Global Scientific JOURNALS

GSJ: Volume 10, Issue 9, September 2022, Online: ISSN 2320-9186

www.globalscientificjournal.com

Cereal-Legume drinks developed using probiotic potential lactic acid bacteria isolated from *Kenoko*

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Abstract

Cereals and legumes are rich in nutrients when blended and can therefore be exploited for production of unique probiotic foods that are equally acceptable by consumers. In this study four functional cereal-legume drinks (BPS1, BPS2, BPS3 and BPS4) with different ratios of cereal and legume flour mixtures were developed using 11 probiotic potential lactic acid bacteria previously isolated from *kenoko*. The products were processed and evaluated for physicochemical properties, viable cell count on storage, shelf life and sensory properties. BPS1 had the highest moisture (84.06%) and fat (2.52%) content while BPS4 recorded an ash content of 0.87%. The protein content of BPS3 and BPS4 was higher at 3.17% and 3.26% respectively. Viable count numbers for probiotic lactic acid bacteria in the products remained reasonably high in all samples throughout the period of storage of 28 days (more than10^7cfu/mL). The performance of products on sensory evaluation was generally above average on most parameters. The overall consumer acceptability for product sample BPS1 and BPS2 was relatively high with a sensory evaluation score of 6.85 and 6.45 respectively. Findings from this study concluded that

kenoko is a potential source of probiotics with unique characteristics which can produce starter cultures for industrial application. More studies are required on products development to assess synergies and interactions between and among the isolates.

Key words: Cereal-Legume, drinks, probiotic lactic acid bacteria, fermented foods, *Kenoko*

Introduction

The quality of diet is a critical link between nutrition and food security (FAO *et al.,* 2020). Majority of claimed functional foods and drinks sold in the supermarkets are derived from milk with very few from plant sources like soyabean. Cereals and legumes are rich in nutrients especially when blended (Yun *et al.,* 2020) and can therefore be exploited for production of unique probiotic foods that are acceptable by consumers. *Kenoko* is a cereal-legume based fermented product found mainly among the indigenous Maragoli people of Western Kenya. It is produced from a blend of cereal and legume flours mixed with some water and left for about two days in a warm place to ferment. Food industry is interested in the development of foods that meet high quality, safety and in addition can boost the health status of an individual (Wang *et al*., 2021). Research interest has advanced from attending to nutrient deficiencies and nutritional adequacy to optimal nutrition by focusing on technologies that improve health and functionality of human health (Shao *et al.,* 2017). Cereals generally are rich in energy and contribute reasonable amounts of fibre, minerals and vitamins, however are limiting in lysine which is an essential amino acid (Kaisa *et al*., 2022). Consumption of cereal diet alone may be considered as nutritionally insecure (FAO *et al.,* 2020). Grain legumes are excellent sources of protein, minerals and contain other important micronutrients (de Jager *et al*., 2019). The research of novel formulations with selected probiotic strains is essential to satisfy the increasing demand of consumers and to obtain functional products in which the probiotic cultures are more active and protected from the gastrointestinal stress (Markowiak and Śliżewska 2017). For good quality and acceptable product from any material, probiotics are not supposed to influence the sensory properties during its shelf life (Terpou *et al.,* 2019). Probiotic cereal-legumes formulated products have an increased protein and energy content including medicinal properties (Yvonne and Victoria, 2016). The product can play a major role in addressing malnutrition in Kenya where diets comprise mainly of cereals as staple foods. This study was undertaken to develop Cereal-Legume functional food drinks using different percentages of cereals and legumes with the addition of probiotic potential LAB *Kenoko* isolates followed by sensory evaluation of the products.

Materials and Methods

1. Preparation of the probiotic potential culture

The LAB strains used in this experiment were previously isolated from cereals and legume *Kenoko* and characterized for probiotic properties (Akweya *et al.*, 2020). They include; $RC0_{PU}2E$, $SB0_{PU}3E$, $RC0_{PU}2m$, $SB0_{PU}2m$, $CP0_{PU}2m$ and $CP0_{PU}1E$ from legumes and MPU1, MPU2, FPU1, FPU2 and SPU2 from cereals. The strains were stored at -20^{o}C in sterile MRS broth (De Man *et al*., 1960) supplemented with 10% glycerol for future use. For this study, the strains were cultivated in MRS broth at 37°C overnight, washed twice in 50ml/L of phosphate buffer (pH 7.0) and resuspended in the water used for making the product.

2. Experimental design and formulation

The formulations for the products were developed to determine the feasibility of using the probiotic potential LAB isolates as functional ingredients in product type creams made with different proportions of mixtures of cereals and legumes. In this study, a total of 4 samples were prepared in replicates as shown in Table 1. Formula BPS1 was made with 100% cereal mix and probiotic isolates; formula BPS2 was prepared with 25% legume mix and probiotic isolates; formula BPS3 contained 50% legume mix and 50% cereal mix and probiotic isolates and BPS4 was prepared with 75% legume mix. The other ingredients, sugar (5%), salt (1%) and water (65%), were added in equal proportions to the 4 formulas above. The cereal-legume formulas were inoculated with 1% (v/v) of probiotic culture. Fermentation was carried out for eight (8) hours at 37°C. Shelf-life stability was then assessed after every seven (7) days for a period of one month (28 days) at 4°C.

Table 1: Formulation of probiotic Cereal-Legume drinks

Ingredients (g)	**Formulation of probiotic Cereal-Legume drinks**			
	BPS1	BPS2	BPS3	BPS4
Cereal mix (Maize, Sorghum and Finger millet in the ratio of 1:1:1)	1000	750	500	250

Legume mix (Rose Coco, Green Grams, Soya Beans and Cowpeas in the ratio 1:1:1:1)	0	250	500	750

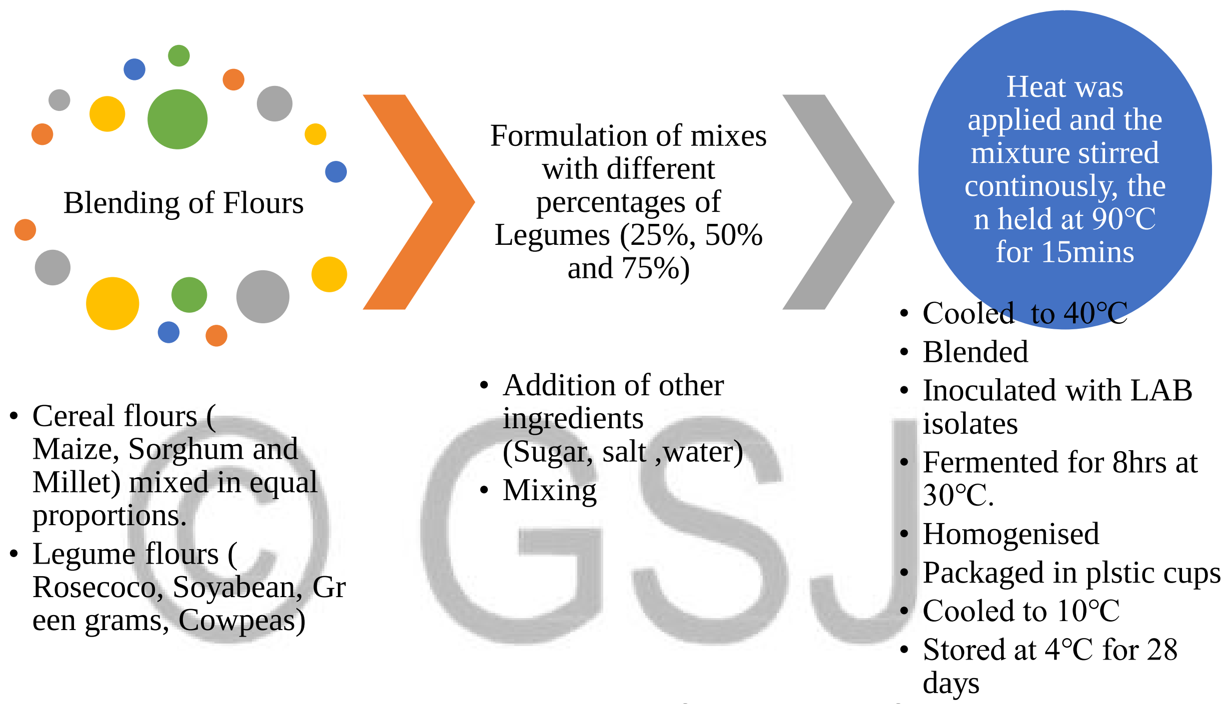

Figure 1: Schematic representation diagram of production of probiotic cereal-legume product

3. Viable cell count in product

The enumeration of probiotic potential LABwas carried out in duplicate using de Man, Rogosa, and Sharpe (De Man *et al.*, 1960)) agar supplemented with 0.15% (wt/vol) of bile salts, incubating anaerobically for 48 hours at 37°C. Blending of samples was done for 2 min at high speed after the addition of 99mL of 0.1% sterile distilled water and subjected to serial dilutions using the same diluent. Spread-plating was done for each dilution in duplicate on MRS agar followed by 48 hours of incubation at 37°C. Colony-forming units (cfu/g) were enumerated and value presented in form of log10 (Somashekaraiah *et al.*, 2019).

4. Physical–chemical analysis

4.1 Moisture content

Moisture was determined using the drying oven method, by drying a representative sample in an oven (AOAC 925.04). The percentage moisture content was calculated by the following formula.

$$\% \text{ moisture}=W_1 - \frac{W_2 \times 100}{W_1}$$

W_1=initial weight of sample; W_2=weight of the dried sample.

4.2 Ash content

Ash was determined according to AOAC 945.46. The percentage ash content was expressed by the formula below;

% ash= (Z-X/Y-X) ×100

Where; X=weight of empty crucible; Y=weight of crucible + sample; Z=weight of crucible + ash

4.3 Fat content

The fat content was determined as described

Fat (AOAC 989.05) was determined through lipid, extraction with ethyl ether, using the Soxhlet device (Association of Official Analytical Chemists 2000).

$$\% \text{ fat}=\frac{\text{weight of extracted fat (g)}}{\text{weight of sample used (g)}} \times 100$$

The percentage fat was calculated by the following formula.

4.4 Protein content

Protein (AOAC 991.20) was estimated by measuring the product nitrogen content by the Kjeldahl method and multiplying it by a conversion factor (6.38). The protein was calculated as:

$$\% \text{ crude protein} = \% \text{ nitrogen} \times 6.38$$

$$\% \text{ nitrogen} = \frac{(ml\ standard\ acid - ml\ blank) \times N\ of\ acid \times 1.4007}{sample\ in\ grams}$$

5. Estimation of shelf life

The shelf life of the fermented products was considered as the period of refrigerated storage at 4°C when the pH remained above 4.0 and the number of viable cell counts above 10^6 Cfu/mL. Refrigerated storage was carried out for 28 days with periodical observations of pH. The pHs of the sample products were measured through electronic digital pH meter. Buffer solution of pH 4 and 9 were used to calibrate the pH meter.

6. Sensory analysis

Sensory evaluation (degree of likeness) of all treatments was carried out by employing a nine-point hedonic scale where '9' represented 'like extremely' and '1' 'dislike extremely'. The analysis was carried out by 25 males and 25 female non trained panelists between the age of 22 and 45 years from the Technical University of Mombasa. White plastic plates labelled with three-digit codes from a random number table were used to conceal the identity of the cream samples. Samples (20ml) of each sample formula and the respective tools for degustation (napkins, knives, unsalted cracker) were served in random order to the panellists, isolated in partitioned booths illuminated with white fluorescent light. Glass of water was provided between the samples to clean the palate.

7. Statistical analysis

All the experiments were performed in triplicate, and all data obtained were calculated as mean values and standard deviations. The data analysis was carried out using SPSS version 25.0 (IBM, USA). The difference was estimated by one-way ANOVA with Duncan's multiple range test and statistical significance difference were calculated at $P < 0.05$ level.

Results

1. Viable cell enumeration in the product

The results of viable cell count during storage are shown in Figure 2. This study showed viable bacterial count from day 0 to day 28 in the products as; BPS1 7.83× 10^8 to 7.32× 10^8, BPS2 8.25× 10^8 to 7.53× 10^8; BPS3 8.28× 108 to 7.67× 10^8 and BPS4 8.21 × 10^8 to 7.98× 10^8. This translates to percentage survivability of 93, 91, 93, 97% respectively of the probiotic viable count. Probiotic potential *Kenoko* isolates used in this study were generally stable in the products during the period of 28 days (Figure 2), though BPS4, recorded highest cell survival (97%).

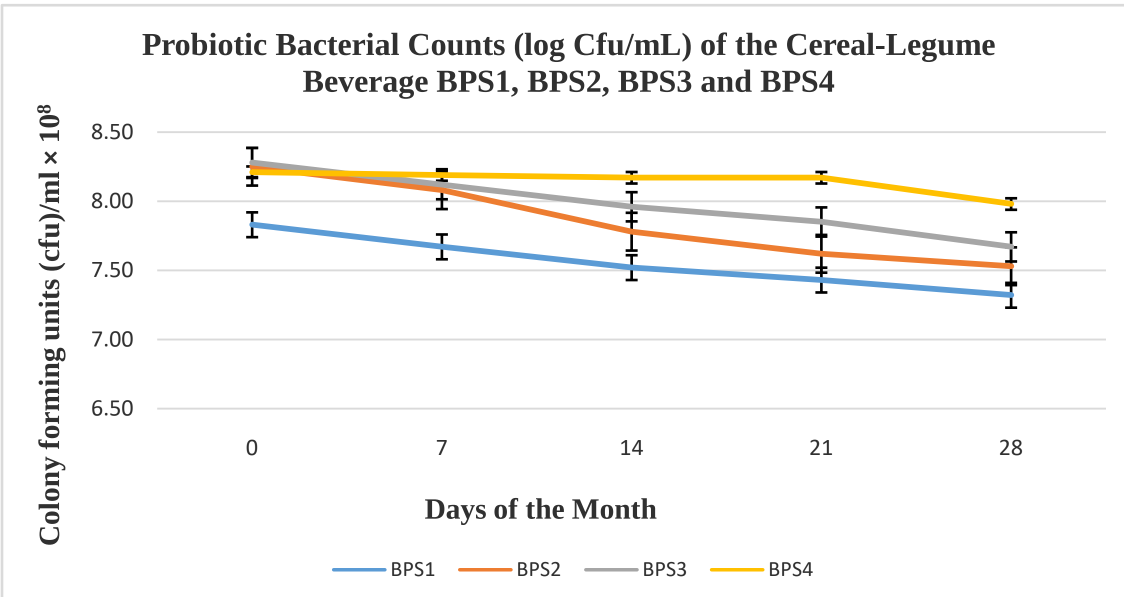

Figure 2 Probiotic bacterial counts (log Cfu/mL) of the Cereal-Legume Beverage BPS1, BPS2, BPS3 and BPS4 There was a significant variation in the mean viable counts of probiotic bacterial cells among the products since the p value was less than 0.05. Significant difference existed between; BPS1 & BPS2, BPS1 & BPS3, BPS1 &BPS4, BPS2 & BPS4, and BPS3 & BPS4.

2. Physical–chemical properties of product samples

The result of the physiochemical properties of the four product samples are summarized in Figure 3. The moisture content of BPS1, BPS2, BPS3 and BSP4 were found to be 84.06, 82.05, 77.49 and 75.82% respectively. BPS1 had the highest moisture content (84.06%) and fat (2.52%) but with lowest ash content. BPS4 had the highest ash content (0.87%). BPS3 and BPS4 had a higher protein content among the four products of 3.17% and 3.26% respectively.

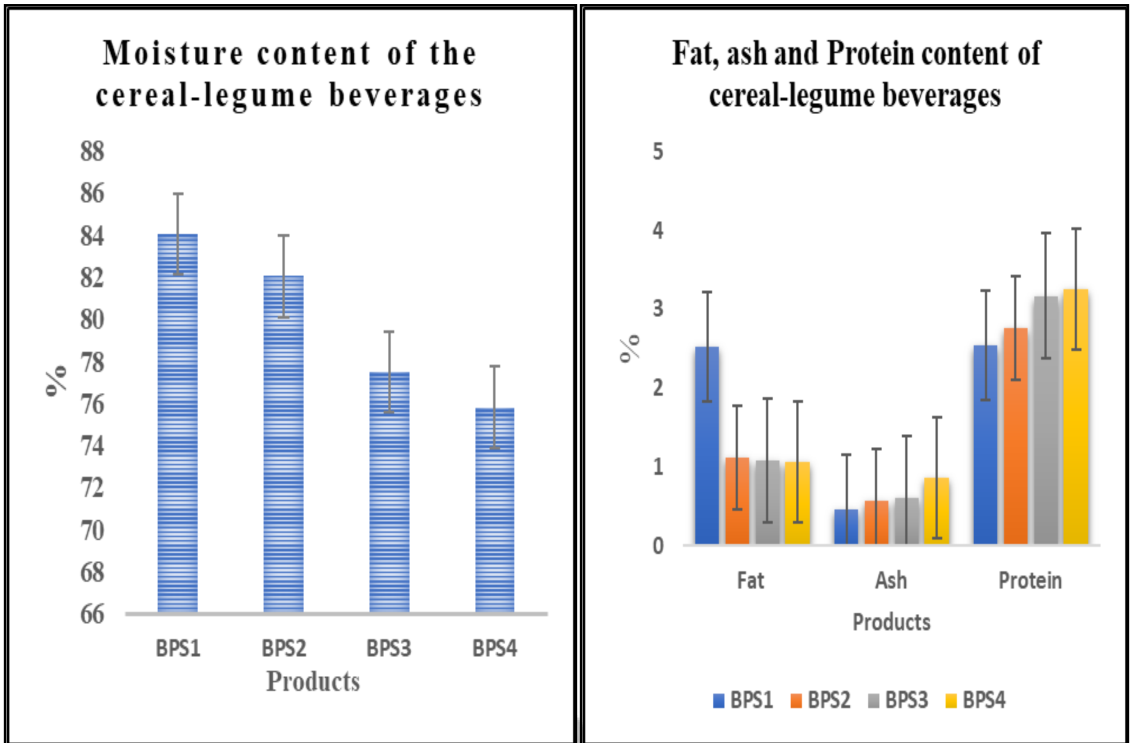

Figure 3. Physical–chemical properties of product samples

Statistical analysis pointed out that there was no significant variation in the mean content among the samples since the p value was more than 0.05. There was significant variation in the mean content among the chemical samples as the p value was less than 0.05. There were significant differences between moisture & fat, moisture and ash, moisture and protein.

3. Shelf-life estimation of the products

In this study the pH change for the cereal-legume products was evaluated. The pH for all the sample products reduced from 4.07 on day 0 with BPS2 recording the lowest drop on day 28. BPS1's acidity dropped below pH 4.0 even by day 21 (Figure 4).

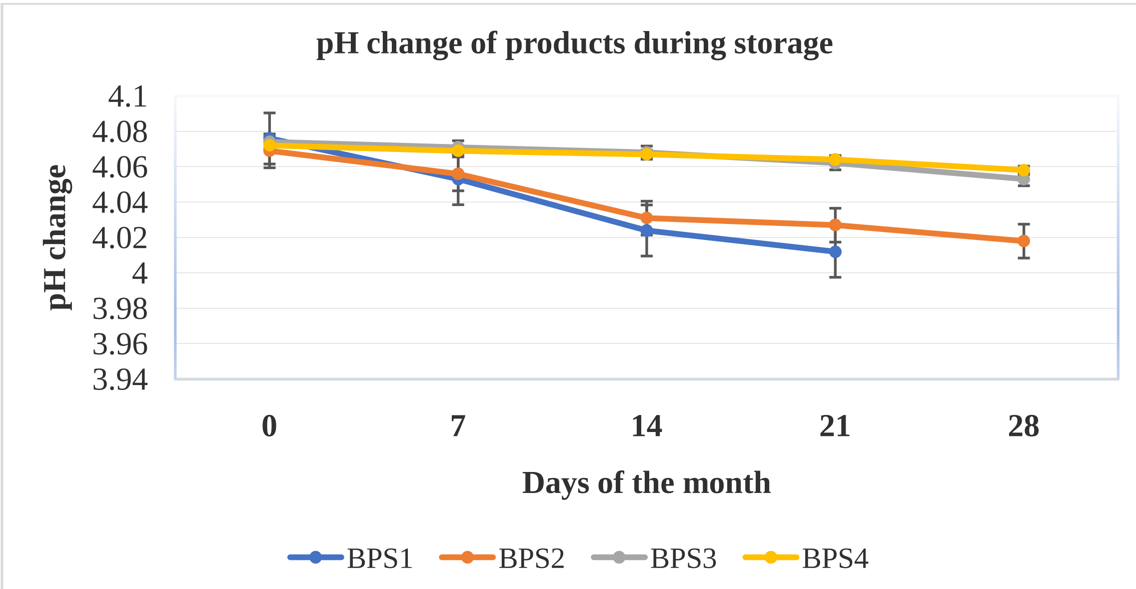

Figure 4. Changes in pH for the Cereal-Legume products on storage

There was no significant variation in the mean pH change among the product formulation since the p value was less than 0.05. There was no significant variation in the mean pH change among the days on the storage since the p value was less than 0.05.

4. Sensory Evaluation of the products

In this study, panelists rated the aroma of BPS1 highest at 7.52 (Figure 5) with the product that had highest % of legume mix scoring lowest (3.64). BPS2 and BPS3 recorded an average score of 6.79 and 6.53 respectively for aroma. The average degree of likeness among the panelist for color was 6.84, 7.55, 7.85, and 6.32 for BPS1, BPS2, BPS3 and BPS4 respectively. BPS3 scoring highest while BPS4 scoring lowest although reasonably not bad. BPS1 had the best taste (7.85) and also ranked highest on overall acceptability (6.85). The overall acceptability of BPS4 was poor (3.47).

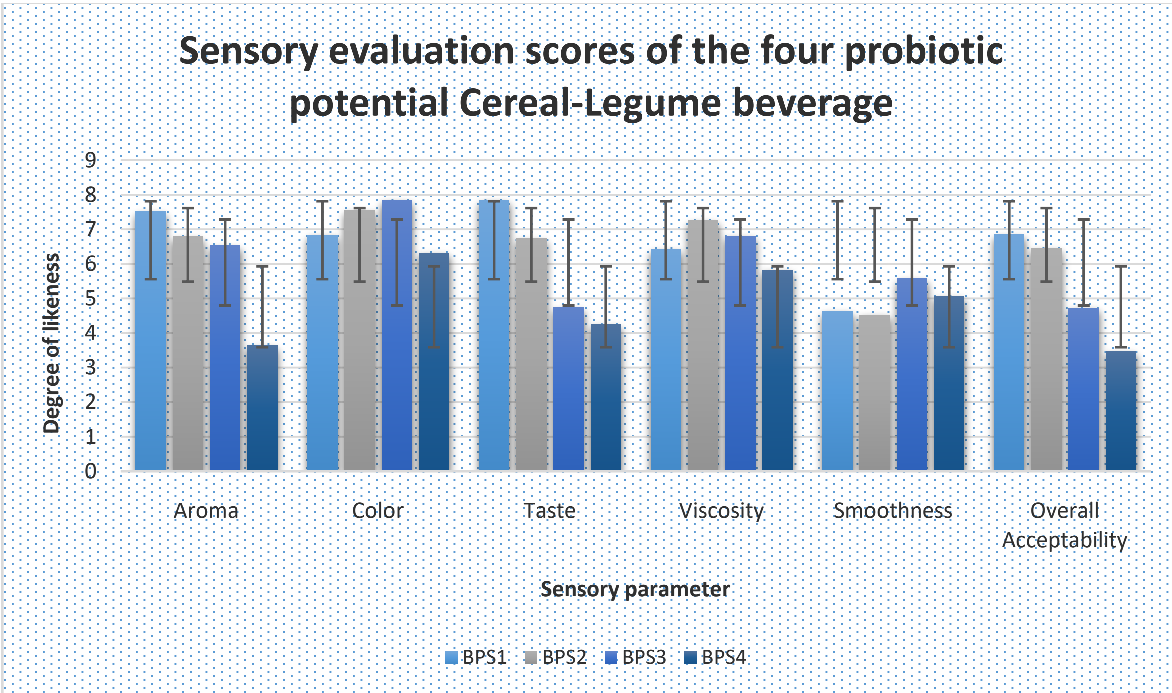

Figure 5. Sensory evaluation scores of the four probiotic potential cereal-legume drinks

Among all the tested parameters, smoothness for cereal legume fermented products was average on degree of likeness. There was no significant variation in the mean sensory evaluation scores among the sensory parameters since the p value was more than 0.05. There was significant variation in the mean sensory evaluation scores among the four products since the p value was less than 0.05. Significant differences were found between BPS1 & BPS4, BPS2 & BPS4, BPS3 & BPS4.

Discussion

Microorganisms may be used intentionally on industrial scale to obtain useful products for humans. These industrial products may include enzymes, biomass, primary and secondary metabolites, recombinant, and biotransformation products. Modification of the food substrate during fermentation process occur due to the biochemical changes that lead to the production of other compounds (such as alcohols and acids). Functional foods are reported to improve health through adequate nutrition. Fermentation process improve the texture, appearance, flavour, colour, shelf life and also protein digestibility of legumes (Frias *et al.*, 2017); Adebiyi *et al.*, 2018). Fermentation decreases the presence of antinutritional factors such as phytates, oligosaccharides, lectins and protease inhibitors. It is reported that lactic acid bacteria may produce a variety of substances that may be of benefit to consumers for breaking up proteins in the surrounding environment for their own growth needs (Wang *et al*., 2021). There is no doubt that lactic acid bacteria can improve the digestibility of protein in food product and therefore enhance the nutritional value. Fermentation process of faba bean dough by a strain of *Lactiplantibacillus plantarum* VTT E-133328 improved the in vitro digestibility of its protein , this was noted especially in the content of essential amino acids and free amino acids (Coda *et al*., 2015). After lactic acid bacteria fermentation of the by-products of pigmented wheat varieties, hull-less barley and emmer combined with xylanase treatment, it was noted that the protein digestibility in vitro was as high as 87%, and the product had high free radical scavenging activity, high concentration of peptides and free amino acids (Pontonio *et al*., 2020). Yoghurt association (NYA) of the United States recommends specification for a probiotic product claimed to possess health benefit. The body specifies that 10^8 cfu/mL of lactic acid bacteria are required at the time of manufacture. In Japan, the fermented milks and lactic acid bacteria beverages Association has specified a minimum of 10^7 cfu/mL of *Bifidobacteria* to be present in fresh dairy products as a standard. There exist no standards so far for plant based probiotic beverages however results from this study showed viable bacterial count form day 0 to day 28 being above 10^7 cfu/g. Product BPS4 with highest percentage of legume mix recorded the lowest loss of viability of microbial count. The number of probiotic bacteria in processed foods should be 10^6 - 10^7 CFU/g or 10^8 -10^9 CFU in 100 g or 100 ml daily food consumption in order to get the medicinal benefit (Kunchala *et al*., 2016; Terpou *et al.*, 2019). Probiotic foods from a single microbial strain are not welcomed by the consumers due to rather sour and acidic taste and therefore it is advised that probiotic strains be a mixture of more than one (Kunchala *et al.*, 2016). The viable count numbers for lactic acid bacteria in this study conforms to both the NYA and Japanese standards of 10^8 and 10^7cfu/mL respectively.

Maintaining the probiotic product viability and survivability during product processing and storage is a very crucial factor for effective product development (Terpou *et al*., 2019); Fenster *et al*., 2019). *Kenoko* isolates used in this study were generally stable in the products during the period of 28 days with BPS4 recording the highest cell survival of 97% (8.21×10^8 to 7.98×10^8). Factors affecting probiotic survivability include the ingredients added, pH and oxygen residuals (Terpou *et al*., 2019). Fermentation process of cereals and legumes may avail more nutrients for probiotic bacteria growth, including improved protein quality, some amino acids such as lysine and others may be synthesized (Nkhata *et al*., 2018). Other factors include decreased level of carbohydrates, availability of some non-digestible poly and oligosaccharides, increased availability of group B vitamins, optimum pH conditions for enzymatic degradation of phytate and release of minerals such as manganese (which is an important growth factor of lactic acid bacteria, iron, zinc and calcium. It is suggested that the physical structure of non-dairy probiotic carrier foods such as cereals and legumes provide a protective environment for probiotics and reduce their exposure to harsh gastrointestinal conditions (Ranadheera *et al*., 2017). This could suggest the reason why the viable counts in the 4 products were above 90% even after 28 days of storage. Food protein can be hydrolysed by lactic acid bacteria into a variety of smaller molecular peptides or free amino acids (Wang *et al*., 2021). The group of *Lactobacilli* in the kefir culture was found to have a strong hydrolysing effect on milk proteins (Dallas *et al*., 2016). Functional foods are classified as probiotic foods containing a single or mixed culture of microorganisms with various prophylactic properties and efficient at a level of 10^6 (cfu g^{-1}) (Terpou *et al*., 2019). Probiotic foods are reported to reduce blood pressure levels, the risk of colon cancer and increase the resistance against invasion by pathogens (Nazir *et al*., 2018; (Gharbi *et al*., 2017)

Estimation of pH

During fermentation, there is production of acids (lactic, acetic malic, propionic and butyric) which lower the pH and enhance the flavor of the final product (Murali *et al*., 2017). The acids also increase food shelf-life by lowering the pH to below 4 and which restricts the growth and survival of most spoilage organisms and some pathogenic organisms. The organic acids released during lactic acid fermentation as by-products lower the pH to levels of 3 to 4 with a titratable acidity of about 0.6% (as lactic acid) (National Research Council-US,1992).Lactic acid bacteria produce lactic acid during fermentation which lower the pH. In this study the pH of all the sample products reduced from about 4 on day 0 with BPS4 recording the lowest drop on day 28. Previous studies have also reported a similar decrease in the pH of yogurts during the extended cold storage (Mohan *et al*., 2020). In the work on physicochemical, microbiological, sensory properties and storage stability of plant-based yoghurt produced from Bambara nut, Soybean and Moringa oleifera seed milks obtained pH values of 4.00-4.50 (Ani, 2018). Food Standard

Code requires that the pH of yoghurt be in the range of 3.9 to 4.5 in order to prevent the growth of any pathogenic organisms (Donkor *et al*., 2006).

Physiochemical properties of the product samples

The result of the physiochemical properties of the four product samples are summarized in figure 3. The moisture content of BPS1, BPS2, BPS and BSP4 were 84.06, 82.05, 77.49 and 75.82% respectively. BPS1 exhibited highest while BPS4 lowest moisture content. The high percentage of legume flour in sample could have contributed to high protein content whose molecules tend to bind more water. From the study by (Matela *et al*., 2019) the moisture content of the nine yoghurt samples were in the range of 80.07 to76.08%. %. The results from this study are also in agreement with reported moisture content values of 78.62 to 82.41% (Igbabul *et al*., 2014). The moisture content of yoghurt is supposed to be less than 84% in order not to affect the texture and mouth feel (Matela *et al*., 2019).

The fat content results showed that BPS1 had the highest fat content compared to the other three samples. BPS3 and BPS4 had the lowest fat content. It has been reported that the percentage of fat content play a vital role in fermented drinks since it improves appearance, texture, flavour and taste. According to United States Department of Agriculture (USDA), for a product to be labelled yoghurt, it should have more than 3.25% of fat content. Those yoghurts with fat content in the range of 0.5-2.0% should be labelled as Low-Fat yoghurt and with less than 0.5% fat content be labelled as Non-Fat yoghurt. The Codex standard for fermented milk states that, yoghurt fat content should be less than 15%. The products developed in this study showed that the fat content of the four samples comply with these standards and fall in the category of low-fat yoghurt.

The ash content of a sample is the indication of the mineral content which promote bone formation and mineralization (Fox *et al*., 1998). The percentage of ash content of BPS1, BPS2, BPS3 and BPS4 were 0.47, 0.58, 0.61 and 0.87% respectively. Product BPS4, with highest quantity of legume mix exhibited the highest percentage of mineral content with the lowest ash content recorded in BPS1 (100% cereal mix).

Codex standards, states that yoghurt should not contain less than 2.70% protein content. The protein content result showed that BPS4 had the highest protein content of 3.26% while BPS1 had lowest protein content of 2.54% which is slightly lower than 2.7%. *Lactobacillus rhamnosus* GG is a probiotic strain that has received intensive clinical investigation and the studies have revealed that the bacteria were found to enhance human natural resistance and healthy digestive system and also to inhibits the adhesion of some pathogens (Pace *et al*., 2015). These probiotic cells revealed a high tolerance to the acidic conditions and responded to sudden changes in their immediate osmotic environmental conditions by accumulating sucrose so as to protect both the membranes and internal organs (Gharbi *et al*., 2017). The strain therefore can be successfully applied in the processing of foods containing sugars and also in preservation processes. *Lactobacillus rhamnosus* GG is finding application in food industry both as a probiotic and as a protective culture in many fermented and nonfermented products (Gharbi *et al.*, 2017).

The increase number of consumers who are vegetarian and lactose intolerance has led to high demand for the vegetarian probiotic products (Gharbi *et al*., 2017). The development of new probiotic or functional food products continue to draw much attention. Cereal-based probiotic products show a beneficent effect for the consumer in terms of health. Plant based food such as cereals and legumes have health-benefiting microbes and potentially prebiotic fibres. Moreso, cereal-legume based products belong to a highly nutritive culinary recipe category (Gharbi *et al.*, 2017). They provide nutrients including dietary proteins, carbohydrates, minerals, polyphenols, vitamins, and non-nutrients compound including dietary fibre and oligosaccharides.

Sensory Evaluation of sample products

Sensory acceptance is one of the factors considered during the development of new products in the market. A product with good sensory score will attract wide market share irrespective of its nutritional value. Consumer product expectation is always given highest priority in an effort to overcome strong competition within the Food sector. The sensorial quality characteristics such as color, taste, flavor and texture of cereal-legume probiotic product play an important role in attracting consumers to purchase the product. The traditional foods made from cereal grains usually lack flavor and aroma (Poonam *et al*., 2021). The production of volatile compounds during cereal fermentation contributes to a complex blend of flavors in fermented legumes and cereals making them more appetizing ((Liptáková *et al*., 2017); Adebo *et al*., 2022). The fermentation of cereals and legumes leads to general improvement in the shelf life of the final products (Nkhata *et al.*, 2017). Acids produced during the fermentation process lower the pH value to 4 or less, hence inhibiting the growth of numerous spoilage organisms (Lorenzo *et al.*, 2018). Lactic acid fermentation of cereals is a long-established processing method used to realize various beverages (busaa, boza and bouza), gruels (togwa), porridge (ogi, yosa) among many (Gharbi *et al.*, 2017).

Panelists in this study were requested to evaluate the sample product acceptance using a 9-point hybrid hedonic scale (Yang & lee, 2018), where 1 = disliked extremely, and 9 = liked extremely. The consumer test was carried out after samples had undergone two weeks of refrigerated storage. This corresponds to half the normal commercial shelf life of such low acid foods. To cleanse the palate after every sample testing, participants were instructed to eat a cracker and drink water between samples. Consumers' expectations and demands for new products that are attractive with health benefits is making development process very challenging. To strike the balance, process optimization to generate the best formulation is key in product development.

Processors need to optimize the levels of each ingredient in the formulation of product in order to attain the best physicochemical properties, sensory, chemical and microbial stability at affordable cost. In this study panelists rated the aroma of BPS1 highest at 7.52 with the product that had highest % of legume mix less liked (3.64).
The average degree of likeness among the panelist for color for sample BPS3 scored highest while BPS4 scored lowest although reasonably not bad. The color of yogurt is an important quality characteristic that influences the consumer liking in sensory evaluations. Generally, the color of the four products was good. The average scores for the taste of the products were 7.85, 6.74, 4.74 and 4.25 for BPS1, BPS2, BPS3 and BPS4 respectively. Product formulation with more than 50% legume mix (BPS3 and BPS4) not rating highly with regard to taste. The viscosity of product sample BPS2 with 25% legume mix had overall high ranking on viscosity (7.25) while on smoothness, BPS3 performed better than the other 3. The general acceptability of BPS1 was highest (6.85) among all the panelist while BPS4 was least acceptable (3.47). There is no significant variation in the mean sensory evaluation scores among the parameters since the p value is more than 0.05. There was significant variation in the mean sensory evaluation scores among the probiotic potential cereal-legume beverage since the p value is less than 0.05. Consumers' judge beverage quality on the basis of sensory parameters, no wonder in some food

products artificial color, sweetener and other additives are added to improve acceptability. The sensory qualities of probiotic product sample BPS3 and BPS4 will need to be adjusted using artificial additives such as color, flavor and sweeteners in order to improve their acceptability. Results on physicochemical properties, pH, growth and survivability in food product in this study suggest that probiotic beverages can be developed from cereal-legume mixtures. The probiotic counts in all of products were more than 10^7 Cfu/mL after four weeks refrigerated storage falling above the recommended dosage levels for probiotics. The low pH maintained during storage at 4 and below further suggest the stability of product samples and safety against pathogenic microorganisms. The performance of products on sensory evaluation was generally above average on most parameters (9- liked extremely). The product sample BPS1 and BPS2 had higher consumer acceptability in sensory trials. The lactic acid bacteria with probiotic potential isolated from *Kenoko* can be used in the development of probiotic beverages. Clinical studies on the in vivo physiological benefits for the host need to be conducted to confirm a prebiotic effect.

Conclusion

The physicochemical properties, pH, growth and survivability of LAB in this study suggested that probiotic beverages can be developed from cereal-legume mixtures. The probiotic counts in all of products were more that 10^7CFU/mL after four weeks refrigerated storage (which are above the recommended levels for probiotics). The low pH of 4 and below that were retained during storage further gave credit to the stability of products BPS1, BPS2, BPS3 and BPS4 against pathogenic microorganisms. The performance of products on sensory evaluation was generally above average on most parameters (9- liked extremely). The product sample BPS1 and BPS2 had higher consumer acceptability in sensory trials. The lactic acid bacteria with probiotic potential isolated from *Kenoko* can be used in the development of probiotic beverages. Clinical studies on the in vivo physiological benefits for the host need to be conducted to confirm a prebiotic effect.

CONFLICT OF INTEREST

The authors have no conflict of interest

AKNOWLEDGEMENTS

This work was financially supported by the National Commission for Science, Technology, and Innovation (Nacosti), courtesy of Dr. Rahma Udu, the dean Applied and Health Sciences department, Technical university of Mombasa.

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