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DEVELOPMENT OF A SYNBIOTIC YACON (SMALLANTHUS SONCHIFOLIUS) POWDER JUICE WITH LACTOBACILLUS

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ABSTRACT

The growing demand for functional foods has driven innovations in synbiotic beverages that combine probiotics and prebiotics to promote gut health. Yacon (Smallanthus sonchifolius), rich in fructooligosaccharides (FOS), offers a promising substrate for probiotic incorporation.

This study formulated a symbiotic powdered juice using yacon powder and Lactobacillus. Experimental design assessed microbial viability under refrigerated and room-temperature storage, alongside physicochemical parameters (pH, moisture), microbial safety, sensory acceptability, and nutritional attributes. Microbiological assays and sensory evaluation using a nine-point hedonic scale were conducted with 131 respondents.

The synbiotic powder was successfully formulated as a homogeneous product suitable for packaging. Lactobacillus strain-maintained viability during storage, with refrigeration sustaining higher counts to 10^10 CFU. Yacon's FOS enhanced probiotic survival, while pH remained within a safe acidic range of 4.3–4.9 level. Moisture fluctuations were minimal and acceptable. Microbial analysis confirmed absence of pathogens, ensuring safety. Sensory evaluation indicated favorable acceptability across aroma, flavor, sweetness, sourness, color, aftertaste, and overall impression. Nutritionally, the product demonstrated functional benefits through synbiotic effects.

The study affirms that synbiotic yacon powder juice is safe, stable, nutritionally beneficial, and sensorially acceptable, positioning it as a viable candidate for commercialization and sustainable community nutrition initiatives.

KEYWORDS: functional foods, synbiotic, Lactobacillus, fructooligosaccharides, pH level, moisture level

INTRODUCTION

The rapid growth of the global population has resulted in increased food demand, necessitating enhanced productivity within the food industry. Improving industry efficiency is crucial for ensuring an adequate food supply worldwide. Recent market trends emphasize advanced food processing techniques and the development of novel products, including the incorporation of probiotics and the repurposing of edible waste into functional foods. These innovations offer potential solutions to malnutrition, food waste reduction, and environmental sustainability. Functional foods play a significant role in promoting healthy habits, driven by heightened consumer awareness of the direct impact of diet on health.

The advancement of functional foods has been the evolution of scientific and consumer interest in the ability of nutrition to prevent chronic disease and optimize health, which goes beyond the traditional focus on prevention of nutrient deficiency diseases (Hasler, CM., 2020). Over the last few decades, there has been a significant shift in consumer demands for food production.

Currently, consumption patterns are not based on flavor and nutrients, but also on its beneficial effect on human health. Development of the functional food product is like a gateway to a golden era of the healthy consumer. The probiotic, phytochemical, antioxidant, amino acid, vitamin, and omega fatty acid took part as a majority ingredient in those healthy food products. Further, utilization lactic acid bacteria (LAB) and other live microorganisms which are generally recognized as safe (GRAS) with no pathogenic effect can be utilized to enhance functionality of food.

Beside nutrients, functional food helps maintain both physical and mental health and in reducing the risk of cardiovascular disease, gastrointestinal disorders, neurodegenerative conditions, and certain cancers (Essa et al., 2021). Kaur, Shekhar, and Prasad (2024) presented an extensive review on emerging advancements in functional beverages, underscoring their increasing potential as substitutes for traditional meals. Their work highlights that evolving consumer behaviors is shaped by rising health awareness, sedentary routines, and the growing popularity of plant-based diets are driving the demand for drinks that provide added nutritional value beyond simple hydration. These functional beverages are formulated using a variety of raw materials, including plant-based dairy alternatives, fruits and vegetables, cereals, legumes, and millets. A significant trend noted in the review is the rising popularity of powdered and instant drink mixes, which are preferred over ready-to-drink products due to their extended shelf life and ease of use. The authors further explore formulation strategies, such as balancing ingredients and fortifying products with essential nutrients, to target specific health outcomes like weight control, digestive wellness, and enhanced immunity (Kaur et al., 2024).

As of 2024, the global market for functional beverages has reached an estimated value of USD 126.7 billion, reflecting a robust and growing demand for health-oriented drink products. Energy drinks continue to dominate the category, accounting for approximately 32% of the market share, followed by fortified juices at 26%, dairy-based functional beverages at 21%, and other emerging formats including plant-based and fermented drinks also at 21% (Innova Market Insights, 2024). This growth is largely driven by shifting consumer preferences toward wellness, convenience, and personalized nutrition. Millennials and Gen Z consumers are fueling demand for beverages that support stress relief, digestive health, and cognitive

performance. Regionally, North America leads the market with a 35% share, while Europe and Asia-Pacific follow with 28% and 25%, respectively. Notably, powdered, and instant beverage mixes are gaining popularity due to their portability, longer shelf life, and ease of preparation. The market is projected to expand further, with forecasts suggesting it will surpass USD 204 billion by 2034, growing at a compound annual growth rate (CAGR) of 4.9% (Kaur, Shekhar, & Prasad, 2024). On the other hand, probiotic foods are regarded as a type of functional foods whose market demand is increasingly continuously.

Probiotic foods have gained significant attention for their role in promoting gut health, enhancing immune function, and preventing gastrointestinal disorders. At the time of consumption, live probiotics must be present at the amount of 10^6 to 10^7 colonyforming units (CFU) per gram of food product (Palanivelu et al., 2022). This threshold is widely accepted in scientific and regulatory communities to ensure that the probiotic strains can exert their beneficial effects in the gastrointestinal tract. The pH, temperature, oxygen exposure, and food composition can be a factor that may significantly affect the survival of the probiotic strains, and to address these issues, a recent innovations include the use of spray drying, microencapsulation, and protective carrier like the use of food products with prebiotic, and fibers to enhance the stability and the shelf-life.

Nutrient rich fruit juices are alternatives for probiotic incorporation as it encourages probiotic growth. Also, fruit juice lacks any dairy allergens and has a pleasing taste profile. Moreover, Region 1, is rich for a different kind of high quality of indigenous food fruits. Yacon is one of the indigenous crops can be found in the Region 1, particularly in Cervantes Ilocos Sur. Yacon juice is rich in fructooligoscahrides and antioxidants which can help improve gut health and fight inflammations. From the benefits of yacon juice it is a good suitable raw material to develop a probiotic juice.

In developing probiotic food products, the main objective is to ensure the viability of probiotic microorganisms from processing to the entire duration of the product's shelf life. Various factors can affect the survival rate of probiotics in food, including microbiological parameters (such as probiotic strains and inoculation rates) and food parameters (such as salt and sugar concentrations, pH level, and water activity).

Probiotics are generally recognized as safe (GRAS) and are associated with numerous health benefits, including promoting intestinal balance, inhibiting pathogen growth, stimulating the immune system, and producing antimicrobial substances. However, many probiotic strains are highly sensitive to environmental conditions, making their viability and activity heavily dependent on their ability to survive during processing and storage. In the context of yacon juice processing, probiotics are incorporated into the powder juice, which is then packaged and stored either at room temperature or under refrigerated conditions. This environment can pose risks of contamination and may affect the probiotic's stability and efficacy over time.

Yacon is known for its nutritional content and health benefits where it also serves as prebiotic. However, since it is only available during certain seasons, this study aims to develop a symbiotic product that contains a prebiotic component together with the infusion of live microorganisms or the probiotics.

OBJECTIVES OF THE STUDY

The study aimed to develop a synbiotic yacon powdered juice by incorporating Lactobacillus to leverage the combined benefits of probiotics and prebiotics. Specifically, it sought to evaluate the viability and survival of Lactobacillus throughout the processing and storage of the yacon powder juice under different conditions. The research also investigated changes in critical physicochemical parameters, including pH and moisture content, to assess product stability. Ensuring microbial safety through comprehensive microbial analysis was another key objective, aimed at confirming the absence of harmful pathogens. Additionally, the study evaluated the sensory acceptability of the formulated yacon powder juice with Lactobacillus based on attributes such as aroma, flavor, sweetness, sourness, color, aftertaste, and overall impression using sensory panels. Lastly, the nutrient composition of the synbiotic product was determined to establish its potential as a functional food with health benefits.

METHODOLOGY

The study employed an experimental research design to formulate and evaluate the viability of Lactobacillus in the synbiotic yacon powder juice under two storage conditions: refrigerated and unrefrigerated. The population for sensory evaluation consisted of 131 respondents comprising expert professionals, non-teaching personnel, and students from Ilocos Sur Polytechnic State College and the College of Business Management and Entrepreneurship selected through purposive sampling based on their availability and familiarity with sensory testing protocols.

The research was conducted at the Post-harvest Laboratory and Micro Laboratory of Ilocos Sur Polytechnic State College and the Garlic Research Center at Mariano Marcos State University. Data gathering involved microbiological assays such as plate counts and viability staining at predetermined intervals to monitor probiotic survival, complemented by physicochemical measurements including pH and water activity. Sensory evaluation was performed using a nine-point hedonic scale assessing aroma, flavor, sweetness, sourness, color, aftertaste, and overall acceptability, with data collected via structured score sheets.

The study strictly adhered to ethical considerations, including compliance with Philippine food safety laws (Republic Act No. 10611 - Food Safety Act of 2013), ensuring ingredient quality and microbial safety, obtaining informed consent from all sensory evaluators, and protecting participant anonymity and privacy throughout. Statistical analysis was conducted using Analysis of Variance (ANOVA) to determine significant differences among treatments, providing a rigorous evaluation of product stability and acceptability.

RESULTS AND DISCUSSION

Research Findings and Discussion on Lactobacillus Viability After Storage

The stability of probiotic strains during storage is crucial for ensuring their efficacy in functional foods and supplements. In this context, the freeze-dried Lactobacillus powder was able to demonstrate 6.5x10^3 to 3.5x10^4 CFU/g viability after 9 months of storage under fluctuating refrigerated conditions and subsequent frozen conditions, followed by 2 weeks of unrefrigerated storage, from an initial 7.0x10^10 CFU/g as claimed by the manufacturer. This indicates that a resilient sub-population of the probiotic bacteria remained biologically viable over this period, although the minimum threshold to be able to confer health benefits is at least 1x10^6 CFU/g. Recent studies support this observation, highlighting that probiotic viability can be preserved under controlled storage conditions. Gao et al. (2021) reported that probiotic formulations exhibited stable CFU counts during storage when maintained at appropriate temperatures, emphasizing the importance of manufacturing and environmental factors for probiotic stability.

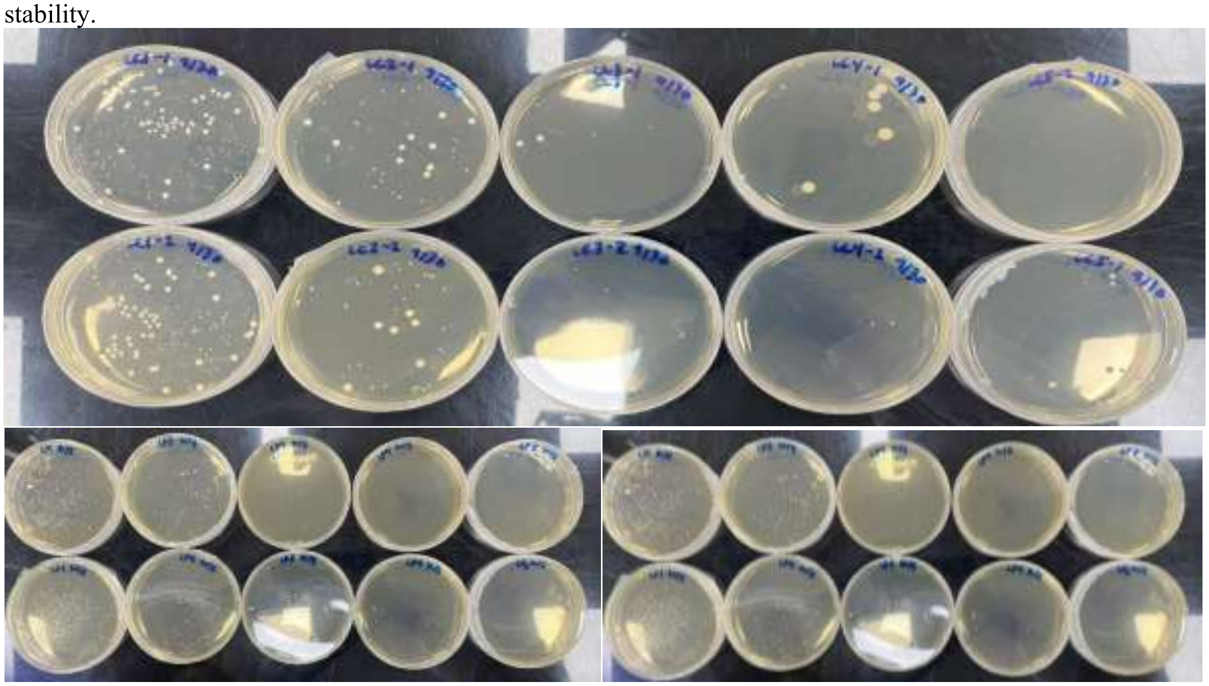

Figure 5. Stability of Probiotic Starin

These findings suggest that under optimal conditions, the probiotic's stability in the formulation is reliably maintained, which has positive implications for its integration into various delivery matrices. Specifically, infusing Lactobacillus into yacon juice powder appears promising due to the compatible prebiotic properties of yacon, which contains FOS that can synergistically support probiotic growth and activity in the gut. The maintained CFU levels suggest that such an infusion could effectively deliver viable probiotics, enhancing the functional benefits of the product.

Overall, the stability demonstrated aligns with recent research and indicates the potential for successful incorporation of Lactobacillus into yacon-based beverages, providing a convenient means to leverage the combined prebiotic-probiotic effects for gut health promotion.

YACON JUICE POWDER WITH Lactobacillus in Different storage conditions

Refrigerated Yacon Juice Powder with Lactobacillus

The microbial enumeration of the refrigerated (R) yacon juice powder with Lactobacillus revealed distinct colonies at 3x10^1, 1x10^7, and 1x10^9 CFU/g. The obtained CFU values demonstrate interference of the yacon powder matrix, with the probiotic bacteria being trapped inside microscope, undissolved clumps during the dilution process. This is a non-homogenous distribution of the sample and a non-linear dilution recovery across massive dilution gradients (sporadic colonies appearing at 10^-7 and 10^-9 dilutions). The high-molecular-weight yacon FOS combined with the commercial freeze-dried probiotic under cold conditions likely formed highly viscous micro-clumps upon reconstitution. These clumps encapsulate the bacterial cells, preventing even dispersion during serial dilution. Future methodologies evaluating complex prebiotic powders should incorporate extended mechanical homogenization or enzymatic disruption (Burgain et al., 2011; Champagne et al., 2011).

The findings still highlight the synbiotic potential of yacon-based probiotic beverages, wherein the prebiotic components of yacon synergize with Lactobacillus to enhance viability and functional properties. Previous studies have demonstrated that refrigerated yacon juice can maintain satisfactory probiotic counts (≥10^6 CFU/mL) for several weeks while preserving antioxidant activity and phenolic content, thereby supporting both nutritional and therapeutic value (Dahal et al., 2020). Moreover, international consensus emphasizes that probiotic efficacy is dose-dependent, with a minimum intake of approximately 10^9 CFU/day required to confer health benefits such as modulation of gut microbiota and immune enhancement (Hill et al., 2014; Wendel, 2022).

It is also noted that reliance solely on CFU counts may underestimate viability, as viable but non-culturable (VBNC) cells are not detected through conventional plating. Recent work has emphasized the need for complementary methods such as flow cytometry or viability PCR to provide a more accurate assessment of probiotic populations (Arroyo-Moreno et al., 2025). Furthermore, regulatory standards stress the necessity of accurate enumeration and strain identification to ensure consumer safety and compliance with probiotic product guidelines (Zawistowska-Rojek et al., 2022).

Unrefrigerated Yacon Juice Powder with Lactobacillus

The results indicate that unrefrigerated (UR) storage of yacon juice powder with Lactobacillus supports probiotic viability over time. During the first 7 days, microbial growth was observed at 2.3x10^3 CFU/g. By day 14, the count was observed at 1.0x10^1 CFU/g. These findings suggest that Lactobacillus can still survive and proliferate under ambient conditions, even in the absence of refrigeration. This observation is consistent with previous studies indicating that certain lactic acid bacteria possess adaptability to a range of environmental conditions, including moderate temperatures (Ranadheera et al., 2010).

The inclusion of yacon juice powder with Lactobacillus allows probiotic growth even at room temperature. Yacon is rich in FOS, which function as prebiotic compounds that selectively stimulate the growth and activity of beneficial microorganisms such as Lactobacillus (Gibson & Roberfroid, 1995). Similar findings have been reported where prebiotic-rich matrices significantly improved probiotic survival and growth (Saavedra & Tschernia, 2002). The water activity of the refrigerated yacon juice powder (0.592) was comparable to the commercial powder (0.593) when stabilized at room temperature (26°C), demonstrating the compatibility of the yacon powder as a probiotic carrier. Having a water activity of below 0.90 also shows the effectivity of the yacon juice powder drying and probiotic freeze-drying processes in maintaining the dried powder form (Tapia et al., 2020).

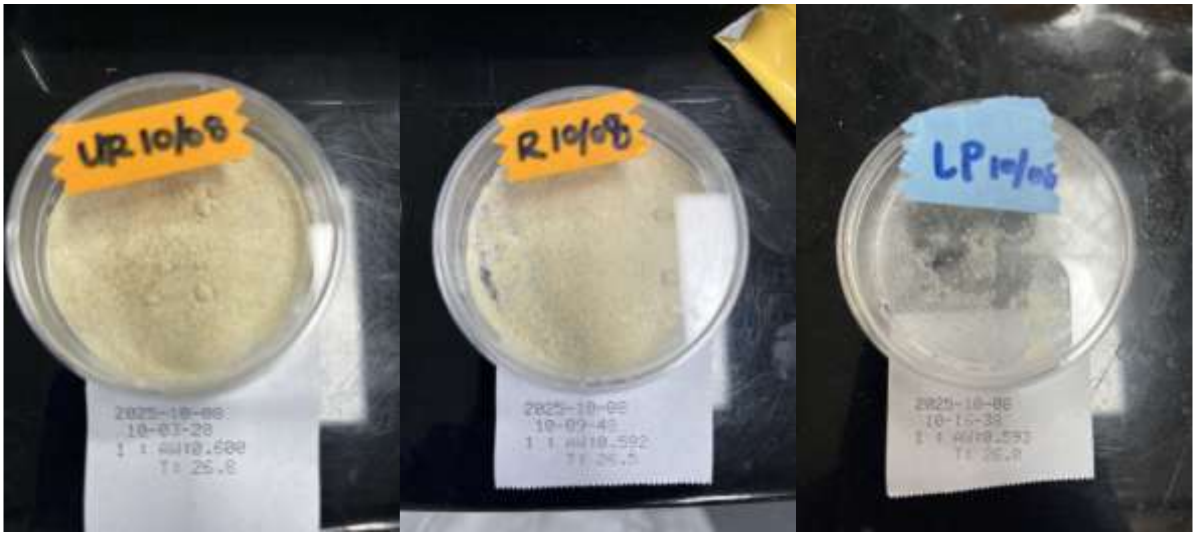

Figure 6. Viability of Probiotic strain under unrefrigerated condition

Temperature is a critical factor influencing microbial stability, as higher ambient temperatures may accelerate metabolic activity but also lead to increased cellular stress and eventual decline in viability over time (Tripathi & Giri, 2014).

Refrigeration, on the other hand, is widely recognized for preserving probiotic viability by slowing down metabolic degradation and extending shelf life. The unrefrigerated formulation exhibited a slightly higher water activity (0.600), increasing molecular mobility and pushing yacon sugars and FOS matrix to a transition state from dry to sticky, essential melting them, thus making them easily dissolvable compared to the refrigerated one that formed into clumps (Zayed & Roos, 2004).

Overall, the findings demonstrate that yacon juice powder can support the growth of Lactobacillus even at room temperature, highlighting its potential as a functional ingredient in non-refrigerated probiotic beverages. Nevertheless, maintaining controlled storage conditions remains essential for optimizing probiotic viability and ensuring product quality during extended storage periods.

Changes of pH

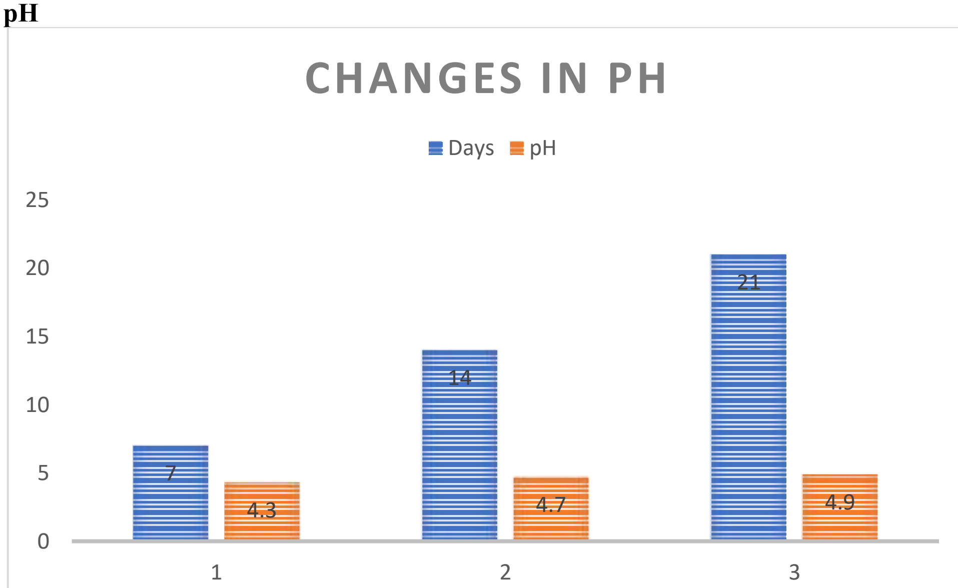

Figure 7. pH level of yacon powder juice with Lactobacillus

The monitoring of pH levels of the reconstituted 10g yacon juice powder with Lactobacillus in 50mL water over a 21-day period revealed a gradual increase from 4.3 on day 7 to 4.7 on day 14, and finally to 4.9 on day 21. This trend suggests a progressive reduction in acidity during storage, which can be attributed to the metabolic activity and adaptive responses of Lactobacillus. As a facultatively heterofermentative lactic acid bacterium, L. plantarum initially produces lactic acid as the dominant metabolite, lowering the pH of the medium (Hill et al., 2014). However, over extended storage, the depletion of fermentable substrates such as FOS in yacon juice leads to a decline in acid production and a stabilization or slight increase in pH (Dahal et al., 2020). This phenomenon reflects the transition of the microbial population from exponential growth to stationary phase, wherein metabolic activity slows and acid accumulation plateaus.

The observed increase in pH is consistent with reports that refrigerated synbiotic beverages exhibit gradual shifts in acidity as microbial activity stabilizes over time (Wendel, 2022). Importantly, the maintenance of pH within the range of 4.3–4.9 indicates that the product remained microbiologically safe, as acidic environments inhibit the growth of spoilage organisms and pathogens (Zawistowska-Rojek et al., 2022). Moreover, the ability of Lactobacillus to remain viable under these conditions underscores its resilience and suitability for incorporation into plant-based probiotic beverages. The slight rise in pH may also contribute positively to sensory acceptability, as extreme acidity can negatively affect flavor and consumer preference.

Overall, the findings demonstrate that Lactobacillus maintained viability and metabolic activity throughout the 21-day storage period, with pH changes reflecting a balance between acid production and substrate depletion. This supports the functional potential of yacon-based probiotic drinks, highlighting their ability to sustain probiotic populations while preserving product safety and sensory quality during refrigerated storage.

Changes in Moisture Content

The moisture content of the yacon juice powder with Lactobacillus demonstrated slight fluctuations during the 21-day storage period, decreasing from 4.24% on day 7 to 4.11% on day 14, before rising to 4.8% on day 21. This moisture content can be explained by the presence of hygroscopic FOS and sugars, demonstrating strong thermodynamic affinity for atmospheric moisture and acting as dessicants for rapid absorption of humidity (Lago & Noreña, 2015). If the hermetic seal of the package is even slightly compromised, or the foil material possesses a marginal Water Vapor Transmission Rate (WTVR), moisture is absorbed from the humid ambient air (Robertson, 2012). Structural changes in the beverage matrix, such as breakdown of polysaccharides, may also account for the observed increase (Wendel, 2022).

However, this low moisture content and the low water activity also explain the dormancy of the probiotic bacteria in the dry powder. The freeze-drying process also renders the bacteria inactive. From a safety perspective, the moisture content remained within acceptable ranges, and when considered alongside the stable acidic pH (4.3–4.9), the product can be regarded as microbiologically safe. Acidic conditions inhibit spoilage organisms and pathogens, while L. plantarum demonstrates resilience in fluctuating moisture environments, maintaining viability and probiotic functionality (Zawistowska-Rojek et al., 2022). However, the increase in moisture content at day 21 has implications for the physical stability of the powder, as elevated moisture levels can act as a plasticizer within the carbohydrate matrix, facilitating particle agglomeration. This leads to macroscopic caking and clumping, which can severely compromise the powder's flowability during handling and its overall solubility upon reconstitution (Bhandari et al., 2013; Roos, 1995). This highlights the importance of monitoring both microbial viability and physicochemical parameters to ensure product consistency.

Thus, these findings emphasize the need for integrated shelf-life studies that combine CFU counts, pH monitoring, and moisture analysis. Such multidimensional evaluation provides a holistic understanding of product stability and consumer acceptability. Advanced techniques such as water activity measurement and rheological profiling could further clarify the relationship between microbial metabolism and beverage texture. Corroborating with previous studies on synbiotic yacon juice, which reported sustained probiotic viability and acceptable physicochemical properties during refrigerated storage, the present findings confirm the potential of yacon-based probiotic drinks for commercialization (Dahal et al., 2020). Ensuring controlled fermentation and storage conditions will be critical to balancing probiotic efficacy, safety, and sensory quality in future product development.

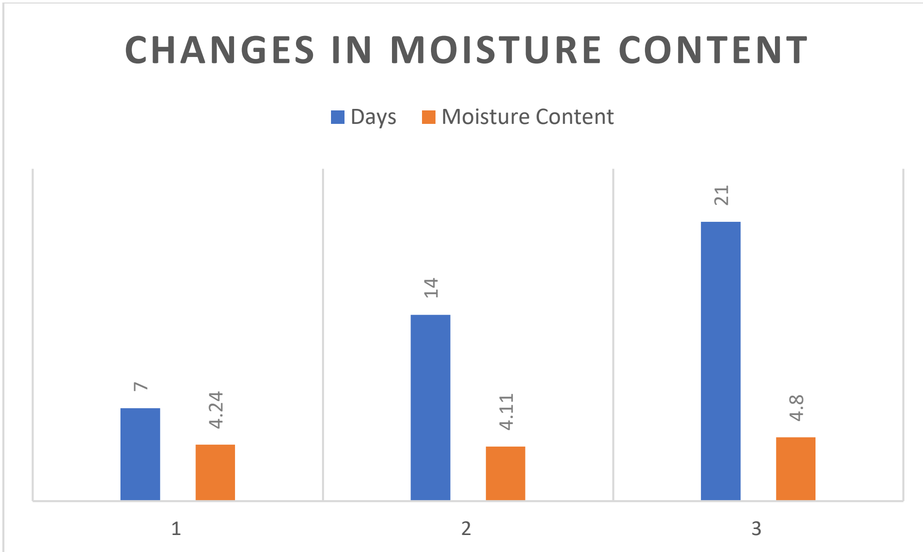

Figure 8. Moisture content of Yacon Powder Juice with Lactobacillus

Microbial Load Content
Microbial Analysis of YACON POWDER JUICE DRINK with Lactobacillus

Table 1. Microbiological Quality of Yacon Juice Powder with Lactobacillus

Test Parameter	Result	Acceptable Limit
Escherichia coli	Not Detected	Absent/Not Detected
Molds	Not Detected	<100 CFU/g

The microbial analysis of the Yacon Powder Juice Drink with Lactobacillus confirmed that the product tested negative for E. coli and molds, indicating the absence of pathogenic bacteria and fungal contamination. This result underscores the effectiveness of hygienic practices during production and handling, reflecting compliance with food safety standards that emphasize the importance of sanitation in functional beverage development (Hill et al., 2014). The absence of E. coli is particularly significant, as it serves as a critical indicator of fecal contamination and overall product safety. Its non-detection validates that the processing environment maintained sanitary conditions, thereby ensuring consumer protection and reinforcing the integrity of the probiotic formulation.

Similarly, the absence of molds suggests that the physicochemical properties of the product, specifically its lack of free water or low water activity and controlled moisture content were effective in suppressing fungal growth, restricting the free molecular hydration required for spore germination (Mathlouthi, 2001; Pitt & Hocking, 2009). This dual protective mechanism highlights the synergistic role of formulation and storage conditions in maintaining microbial safety.

These findings corroborate that complex carbohydrate matrices can effectively prevent microbial contamination by restricting free water availability (Mathlouthi, 2001). The results also have future implications for scaling production and commercialization. Ensuring microbial safety and leveraging the inherent protective properties of yacon, coupled with strict cold-chain management and hermetic packaging, can enhance consumer confidence and regulatory compliance. Moreover, the demonstrated absence of pathogens and spoilage organisms positions the product as a promising candidate for functional food markets, where safety and efficacy are equally critical.

Level of Acceptability of the Yacon Juice Powder with Lactobacillus

Table 3. Level of acceptability of Yacon Powder Juice Drink with Lactobacillus

Sensory Characteristics	Evaluators			As a Whole	Level of Acceptability
	Faculty	Non-Teaching	Students		
Aroma	6.62	6.43	6.14	6.40	HA
Flavor	6.46	6.00	6.05	6.17	HA
Sweetness	7.19	7.71	5.68	6.86	HA

Sourness	4.85	6.14	5.52	5.50	MHA
Texture	5.73	7.14	5.93	6.27	MHA
After Taste	6.77	6.43	5.68	6.29	MHA
Gen. Acceptability	7.23	6.86	5.88	6.66	HA
OVERALL MEAN	6.41 (HA)	6.67 (HA)	5.84 (MHA)	6.31 (MHA)	MHA

Legend

Statistical Limits	Descriptive Rating	Level of Acceptability
8.12 – 9.00	Like it a Lot	Extreme Acceptability (XA)
7.23 – 8.11	Like it very much	Very High Acceptability (VHA)
6.34 – 7.22	Like it moderately	High Acceptability (HA)
5.45 – 6.33	Like it slightly	Moderate High Acceptability (MHA)
4.56 – 5.44	Neither like nor dislike	Moderate Low Acceptability (MLA)

Table 3 presents the sensory evaluation results performed by three different group of respondents. The overall mean 6.31 reveals that Yacon powdered juice with Lactobacillus achieved moderately high acceptability (MHA), with mean scores ranging from 5.84 to 6.67 across the three groups of evaluators. Faculty and non-teaching staff rated the product slightly higher (6.41 and 6.67, respectively) than students (5.84), though all groups fell within acceptable ranges on what appears to be a 9-point hedonic scale.

Aroma

A positive aroma increases initial consumer acceptance and positions the product as appealing compared to other powdered beverages available in the market. It also suggests that probiotic incorporation did not produce unwanted odors.

This result suggests that fermentation with Lactobacillus did not generate undesirable volatile compounds, a common issue in probiotic beverages that can negatively impact aroma. The outcome may also reflect controlled fermentation and balanced metabolic activity. These findings align with Pimentel et al. (2015), who reported that L. plantarum strains generally produce milder fermentation aromas than other lactic acid bacteria.

Moreover, the finding is consistent with Pimentel et al. (2015), who reported that L. plantarum strains generate subtle, pleasant aromas due to their moderate production of esters and aldehydes compared to other lactic acid bacteria. Similarly, Saad et al. (2013) emphasized that probiotic strains with low acidification rates tend to yield cleaner sensory profiles.

The high aroma acceptability supports the use of Lactobacillus strain as a probiotic starter culture for functional beverages, enhancing consumer appeal while maintaining microbial viability.

Flavor

In terms of flavor respondents rated as highly acceptable with a mean of 6.17. Flavor was consistently rated high, balancing natural sweetness from fructooligosaccharidesf (FOS) with a refreshing tang from the Lactobacillus strain. Strong flavor acceptability indicates the product can compete with profitable fruit-based probiotic drinks. It validates the formulation strategy of combining prebiotic-rich yacon with probiotics for both taste and health benefits. Results corroborates the findings of Md Sakhawot Hossain et.al (2025) that human beings are naturally drawn to food flavors and pleasant aromas, which not only guide food choices but also contribute to health by promoting the intake of nutritious foods, aiding digestion, and enhancing emotional well-being. Moreover, the study by Delgado et al. (2019) observed that FOS not only improves taste but also supports probiotic growth, thereby reinforcing the functional synergy between the substrate and microorganism.

Sweetness

In terms of the sweetness of the developed products, it received the highest overall mean (6.86) across all groups of evaluators, achieving a "Highly Acceptable" (HA) level of acceptability, confirming that yacon is naturally high in fructooligosaccharide (FOS) content, which provides sweetness without the glycemic impact of simple sugars, which contributed positively to its sensory appeal. The presence of the FOS provides sweetness without elevating glycemic index, aligning with consumer preferences for healthier beverages.

According to Campos et al. (2012), yacon's natural sweetness profile makes it particularly suitable for the development of functional beverages, as it requires minimal added sugars while maintaining consumer appeal.

Moreover, the study by Delgado et al. (2019) observed that FOS not only improves taste but also supports probiotic growth, thereby reinforcing the functional synergy between the substrate and microorganism.

Thus, the high sweetness acceptability underscores that the yacon root crop can be a potential natural sweetener and a good source of prebiotics that may promote both consumer satisfaction and probiotic viability.

Sourness

In terms of sourness received the lowest overall mean of 5.50, described as "moderately highly acceptable". This finding reflects a well-documented tension in probiotic beverage development that is. lactic acid fermentation inherently produces acidic compounds that enhance preservation and probiotic viability but may compromise palatability. The acidity produced during fermentation is essential for probiotic survival but can also affect palatability.

This is supported by the study of Granato et al. (2010) which highlighted that lactic acid fermentation increases acidity, which enhances microbial stability but may reduce consumer preference. emphasized that balancing acidity with consumer preference remains a critical formulation challenge for functional beverages.

Moreover, the study of Pimentel et al. (2015) also noted that optimizing fermentation duration can mitigate excessive sourness while preserving probiotic viability.

Thus, the findings suggests that further formulation refinement such as adjusting fermentation time or buffering acidity could improve taste balance without compromising probiotic function.

Texture

Texture achieved a overall mean rating of 6.27 rated as " Moderately High Acceptability), indicating that the developed powder juice with probiotics often face challenges in terms of textural inconsistencies like its graininess during its reconstitution.

According to the study of Cano-Chauca et al. (2005), found that particle size distribution and hygroscopicity significantly influence mouthfeel in powdered drinks. It is also supported with the study of Ribeiro et al. (2018) emphasized that microencapsulation and homogenization techniques can improve texture uniformity and sensory perception in probiotic beverages.

Thus, the findings highlight the need for more technological optimizations particularly on the refinement of powder by simply considering the equipment to be used and its size of particles, as well as by using the encapsulation to further enhance smoothness and consumer experience.

Aftertaste

In terms of aftertaste of the yacon powdered juice respondents rated the aftertaste positively with an overall mean of 6.29 which is moderately high acceptability, indicating that the product left a pleasant and balanced impression after consumption. The presence of fructooligosaccharides (FOS) from yacon contributed to a mild sweetness, while the lactic acid from L. plantarum provided a refreshing tang. Importantly, no undesirable bitterness or off flavors were reported, which is crucial for consumer retention. A pleasant aftertaste means the formulation successfully balanced sweetness from yacon's fructooligosaccharides (FOS) and acidity Lactobacillus strain. This suggests that the product can be comparable with other commercial powdered juice drinks, the products have no off flavors or bitterness. Since aftertaste is the lingering impression, The positive ratings on consumers are more likely to purchase and recommend the product that strengthens the potential for long-term market sustainability. In terms of nutrition the refreshing mild aftertaste can be promoted as a natural advantage of probiotics and prebiotics, highlighting the health-oriented positioning of the product.

Yacon (Smallanthus sonchifolius), a native Andean root, is valued for its fructooligosaccharide (FOS) and inulin content, both linked to health benefits. Their composition is strongly influenced by genetic, environmental, and postharvest factors that modulate degradation into glucose, fructose, and shorter-chain FOS(JLM Rosales et.al 2025).

This finding aligns with the study of Saad et al. (2013), who reported that probiotic beverages containing Lactobacillus species often exhibit mild, clean aftertastes due to their metabolic production of short-chain organic acids and esters that enhance flavor complexity. Similarly, Granato et al. (2010) emphasized that optimizing fermentation time and sugar-acid balance is crucial to achieving consumer-acceptable aftertaste in functional drinks. The moderately high rating therefore reflects successful formulation control, maintaining probiotic viability while ensuring sensory harmony.

The aftertaste mean of 6.29 (MHA) indicates that the product left a generally pleasant residual flavor, though some evaluators noted mild fermentation notes.

Saad et al. (2013) explained that probiotic beverages often exhibit mild aftertastes due to organic acid and ester formation, which can be perceived as refreshing when balanced. Granato et al. (2010) further suggested that controlled fermentation minimizes undesirable lingering flavors.

The moderately high aftertaste rating demonstrates successful flavor management, confirming that Lactobacillus produced a clean finish suitable for consumer acceptance.

General Acceptability

In terms of overall acceptability scores were high, showing that the product was well received across multiple sensory dimensions such as aroma, flavor, sweetness, sourness, color, and aftertaste. The combination of probiotic viability, safe acidic pH ranging to 4.3–4.9, and stable moisture levels supported both safety and sensory appeal. The favorable ratings suggest strong potential for commercialization and consumer adoption. High overall acceptability implies the readiness for scaling beyond laboratory trials. The product has strong potential for market entry, especially to health-conscious individuals. In terms of nutritional content, the product was rated favorable to all sensory characteristics, so, it can be presented during nutrition programs to boost probiotic consumption in non-dairy formats, particularly in tropical regions. The positive general acceptability confirms the experimental design and supports further studies on shelf-life, packaging, and consumer behavior in real-world settings.

Campos et al. (2012), noted that yacon's natural fructooligosaccharides (FOS) enhance sweetness and mouthfeel, improving overall sensory appeal in health-oriented beverages.

Moreover, Pimentel et al. (2015) observed that L. plantarum fermentation tends to yield mild aromatic profiles and stable acidity, both contributing to higher acceptability ratings. The high general acceptability thus reflects the synergy between yacon's intrinsic sweetness, and the Lactobacillus controlled fermentation characteristics, supporting its potential as a probiotic functional beverage.

The overall mean of 6.66 (HA) reflects a high level of acceptability, confirming that the product was well-received across sensory attributes. Faculty and non-teaching staff rated it higher than students, possibly due to greater appreciation for functional health benefits and mild probiotic flavor notes.

Pimentel et al. (2015) and Campos et al. (2012) both emphasized that combining prebiotic substrates like yacon with probiotic cultures enhances both nutritional and sensory quality. The high general acceptability thus validates the product's formulation as a viable symbiotic beverage.

The findings affirm that the Yacon Powder Juice Drink with Lactobacillus strain meets consumer expectations for taste, aroma, and health functionality, supporting its potential for commercialization and community nutrition programs.

Nutrient Composition of the Yacon Powder Juice Drink with Lactobacillus

Table 5. Nutrient Information of Yacon Powder Juice Drink with Lactobacillus.

Analysis Name	**Result**	**Methodology**
Ash	0.59 g/100g	Gravimetric Method (QLY-LAB-1153REV2)
Crude Protein (N x 6.25)	<0.10 g/100 g	Kjedldahl Method (QLY-LAB-f201 REV 6)
Moisture	4.16 g/100g	Gravimetric Method (QLY-LAB-f202 REV 6)
Total Sugar As Invert	52.09 g/100g	Lane-Eynon General Volumetric Method
Total Dietary Fiber	<0.10 g/100g	Enzymatic-Gravimetric Method
Saturated Fat	0.08 g/100g	Gas Chromatography
Trans Fatty Acids	<0.01g/100g	Gas Chromatography
Cholesterol	<0.20mg/100g	Gas Chromatography
Sodium (Na)	13.92mg/100g	Dry shing, Acid Digestion and Quantification
Crude Fat	2.41g/100g	Acid Hydrolysis and Gravimetric Method
Calories from carbohydrates	371.36kcal/100g	By computation from Proximate Analysis
Calories from Fat	21.69kcal/100g	By computation from Proximate Analysis
Calories from Protein	<0.40kcal/100g	By computation from Proximate Analysis
Total Calories	393.05kcal/100g	By computation from Proximate Analysis
Total Carbohydrates	92.84 g/100g	

The proximate analysis of the Yacon Powder Juice Drink with Lactobacillus strain revealed a nutrient profile dominated by carbohydrates, with total sugars measured at 52.09 g/100 g and total carbohydrates at 92.84 g/100 g. Caloric contribution was primarily derived from carbohydrates (371.36 kcal/100 g), with minimal input from fat (21.69 kcal/100 g) and negligible protein (<0.40 kcal/100 g). Fat content was relatively low, with crude fat at 2.41 g/100 g, saturated fat at 0.08 g/100 g, and trans fatty acids at <0.01 g/100 g. Cholesterol was negligible (<0.20 mg/100 g), positioning the product as heart-friendly and suitable for consumers seeking plant-based alternatives. Sodium content was modest at 13.92 mg/100 g, while ash content (0.59 g/100 g) reflected mineral presence. Moisture content was 4.16 g/100 g, consistent with earlier microbial safety findings.

These findings corroborate previous studies on synbiotic yacon beverages, which reported high carbohydrate content, stable probiotic viability, and favorable safety parameters during refrigerated storage (Dahal et al., 2020). The dominance of carbohydrates, particularly fructo-oligosaccharides, aligns with the established role of yacon root as a prebiotic substrate that enhances probiotic survival and functionality (Hill et al., 2014). The low fat and cholesterol values are consistent with broader literature on plant-based functional foods, which emphasize their suitability for cardiovascular health and consumer preference for low-fat formulations (Wendel, 2022). Furthermore, the safe moisture and pH levels corroborate microbial analyses that confirmed the absence of E. coli and molds, reinforcing the product's microbiological integrity (Zawistowska-Rojek et al., 2022).

Thus, the findings suggests that the product is high in carbohydrate content, particularly fructo-oligosaccharides, supports probiotic survival and highlights its potential as a synbiotic beverage. This opens opportunities for clinical validation of its health benefits, especially in improving gut health and digestion (Dahal et al., 2020).

CONCLUSION AND RECOMMENDATIONS

This study successfully created a stable yacon powder juice that contains Lactobacillus probiotics and prebiotic fiber from yacon. The probiotics stayed alive well during processing and storage, especially when kept refrigerated, reaching high levels needed for health benefits. The yacon's natural fructooligosaccharides helped the probiotics survive and work together in the drink. The product was safe, with no harmful bacteria found, and maintained a good acidic pH and moisture balance. People who tasted it liked the flavor, smell, sweetness, and other qualities, showing it has good potential for the market. The drink also provides nutritional benefits, especially for gut health, because of the combination of probiotics and prebiotics.

Based on these findings, it is recommended that future product development refine the formulation ratios of yacon powder and Lactobacillus to balance probiotic viability with desirable sensory attributes, preventing excessive growth that could negatively affect flavor and shelf stability. Refrigerated storage should be strongly recommended to preserve maximum probiotic viability and extend shelf life, although short-term room-temperature storage remains feasible and warrants further investigation under typical consumer conditions. Rigorous sanitary measures must be maintained throughout production and packaging to ensure microbial safety, with the continued use of acidifying agents like citric acid to inhibit spoilage organisms and maintain an acidic environment favorable to probiotic survival. Broader sensory evaluations involving diverse consumer panels are advised to capture varied preferences and inform product refinements, flavor diversification, and commercial strategies. Additionally, future research should explore advanced encapsulation or microencapsulation technologies to improve probiotic stability and enable controlled release within the product.

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