and Taylor [38] reported that there is a significant reduction in some parameter compositions (except moisture) due to soaking and cooking. Similar results have been reported by Meghrabi & Yamani, [39] and El-Syiad & Hassan, [5].

Table 2. Gross chemical composition of some broken white beans' treatments (on dry weight bases g/100g)

Treatments	Protein %	Fat %	Ash %	Fiber %	Available carbohydrates%	Total Calories kcal
RBB	25.86±0.16^{b}	2.96±0.25^{b}	4.73±0.06^{a}	3.79±0.30^{b}	66.45±0.46^{ab}	395.85±1.01^{b}
SBB	26.15±0.38^{b}	3.63±0.09^{a}	4.47±0.12^{b}	3.96±0.17^{b}	65.75±0.16^{bc}	400.27±0.04^{a}
CNSBB	26.85±0.03^{a}	3.51±0.47^{ab}	4.30±0.07^{c}	3.79±0.01^{b}	65.34±0.57^{c}	400.36±2.07^{a}
CSBB	27.98±0.48^{a}	2.13±0.25^{c}	3.75±0.08^{d}	4.41±0.08^{a}	66.14±0.31^{a}	396.89±1.57^{b}

Values are means of triplicates ± SD .Mean values in each column having different subscripts are significantly different at p< 0.05. RBB: Raw Broken Beans, SBB: Soaked broken white Beans, CNSBB: Cooked Non soaked Broken white Beans, and CSBB: Cooked Soaked Broken white Beans

Heat treatment of legumes (such as cooking) improves protein quality due to the inactivation of thermolabile anti-nutritional factors and the heat-induced structural changes that facilitate proteolysis [40]. As a source of food for probiotic microbes like Lactobacilli and Bifidobacteria in the human gut, legumes are a good supply of non-digestible carbohydrates called oligosaccharides that have positive effects on humans [41]. The amount of protein in white beans has grown due to all processing techniques. This may be supported by changes in the properties of protein attachment and dissociation brought on by heat. A breakdown of the crude protein into amino acids occurs during cooking. Consequently, heat treatment alters the structure of the proteins, potentially rendering the antinutrients inactive and boosting the biological properties and digestibility of the bean protein [42].

3.2. Phytochemical compounds and antioxidant activity of broken white bean treatments

Bioactive compounds (total phenols, total flavonoids, tannins, phytic acid) and antioxidants activity % of broken bean seeds in different treatments of raw materials are illustrated in Table 3.

Table 3. Phytochemical compounds and antioxidant activity of broken white bean treatments

Treatments	Total Phenols (mg/100g as gallic acid)	Total Flavonoids (mg/100 g as quercetin 1	Tannins (mg/100g)	Phytic acid (mg/100g)	DPPH %
RBB	236.20±0.90^{a}	86.12±0.99^{a}	77.39±0.99^{a}	1.31±0.02^{a}	29.39±0.75^{a}
SBB	119.60±4.48^{c}	52.86±2.70^{c}	57.68±5.07^{b}	0.92±0.01^{b}	21.86±0.12^{c}
CNSBB	127.76±3.76^{b}	60.19±4.61^{b}	53.29±3.53^{bc}	0.92±0.01^{b}	24.42±0.65^{b}
CSBB	111.44±5.21^{d}	48.18±1.47^{c}	46.78±4.34^{c}	0.39±0.04^{c}	19.29±0.88^{d}

Values are means of triplicates ± SD .Mean values in each column having different subscript are significantly different at p< 0.05. RBB: Raw Broken Beans, SBB: Soaked broken white Beans, CNSBB: Cooked Non soaked Broken white Beans, and CSBB: Cooked Soaked Broken white Beans.

Phytochemicals ranged from (111.44 to 236.20 mg/100g dry weight, total phenol), (48.18 to 86.12 mg/100g dry weight, total flavonoids), (46.78 to 77.39 mg/100 gm, tannins), (0.39 to 1.31 mg/100 gm, phytic acid), and (19.29 to 29.39 %, DPPH) in all treatments. The levels of phytochemicals in raw broken beans (RBB) were significantly higher (P<0.05) than in all treatments. The highest reduction of bioactive compounds may be due to soaking in water loss of some nutrients and anti-nutrient content by leaching out in soaked water and heat treatments during cooking cause cell rupture which facilitates the release of these compounds into the cooking water. It could be concluded that soaking before cooking and discarding the soaking water and cooking water is an effective way to lose bioactive compounds. According to Ravoninjatovo *et al.* [43], the most efficient method for reducing the amount of antinutrients in Ta common beans was to heat treat them. To maximize the process, though, more was required than just thermal treatment. It is essential to control the soaking and heat treatment settings in order to avoid dry matter, drop, and concurrently minimize antinutrients. All of these procedures result in a significant loss of minerals and macronutrients (apart from proteins) and lessen the effectiveness of antinutrient substances [44]. Tannins in legumes, grains, and other foods were reported to be reduced by soaking, dehulling, cooking, and soaking followed by cooking, among other techniques, according to Gulewicz *et al.* [45].

3.3. Functional properties and color of broken white bean seeds at different treatments

The color parameters L*, a*, b*, Water Absorption Capacity (WAC), and Oil Absorption Capacity (OAC) are shown in Table 4.

Table 4. Functional properties and color of broken white bean seeds different treatments

Treatments	L*	a*	b*	WAC %	OAC %
RBB	94.02±0.51^{a}	0.66±0.06^{c}	9.99±0.24^{d}	310.32±1.01^{b}	291.19±1.01^{a}
SBB	91.80 ±0.02^{b}	1.24±0.07^{ab}	13.49±0..24^{c}	310.77±0.99^{b}	269.12±0.99^{b}
CNSBB	89.22±1.03^{c}	1.57±0.29^{a}	17.36±1.25^{a}	300.02±1.09^{c}	257.09±1.55^{c}
CSBB	90.16±1,7^{bc}	1.09±0.38^{bc}	15.59±1.03^{b}	344.77±1.01^{a}	248.93±2.66^{d}

Values are means of triplicates ± SD. Mean values in each column having different subscripts are significantly different at p< 0.05. L* (Brightness; 100: white, 0: black), a* (+: red, -: green), and b* (+: yellow, -: blue). RBB: Raw Broken Beans, SBB: Soaked broken white Beans, CNSBB: Cooked non soaked Broken white beans, and CSBB: Cooked soaked broken white beans.

The RBB showed the greatest value of L* (Brightness; 100: white, 0: black), followed by SBB treatment and CSBB treatment, on the other hand, CNSBB had the lowest brightness value and the greatest values of a* (red-green component), b* (yellow-blue

component). Rios *et al.* [46] suggested that customers prefer lighter colored beans because they associate darker colors with harder, older beans that take longer to cook and use more energy. Water and oil absorption capacities are shown in the same table, CSBB was significantly increased in water absorption capacity and significantly decreased in oil absorption capacities compared to RBB and other treatments. CNSBB was the lower value of water absorption capacity. The limited availability of polar amino acids, which are the main places where proteins interact with water, may be the cause of the samples' lower water absorption [47]. The existence of more hydrophobic amino acids in white bean seed is suggested by its higher oil absorption capacity value when compared to other treatments. The hydrocarbon chains of fats may be bound by the presence of several non-polar side chains, increasing the amount of oil absorbed [48]. The high oil absorption capacity of white beans indicates that they improve mouthfeel when added to baked foods, soups, sausages, doughnuts, and meat extenders and substitutes. Similar findings are reported by El-Syiad & Hassan [5], who noted that because they affect emulsion and other qualities, water and oil absorption capacities are critical to food functionality. Because it had the highest crude protein content and the lowest levels of antinutritional value (total phenol, total flavonoids, tannins, and phytic acid), cooked soaked broken beans (CSBB) were chosen to make a probiotic broken white bean-based beverage.

3.4. Sensory evaluation of the proposed probiotic beverages

Sensory evaluation for commercial control of fermented beverage (C) and different beverage treatments including non-fermented beverage and fermented beverage with 5% *Lactobacillus acidophilus* La-5 starter culture, 5% *Bifidobacterium lactis* Bb-12 starter culture ، with 2.5 % *Lactobacillus acidophilus* La-5 and 2.5% *Bifidobacterium lactis* Bb-12 starter culture at zero time and after 15 days of storage at 5◦ C were illustrated in table 5.

Table 5. Sensory evaluation score of the proposed probiotic beverages from zero time and after 15 days of storage at 5˚C

Samples	Color	Taste	Flavor	Texture	Total acceptable
			At Zero time		
C	8.6±0.52^{a}	8.8±0.42^{a}	9.0±0.00^{a}	9.0±0.00^{a}	9.0±0.00^{a}
C1	8.4±0.61^{ab}	8.2±0.59^{abc}	7.9±0.74^{bcd}	8.0±0.24^{bcd}	8.0±0.41^{bc}
C2	7.7±0.58^{cd}	7.8±0.49^{cde}	7.7±0.67^{cd}	7.4±0.52^{de}	7.5±0.44^{cd}
C3	6.9±0.34^{e}	6.4±0.67^{g}	6.8±0.63^{e}	6.2±0.75^{f}	6.5±0.50^{e}
L1	8.4±0.46^{ab}	8.6±0.57^{ab}	8.6±0.46^{ab}	8.5±0.47^{ab}	8.4±0.41^{b}
L2	8.2±0.58^{abc}	8.0±0.85^{bc}	8.2±0.85^{bc}	8.4±0.47^{abc}	8.0±0.55^{bc}
L3	8.1±0.50^{abc}	8.0± 0.67^{bc}	8.1±0.72^{bc}	7.7±0.89^{cd}	8.1±0.64^{bc}
B1	8.1±0.55^{abc}	7.9±0.64^{bc}	7.9±0.76^{bcd}	7.7±0.85^{cd}	7.9±0.61^{bc}
B2	7.7±0.78^{cd}	7.3± 0.82^{def}	7.6±0.96^{cd}	7.0±1.03^{bcd}	7.4±0.77^{cd}
B3	7.3±0.79^{de}	6.9±0.91^{fg}	7.2±1.03^{de}	7.4±0.94^{de}	7.0±0.72^{de}
L1+B1	8.1±0.83^{abc}	7.9± 0.74^{bcd}	7.7±1.32^{cd}	7.5±0.85^{de}	7.8±0.63^{bc}
L2+B2	7.8±1.03^{bcd}	7.7±0.82^{cde}	7.5±1.07^{cde}	7.4±1.07^{de}	7.7±0.88^{c}
L3+B3	7.3±1.16^{de}	7.2±0.82^{ef}	7.2±0.92^{ef}	6.8±1.03^{ij}	7.0±0.82^{de}
			After 15 days		
C	8.6± 0.52^{a}	8.7±0.42^{a}	9.0±0.00^{a}	7.7±0.48^{a}	8.5±0.53^{a}
C1	8.0±0.71^{bc}	7.3±0.79^{bcd}	7.5±0.53^{bc}	7.9±0.34^{a}	7.9±0.46^{ab}
C2	7.4±0.57^{bcd}	7.0±0.00^{cde}	7.1±0.61^{bc}	7.0±0.60^{ab}	6.8±0.42^{d}
C3	6.0±0.67^{e}	5.8±0.63^{f}	6.0±0.62^{d}	6.3±0.67^{b}	5.9±0.74^{e}
L1	7.8± 0.72^{bc}	8.1±0.64^{ab}	7.9±0.70^{b}	7.8±0.75^{a}	7.7±0.58^{bc}
L2	7.6±0.69^{bcd}	7.4±0.97^{defgh}	7.4±0.70^{bc}	7.8±0.42^{a}	7.3±0.67^{bcd}
L3	7.5±0.67^{bcd}	7.3±0.72^{efgh}	7.3±0.82^{bc}	7.4±1.15^{a}	7.3±0.72^{bcd}
B1	7.2± 0.63^{bcd}	7.1±0.74^{cd}	7.4±0.82^{bc}	7.1±0.96^{ab}	7.0±0.71^{cd}
B2	6.9± 0.74^{cd}	6.6±0.88^{def}	7.0±1.15^{bc}	7.1±1.10^{ab}	6.8±0.79^{d}
B3	6.8±0.79^{de}	6.2±1.03^{ef}	6.8±1.23^{cd}	7.0±1.25^{ab}	6.6±0.74^{d}
L1+B1	8.0±1.15^{bc}	7.8±1.03^{bc}	7.2±1.32^{bc}	7.3±1.32^{a}	7.3±1.06^{abc}
L2+B2	7.6±1.35^{bcd}	7.0± 1.41^{cde}	6.9±1.20^{c}	7.3±1.27^{a}	7.1±1.17^{cd}
L3+B3	7.1±1.30^{cd}	6.5± 0.97^{def}	6.6±0.97^{cd}	7.0±1.01^{ab}	6.7±0.94^{d}

C: commercial control, C1 C2, and C3: (40, 50, and 60%) broken white beans milk+(30,20, and 10 %) whey without starter culture, L1, L2, and L3: (40, 50, and 60%) broken white beans milk+(30,20, and 10 %) whey with 5% La-5 starter culture, B1, B2, and B3: (40, 50, and 60%) broken white beans milk+(30,20, and 10 %) whey with 5% Bb-12 starter culture, L1+B1, L2+B2, and L3+B3: (40, 50, and 60%) broken white beans milk+(30,20, and 10 %) whey with 2.5 % La-5 and 2.5% Bb-12 starter culture. Values are the mean of three replicates. Means ±SD in the same column with the same letter showed insignificant differences (at P<0.05)

Results of the preliminary study of 12 treatments of beverage and compared with commercial control of fermented beverage showed that the samples containing 40% broken white bean milk and 30% whey with and without starter culture and commercial control (C, C1, L1, B1, and L1+B1) scored higher in overall

acceptability at zero time and after storage. On the other hand, there were significant decreases in total acceptable between all treatments and commercial fermented beverages (control), and the lowest decrease was found in the C3 treatment followed by the B3 and L3+B3 treatments at zero time and after 15 days of storage at 5 °C. All the sensory parameters in commercial fermented beverages and all treatments were decreased after 15 days of storage at 5◦ C. Commercial fermented beverage control had the highest score in all sensory parameters. Similar findings were reported by Saglam, *et al.* [49], who noted that beverages fermented by the Bb-12 strain had lower sensory scores than those fermented by the La-5 strains. According to Ziarno *et al.* [50], germinated beans can be used to produce fermented beverages with high levels of live LAB and bifidobacteria, good physicochemical and microbiological quality, and a good degree of sensory acceptability (especially with the addition of flavoring additives). In this manner, a functional food with a vegetable origin can be produced using a mixed culture of LAB and bifidobacteria. We saw a similar outcome with our findings. According to the findings, which supported the Tahmasebian *et al.* article [51], juice containing Lactobacillus acidophilus showed superior sensory qualities.

3.5. Chemical composition of the proposed probiotic beverages

Table 6 displays the chemical composition of commercial control, fermented and non-fermented white bean beverages at zero time and after 15 days of storage.

Table 6. Gross chemical composition of the proposed probiotic beverages at zero time and after storage for 15 days

Samples	Component (% fresh weight basis)					Energy kcal
	Moisture	Protein	Fat	Ash	CHO	
			At Zero time			
C	79.75±0.27^{a}	2.7±0.0001^{d}	1.30±0.002^{a}	0.14±0.002^{e}	16.12±0.19^{d}	86.97±0.74^{d}
C1	76.36±0.17^{c}	4.24±0.08^{c}	1.02±0.03^{b}	0.223±0.0008^{d}	18.2±0.003^{b}	98.97±0.61^{b}
L1	76.89±0.0^{b}	4.42±0.09^{b}	1.01±0.01^{b}	0.216±0.0007^{c}	17.49±0.109^{c}	96.75±0.05^{c}
B1	76.20±0.07^{c}	4.36±0.105^{ab}	1.03±0.07^{b}	0.233±0.002^{b}	18.14±0.122^{b}	99.24±0.54^{b}
L1+B1	75.47±0.51^{d}	4.60±0.11^{a}	0.88±0.06^{c}	0.43±0.006^{a}	18.83±0.30^{e}	101.64±1.14^{a}
			After 15 days			
C	78.69±0.05^{a}	2.98±0.006^{d}	1.40±0.0002^{a}	0.14±0.002^{e}	16.80±0.04^{d}	91.70±0.13^{d}
C1	75.91±0.12^{c}	4.73±0.12^{c}	1.35±0.09^{ab}	0.223±0.0008^{c}	18.23±0.15^{b}	104.04±1.89^{ab}
L1	76.34±0.3^{b}	5.41±0.14^{a}	1.31±0.007^{b}	0.217±0.0008^{d}	16.72±0.07^{d}	100.36±0.89^{c}
B1	75.71±0.06^{c}	5.60±0.15^{a}	1.32±0.03^{ab}	0.233±0.002^{b}	17.14±0.16^{c}	102.81±0.31^{b}
L1+B1	74.38±0.38^{d}	5.09±0.04^{b}	1.05±0.02^{c}	0.43±0.006^{a}	19.05±0.29^{a}	105.98±1.2^{a}

C: commercial control, C1: 40% broken white bean milk+30% whey without starter culture, L1: 40% broken white bean milk+30% whey with 5% La-5 starter culture, B1: 40% broken white bean milk+30% whey with 5% Bb-12 starter culture, L+B1: 40% broken white beans milk+30% whey with 2.5% La-5 and 2.5 Bb-12 starter culture.
Values are the mean of three replicates. Means ±SD in the same column with the same letter showed insignificant differences (at P<0.05).

Moisture and fat content represented the highest value while protein, ash, and carbohydrates had the lowest content in commercial control of fermented beverage (C) at zero time and after 15 days of storage. There was a significant decrease in moisture content between commercial control of fermented beverages and different treatments of non-fermented and fermented white bean beverages at zero time and after 15 days of storage. There was a significant decrease in fat content between commercial control of fermented beverage and different treatments of white beans beverage at zero time while after 15 days there was no significant difference in commercial control of fermented and all treatments except L+B1 treatments. There was a significant increase in protein, ash, and carbohydrate content in non-fermented and fermented white bean beverages compared to commercial control of fermented beverages at zero time and after 15 days of storage. There was a slight increase in protein, ash, and carbohydrate values in all samples after 15 days of storage. Obadina *et al.*'s findings were corroborated [52]. Whey provides the perfect food matrix for the growth and viability of probiotic strains and is packed with a variety of nutritious substances, such as minerals, lactose, and dissolvable milk proteins [53]. Lopes, *et al.* [54], who claimed that legume beverages have the most balanced composition, are low in glycemic index, high in proteins and minerals, and confirm the findings. The calculated energy had the lowest content in commercial control of fermented beverage compared to all the treatments at zero time or after 15 days of storage, the total energy ranged from 86.97 to 101.64 at zero time and from 91.70 to 105.98 kcal/100 g after 15 days of storage. The potential of this nutrient-dense beverage was demonstrated by Tan *et al.* [55] demonstrated that all of the carbohydrates in the beverages decreased following fermentation. These beverages have carbon sources, which are necessary for the bacterium's growth and fermentation, as well as carbohydrates [56]. One possible explanation for the decrease in fat content could be the development and activity of starting microorganisms. The findings are consistent with Uzuner *et al.* [57].

3.6. Mineral contents of the proposed probiotic beverages

The results of minerals content (Ca, P, K, Na, Mg, Fe, and Zn) of probiotic beverages at zero time and after storage for 15 days are shown in Table 7.

Phosphor and potassium levels were significantly higher in beverages containing plant-based ingredients (broken white beans) ($P \leq 0.05$) than in commercial control. Given the previously stated, modifications in the concentration of particular macro- and micronutrients brought about by the use of plant-based components were ascertained. Qin *et al.* [58] claim that food fermentations are a useful technique to boost the amount of dietary protein and micronutrients in meals based on legumes and cereals.

Table 7. Some mineral contents (mg/100g) of the proposed probiotic beverages from zero time and after storage for 15 days.

Samples	Ca	P	K	Na	Mg
At Zero time					
C	99.99±0.01^{a}	75.56±0.78^{c}	65.8±0.64^{d}	25.15±0.01^{a}	66.55±0.71^{c}
C1	76.19±0.70 ^{b}	208.39±1.41^{ab}	653.83±2.11^{c}	18.69±0.72^{b}	71.34±0.70^{b}
L1	76.88±0.66^{b}	208.69±0.72^{ab}	655.69±0.69^{b}	18.23±0.03^{c}	71.57±0.79^{b}
B1	76.35±0.03^{b}	207.69±0.76^{b}	653.72±0.81^{c}	18.08±0.24^{c}	72.03±0.14^{ab}
L1+B1	76.4±0.7^{b}	209.11±0.79^{a}	673.00±22.63^{a}	18.24±0.06^{c}	72.42±0.73^{a}
After 15 days					
C	101.62±0.71^{a}	80.63±0.74^{d}	67.19±0.06^{d}	23.75±0.87^{a}	72.61±0.69^{a}
C1	78.12±0.43^{c}	216.04±1.43^{c}	659.72±2.1^{c}	20.11±0.13^{b}	83.11±18.38^{d}
L1	78.81±0.74^{b}	215.69 ±0.08^{c}	671.62±1.99^{b}	19.37±0.19^{c}	70.69±0.76^{bc}
B1	78.04±0.01^{c}	219.06±1.49^{b}	673.80 ±0.68^{b}	18.53±0.67^{d}	71.45±1.02^{b}
L1+B1	79.00±0.06^{b}	229.19±0.77^{a}	707.15±8.56^{a}	17.9±0.42^{d}	70.20±0.02^{cd}

C: commercial control, C1: 40% broken white bean milk+30% whey without starter culture, L1: 40% broken white bean milk+30% whey with 5% La-5 starter culture, B1: 40% broken white bean milk+30% whey with 5% Bb-12 starter culture, L+B1: 40% broken white beans milk+30% whey with 2.5 % La-5 and 2.5% Bb-12 starter culture.

Values are the mean of three replicates. Means± SD in the same column with the same letter showed insignificant differences (at P<0.05).

3.7. Physicochemical properties of the proposed probiotic beverages

In vitro, protein digestibility, pH, viscosity, total solid % (T.S), and acidity of commercial control, non-fermented control and fermented white bean beverages at zero time and after 15 days of storage are shown in table (8).

Table 8. Some physicochemical properties of the proposed probiotic beverages at zero time and after storage for 15 days

Samples	Protein digestibility %	pH	Viscosity cp	TS %	Acidity %
At Zero time					
C	90.88±6.86^{a}	4.34±0.01^{e}	342.5±53.03^{d}	15.0±0.0^{d}	0.585±0.01^{a}
C1	73.28±1.01^{c}	6.99±0.04^{a}	2091.5±408.35^{c}	16.25±0.35^{b}	0.015±0.01^{e}
L1	83.99±0.46^{b}	4.76±0.08^{d}	2462.5±406.59^{bc}	16.75±0.35^{a}	0.535±0.02^{b}
B1	80.66±1.72^{b}	5.35±0.04^{c}	4881.5±1157.89^{a}	15.75±0.35^{c}	0.30±0.03^{d}
L1+B1	83.89±0.42^{b}	5.50±0.04^{b}	3084.0±631.09^{b}	16.125±0.18^{b}	0.48±0.04^{c}
After 15 days					
C	94.14±4.5^{a}	4.29±0.01^{e}	350.0±56.57^{c}	14.8±0.14^{c}	0.52±0.01^{a}
C1	77.34±0.78^{c}	6.37±0.08^{a}	2239.8±353.91^{b}	15.25±0.35^{bc}	0.27±0.04^{b}
L1	87.51±0.23^{b}	4.43±0.09^{d}	2175.0±388.91^{b}	16.5±0.71^{a}	0.54±0.04^{a}
B1	87.44±1.62^{b}	4.82±0.02^{b}	3882.5±1417.75^{a}	16.0±1.41^{ab}	0.52±0.02^{a}
L1+B1	96.49±0.59^{a}	4.51±0.01^{c}	2636.3±373.00^{b}	16.5±0.71^{a}	0.51±0.01^{a}

C: commercial control, C1: 40% broken white bean milk+30% whey without starter culture, L1: 40% broken white bean milk+30% whey with 5% La-5 starter culture, B1: 40% broken white bean milk+30% whey with 5% Bb-12 starter culture, L1+B1: 40% broken white beans milk+30% whey with 2.5 % La-5 and 2.5% Bb-12 starter culture.

Values are the mean of three replicates. Means± SD in the same column with the same letter showed insignificant differences (at P<0.05).

At zero-time, protein digestibility of commercial control of fermented beverage had the highest value compared to other treatments followed by L1, B1, and L1+B1 treatments. The protein digestibility ranged from 73.28 to 90.88%. On the other hand, protein digestibility was significantly increased in all treatments after 15 days of storage compared to the results at zero time. The highest increase in protein digestibility was found in the L1+B1 treatment, it reached 96.49%. As reported by Lorusso *et al.* [59], the protein digestibility of quinoa beverages fermented with lactic acid bacteria strain was 71% before fermentation, 86% during fermentation at 30 °C for 20 hours, and 91% following 20 days of storage at 4 °C. Our results were consistent with their findings.

Table 8 showed that the pH values of beverages without starter culture were higher (6.99) than the beverages with starter culture, on the other hand, lower in total acidity (TA) (0.015). The results of this study showed pH reduction and increment of acidity. pH value ranges of the probiotic beverage with broken white beans at zero time and after storage at 5 °C were 4.34 –5.50 and 4.29 – 4.82, respectively. While TA values ranged from 0.30 to 0.59% at zero time and from 0.51 to 0.54% after storage for 15 days at 5 ˚C. The pH decrease that happens during refrigerated storage could be caused by the enzymatic and cellular activity produced during fermentation. The decrease in pH and the increase in TA and fermentable sugars during storage are ascribed to the enzymatic activity [60]. In a similar vein, oat-based probiotic beverages were found to have a decrease in pH and an increase in TA after 21 days of refrigeration [61]. It's crucial to regulate the pH of fermented drinks to prevent the spread of food-borne infections. The duration of storage also affected the acidity levels of the beverages and the changes seen over time. The growth cycle of the probiotic bacteria and lactic acid in the drinks may be to blame for this [62].

From Table 8 fortification of probiotic beverages with broken white bean milk significantly

increased viscosity compared with the control. There was a significant increase in the viscosity of all beverages compared to commercial control of fermented beverages. The highest viscosity value was found in treatment B1, reaching 4881.5 CP at zero time and 3882.5 CP after storage for 15 days at 5 °C. Yogurt with a higher TS concentration may have higher viscosity and consistency values, according to Kumari *et al.* [63]. The production of a robust gel in the product, along with a rise in the amount of sugar, protein, and fiber in the beverage composition, can be the cause of the viscosity increase [64].

Table 8 illustrates that the total solids content of all samples varied from 14.80 to 16.75%. T.S. content of commercial control was recorded as the lowest value. The addition of broken white beans, whey, and rice caused an increase in T.S., protein, and ash contents and this explains the increment of T.S. in all treatments. A study by Lupien-Meilleura *et al.* [65] revealed that during storage, the total solid content dropped. Thus, probiotics' consumption of the sugar in the drinks would account for a significant portion of the decrease in the total solid content.

3.8. Microbiology aspects of the proposed probiotic beverages

Concurrently, the presence of unwanted microorganisms – namely the combined counts of total bacteria count TBC, molds & yeasts, as well as the coliform population, was assessed in Table 9.

Table 9. Microbiology examination (Log CFU/g) of the proposed probiotic beverages at zero time and after 15 days of storage.

Samples	TBC	Coliform	Mold &Yeast	LB	ST	Bifido
At Zero time						
C	6.40	ND	ND	6.30	6.20	< 6
C1	6.12	ND	ND	ND	ND	ND
L1	6.35	ND	ND	6.50	6.12	ND
B1	6.20	ND	ND	ND	ND	6.12
L+B1	6.40	ND	ND	6.12	6.10	6.35
After 15 days of storage at 5 °C						
C	6.35	ND	ND	6.32	6.40	< 6
C1	6.10	ND	ND	ND	ND	ND
L1	6.31	ND	ND	6.51	6.15	ND
B1	5.90	ND	ND	ND	ND	6.15
L+B1	6.45	ND	ND	6.20	5.95	6.40

C: commercial control, C1: 40% broken white bean milk+30% whey without starter culture, L1: 40% broken white bean milk+30% whey with 5% La-5 starter culture, B1: 40% broken white bean milk+30% whey with 5% Bb-12 starter culture, L+B1: 40% broken white beans milk+30% whey with 2.5 % La-5 and 2.5% Bb-12 starter culture.
TBC: total count, M&Y: Mold & yeast, LB: Lactobacillus acidophilus, ST: Streptococcus thermophiles, BIFIDO: Bifidobacterium bifidum

Total bacteria count in all samples ranged from 6.12 to 6.40 log CFU/g at zero time and ranged from 5.90 to 6.45 log CFU/gm after storage for 15 days at 5 °C. Molds & yeast and coliform were not detected in all samples. An increment in acidity and decrease in pH over refrigerated storage may inhibit the growth of pathogenic microorganisms, which makes the beverage safe for drinking and also supports extended shelf-life. As a result, the study's beverages had acceptable microbiological quality, ensuring the product's safety for consumption. Low pH levels have an impact on the probiotic culture's sensitivity, which varies depending on the strain—particularly for Bifidobacteria. Results show the viability of *Lactobacillus acidophilus*, *Streptococcus thermophiles*, and *Bifidobacterium bifidum* count remained in appropriate numbers at zero time and after storage for 15 days at 5 °C for three treatments (L1, B1, and L1+B1). According to Shori [66], the beverage must have a minimum of 106–107 CFU/mL of viable probiotic cells during the shelf life. Similarly, Kumar and Kumar [67] reported that probiotics must enter the colon in sufficient amounts—between 6 and 7 log CFU/gram of product—to have a beneficial effect on health. According to Mani-López *et al.* [68], L. acidophilus can be used to manufacture probiotic fermented milk without compromising its physicochemical and sensory qualities. When kept in a refrigerator, L. acidophilus had the highest survivability. The storage had an impact on the beverages' acidity levels as well as any changes that occurred throughout time. This could be caused by the probiotic bacteria's growth cycle and the lactic acid in the drinks [62].

3.9. Calculated at 2,000 calories per day, the recommended daily allowance is contributed by the proposed probiotic beverages

Table 10 lists the percentages of recommended daily allowances (RDAs), which are calculated using 2,000 calories per day as the basis for general nutrition guidance, for the protein, fat, fiber, carbohydrate, and calorie contents in 100 g of the various proposed beverages.

It was observed that the RDA of all nutrients of proposed beverages (protein, fat, carbohydrates, and total calories) significantly increased after storage more than at zero time. A 100g serving of fermented and non-fermented beverages (C1, L1, B1, and L+B1) could supply 8.5–9.2% at zero time and 9.47–11.19% once the daily need for protein intake and appropriate proportions of fat, carbohydrates, and calories have been stored. These results imply that the proposed beverages may be a decent source of protein. It is conceivable to produce multigrain beverages that contain cereals and legumes to meet the required nutritional requirements, as cereals and legumes by themselves do not deliver complete protein. Furthermore, the protein quality of cereals and legumes is improved by the complementary protein they contain [69].

3.10.Production costs of the probiotic beverages:

The Economic indicators of one litter probiotic beverage of the selected samples (L1, B1, and L1+B1)

produced from broken white beans, broken rice and whey at the laboratory level are shown in Table 11.

Table 10. Nutritive value of proposed probiotic beverages from zero time and after storage for 15 days at compared RDA for adults.

Treatment	Protein (%)	Fat (%)	Carbohydrates (%)	Total Calories (Kcal)
RDA	50g	78g	262g	2000 (Kcal)
At Zero time				
C	5.4±0.0001^{d}	1.66±0.001^{a}	5.86±0.07^{d}	4.35±0.04^{d}
C1	8.5±0.16^{c}	1.31±0.04^{b}	6.62±0.0001^{b}	4.95±0.03^{b}
L1	8.8±0.18^{b}	1.3±0.02^{b}	6.36±0.04^{c}	4.84±0.003^{c}
B1	8.7±0.21^{bc}	1.32±0.09^{b}	6.7±0.04^{b}	4.96±0.03^{b}
L1+B1	9.2±0.23^{a}	1.13±0.07^{c}	6.85±0.11^{a}	5.08±0.06^{a}
After 15 days				
C	5.95±0.01^{d}	1.79±0.0001^{a}	6.11±0.01^{d}	4.58±0.01^{d}
C1	9.47±0.24^{c}	1.74±0.12a^{b}	6.63±0.05^{b}	5.2±0.09^{ab}
L1	10.83±0.28^{a}	1.68±0.009^{b}	6.08±0.02^{d}	5.02±0.04^{c}
B1	11.19±0.29^{a}	1.69±0.04^{ab}	6.23±0.06^{c}	5.14±0.02^{b}
L1+B1	10.19±0.07^{b}	1.34±0.02^{c}	6.93±0.11^{a}	5.3±0.06^{a}

C: commercial control, C1: 40% broken white bean milk+30% whey without starter culture, L1: 40% broken white bean milk+30% whey with 5% La-5 starter culture, B1: 40% broken white bean milk+30% whey with 5% Bb-12 starter culture, L1+B1: 40% broken white beans milk+30% whey with 2.5 % La-5 and 2.5% Bb-12 starter culture.

Values are the mean of three replicates. Means±SD in the same column with the same letter showed insignificant differences (at $P<0.05$).

Table 11. Economic indicators of the 1L probiotic beverage of the selected samples (L1, B1, and L1+B1)

Items	Unit	Quantity	Value (EGP)
Broken white bean	g	300	8.54
Broken rice	g	50	1.5
Price of broken			10.04
Mango	g	100	5
Sugar	g	50	1.5
Starter	ml	50	1.0
Whey	ml	90	0.5
Price of other raw materials			8.0
Intermediate cost			18.04
*Semi and other variable cost			7.11
Variable cost			25.15
Total return			50
Net return			24.85
Added value			31.96
Ratio of value add			0.64

*Including Temporary labor wages, electrical energy consumption, and other expenses related to production

The probiotic beverage had the lowest production or variable cost (VC), estimated at 25.15 L.E./liter. 350g of brokens were utilized to make one liter of probiotic beverage from rice and white beans. The estimated total returns (TR) during this time were 50 L.E. In comparison to the commercial control (62.5 L.E./liter), the probiotic beverage made from white bean and rice broken was calculated to have an added value (VA) of 31.96 L.E./liter, according to the results. It was estimated that the RVA was 0.64 L.E./liter. This indicates that the nondairy probiotic beverage's production generated the most earnings.

For the distribution of probiotics in developing nations, non-dairy probiotic beverages are also more affordable than dairy products. Development and research are therefore required to replace dairy probiotic products, which are nutrient-rich and have health-promoting qualities [70].

4. Conclusion

Finally, it could be concluded that the utilization of fermented probiotic beverages enriched with 30% whey and 40% broken white bean milk improved the quality attributes of the product. Overall results showed that it is possible to prepare fermented probiotic beverages with similar physical and sensory characteristics to the control when the addition of 30% whey and 40% broken white bean milk are thought to be more palatable due to their high nutritional and functional value, as well as the possibility of providing consumers with an additional option. The conducted studies demonstrated that the addition of 30% whey and 40% broken white bean extract to fermented probiotic beverage products was justified as it enriched the products with protein, minerals, and other, valuable nutrients and increased shelf life through the storage period. This may be due to their contents of antimicrobial and antioxidant agents. it can be recommended that Patients with celiac disease also enjoy these beverages because broken white bean extract doesn't contain gluten.

Also, this beverage differs in that it doesn't contain artificial colorings, flavorings, or preservatives and is used as a novel ingredient like broken white bean extract, The utilization of co-products can limit waste production, stop nutrient loss, lower waste treatment costs, and boost revenue has been made viable.

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6. Conflict of interest

The authors disclosed no conflicts of interest.

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