





























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  $10^7$ CFU/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

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