

## Optimization and Nutritional Enhancement of Fermented Corn-Plantain Pudding (“Epiti”) Using Probiotics by Response Surface Methodology

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### ABSTRACT

Epiti (corn-plantain pudding) is a traditional fermented food typically produced via spontaneous uncontrolled method that rely on naturally occurring microflora to enhance its nutritional value. The aim of this study is to optimize and enhance the nutritional quality of Epiti using probiotics. Unpasteurized Vinegar containing Lactic acid bacteria and “Kunu” locally prepared from cow milk were used as sources of the probiotics in the study. Yellow variety of maize (*Zea mays*) and very ripe plantain were used in preparation of the Epiti. Full cream evaporated milk was used as the protein source. Standard microbiological procedures were used to screen and identify the potential probiotic used for the enhancement. Optimization process involved the use of evaporated milk, Lactic acid bacteria and fermentation time to enhance product quality. Different experimental setups were employed according to the Box-Behnken experimental design. Epiti sold in local market at Rumuadi Ogbogoro in Obio/Akpor, Rivers State served as control. Data and responses on Epiti produced were resolved through response surface methodology (RSM) as to obtain combination of the three Optimization factors. Proximate and microbiological analyses of the Epiti samples were evaluated using standard analytical procedures. Organoleptic characteristics of the epiti were determined using the 5-point hedonic scale. Results of molecular analysis revealed that the potential probiotics isolated and subsequently used in this study belong to the genera *Weissella* and *Lactobacillus*. Rating of responses in structured questionnaire showed that the overall acceptability of the Epiti ranged from 2.83±0.52 to 4.0±0.55. Notably, the maximum predicted mean overall acceptability of 4.2 was achieved with a probiotic concentration of 1%, a fermentation time of 3 days, and a milk concentration of 5%. Proximate composition of the optimized Epiti was Ash 3.51%, Moisture 21.91%, Crude Lipid 4.38%, Crude Fiber 1.07%, Crude Protein 9.38%, and Carbohydrate 59.78%. In contrast, the commercially prepared Epiti had Ash had 3.57%, Moisture 24.1%, Crude Lipid 6.22%, Crude Fiber 1.02%, Crude Protein 8.97%, and Carbohydrate 56.19%. The findings showed that, optimizing fermentation conditions with probiotic incorporation significantly improved the sensory and nutritional qualities of Epiti. The study is a novel approach to improving traditional fermented foods by integrating controlled probiotic fermentation and response surface methodology for optimization.

**Keywords:** Epiti, Fermentation, Optimization process, Probiotics, Maize seed, Plantain, Response Surface Methodology.

### Introduction

The fermented corn pudding known as Epiti, is made locally from ride plantain (*Musa paradisiaca*) and corn (*Zea mays*). It is widely consumed as a quick and high-energy food in some countries in West Africa, including Nigeria. Traditional fermentation of corn-plantain pudding (Epiti) is typically carried out by spontaneous and uncontrolled methods that rely on naturally occurring microflora (Akusu and Kiin-Kabari, 2012). This could lead to uneven product quality, consumers’ safety, and poor nutritional value (Falana et al., 2011).

Epiti serves as a staple food in many low-income communities due to its affordability and accessibility, but it remains nutritionally limited. Epiti has low nutritional value with respect to protein as it is usually produced in most cases without addition of meat, fish or other protein sources (Oranusi et al., 2014). Selected probiotic strains have proven to improve the nutritional, functional, and microbiological quality of fermented foods (Marco et al., 2017).

However, the application of probiotics in the fermentation of Epiti has not been well-explored or standardized.

Also, the optimization process of fermentation such as temperature, time and inoculum size required to achieve maximum probiotic activity and nutrient enrichment in Epiti is yet to be established.

Optimization refers to the process of making a system, design, or decision as effective or functional as possible. Therefore, optimizing fermentation process involves fine-tuning parameters such as temperature, pH, inoculum size, fermentation time, and moisture content. These variables have a direct impact on microbial growth dynamics, metabolite production, and degradation of undesirable compounds (Montemurro *et al.*, 2019). It plays a central role in fields such as engineering, economics, computer science, and operations research (Zhang *et al.*, 2013).

The use of probiotics in traditional fermented foods has health advantages such as enhance immunity, promote gut health, aid in the synthesis of vitamins (particularly B-vitamins), and even lower the risk of some gastrointestinal disorders (Hill *et al.*, 2014). Probiotics is defined as "live microorganisms which, when administered in adequate amounts, confer a health benefit on the host (Cunningham *et al.*, 2021, FAO/WHO 2002). Many of the probiotic strains that are frequently utilized in food fermentation to improve microbial safety, nutrient content, and functionality include *Lactobacillus*, *Bifidobacterium*, and *Saccharomyces* species (Ranadheera *et al.*, 2010). Probiotics have also been used in the form of dietary supplements (Maftai *et al.*, 2024). Probiotics, when carefully chosen, can enhance the nutritional quality, safety, and functional properties of fermented foods while also supporting gut health and overall well-being (Cunningham *et al.*, 2021). Therefore, the aim of this study is to optimize and enhance the nutritional quality of fermented corn-plantain pudding (Epiti) using probiotics by response surface methodology.

## Materials and Methods

### Collection of Samples

Unpasteurized Vinegar was purchased from a supermarket and locally prepared Kunu (from cowmilk) from Azikiwe road, near the back gate of the Rivers State University. The Vinegar and Kunu samples were the sources of the probiotics used in the study.

The yellow variety of maize (*Zea mays*) seeds and ripe plantains used in this study were obtained from Mile 3 Market. Full-cream evaporated milk was sourced from a supermarket in Port Harcourt, while the commercially prepared Epiti was purchased from a local market in Rumuadi Ogbogoro, located in Obio/Akpor Local Government Area of Rivers State. All Samples were transported in an ice – chest cooler filled with ice blocks, within few hours to the Microbiology Laboratory of the Department of Microbiology Rivers State University.

### Isolation of Potential Probiotic(s)

Isolation of the potential probiotic was carried out using the method described by Vantsawa *et al.*, (2010) with slight modifications. A volume of 10 ml of Vinegar and Kunu were introduced into 90ml of sterile peptone water separately and homogenized. Ten-fold serial dilution was carried out on the homogenized suspension to a dilution of  $10^{-3}$ . An aliquot of 0.1ml of the different dilutions were inoculated in duplicates on prepared de Man Rogosa and Sharpe (MRS) agar. The plates were incubated at 35 °C under aseptic anaerobic conditions using anaerobic jars for 48 hours.

### Preliminary Screening and Identification of Potential Probiotics

Ensuing colonies on the MRS plates were sub-cultured onto nutrient agar plates to obtain pure isolates. The isolates were subjected to morphological and biochemical characterization using the following tests: Gram staining biochemical tests: Catalase, oxidase, bile salt tolerance, acid tolerance, indole, methyl red, voge Proskauer, citrate utilization, and sugar fermentation. The tests were carried out as described by Peekate (2022), and Barrow & Feltham (2003). Further identification of the suspected probiotics was carried out using molecular approaches according to the method of Bell *et al.*, (1998).

### Optimization Process

The optimization process involved the use of evaporated milk, Lactic acid bacteria and fermentation time to enhance product quality was employed. The values were chosen based on the Box-Behnken coded value level (Table 1) (Box *et al.*, 1960). Thus, for the equidistant coded levels, -1, 0, and +1, equidistant milk concentrations of 2, 4, and 6% were used.

The equidistant concentration of 1, 5 and 9% were used for the probiotics; and equidistant duration of 1, 2 and 3 days were used for the fermentation duration. The experimental design matrix for these values were based on the Box-Behnken experimental design (Table 2) as described by Zhang and Dequan (2013). In line with the design matrix, variety of Epiti were prepared. After preparation, the Epiti was subjected to sensory evaluation test by a group of panelist for tasting and scoring. The scoring obtained and values of the factors were fitted using the generalized polynomial model for 3-factor design as described by Kumar *et al* (2015). The various polynomial equations obtained from the model fitting were resolved through matrices to a single polynomial equation. The calculations were carried out using Microsoft excel. The derived single polynomial equation was then used to generate prediction profile of the scoring from different theoretical combination of extended value ranges of the 3 parameters. From the prediction profile, the combined value of the 3 factors that led to the highest score was determined using:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_{1,2}X_1X_2 + \beta_{1,3}X_1X_3 + \beta_{2,3}X_2X_3 + \beta_{1,1}X_1^2 + \beta_{2,2}X_2^2 + \beta_{3,3}X_3^2$$

Where Y is the predicted response (score); X<sub>1</sub>, X<sub>2</sub>, and X<sub>3</sub> represent the values of the factors (probiotics concentration, fermentation duration, and milk concentration); β<sub>0</sub> is the value of fitted response at the centre point of the design; β<sub>1</sub>, β<sub>2</sub>, and β<sub>3</sub> are the linear coefficients; β<sub>1,2</sub>, β<sub>1,3</sub>, and β<sub>2,3</sub> are the interaction coefficients; and β<sub>1,1</sub>, β<sub>2,2</sub>, and β<sub>3,3</sub> are the quadratic coefficient.

**Table 1: Variation range of the Factors for the Optimization Process**

Factors	Factor Codes	Coded Levels		
		-1	0	+1
LC (%)	X <sub>1</sub>	1	5	9
FD (Days)	X <sub>2</sub>	1	2	3
MC(%)	X <sub>3</sub>	2	4	6

**Note:** LC = Probiotic Concentration; FD = Fermentation Duration; MC = Milk Concentration

**Table 2: Design Matrix for the Optimization Process**

EN	LC(%)	FD(Days)	MC (%)
	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>
1	-1 (1)	-1 (1)	0 (4)
2	-1 (1)	+1 (3)	0 (4)
3	+1 (9)	-1 (1)	0 (4)
4	+1 (9)	+1 (3)	0 (4)
5	-1 (1)	0 (2)	-1 (2)
6	-1 (1)	0 (2)	+1 (6)
7	+1 (9)	0 (2)	-1 (2)
8	+1 (9)	0 (2)	+1 (6)
9	0 (5)	-1 (1)	-1 (2)
10	0 (5)	-1 (1)	+1 (6)
11	0 (5)	+1 (3)	-1 (2)
12	0 (5)	+1 (3)	+1 (6)
13	0 (5)	0 (2)	0 (4)
14	0 (5)	0 (2)	0 (4)
15	0 (5)	0 (2)	0 (4)

**Note:** EN = Experiment number, LC = Probiotic Concentration, FD = Fermentation Duration, MC = Milk Concentration.

**Preparation of Epiti**

Different set of corn after washing with clean water (150g) were soaked in sterile potable water (150ml) for 3 days according to the experimental design. After that, the corn was mixed with ripe plantain (300g) and blended using electric blender.

The resulting slurry obtained was mixed with quantity of onion (60g/kg), salt (34 g/kg), palm oil (0.93 g/ml), pepper (10g/kg) and seasoning cubes (2g/kg). Milk of 2, 4 or 6% calculated based on the final volume of the mixture, was added to the different set of slurry based on the experimental design. The final mixtures were packaged into 15 transparent nylons, and boiled for an hour. After boiling, they were allowed to cool and presented for sensory evaluations.

**Determination of Organoleptic characteristics of Prepared Optimized and Commercial Epiti Sensory Evaluation of Epiti**

The organoleptic properties of the prepared optimized and commercially produced Epiti were determined using 5-point hedonic scale (El-Tinay *et al*. 1984). The characteristics assessed were appearance, aroma, taste, texture or mouth feel, and overall acceptability.

Potable water was used to rinse the mouth between successive evaluations. Questionnaires were given to ten-person panelist including staff and students to comment on how much they liked or disliked the product.

### Statistical Analysis

SPSS version 22 was used to perform all statistical analysis to test for significance and percentages for all the parameters analyzed during the study. P-value of less than 0.05 was considered to be statistically significant (<0.05).

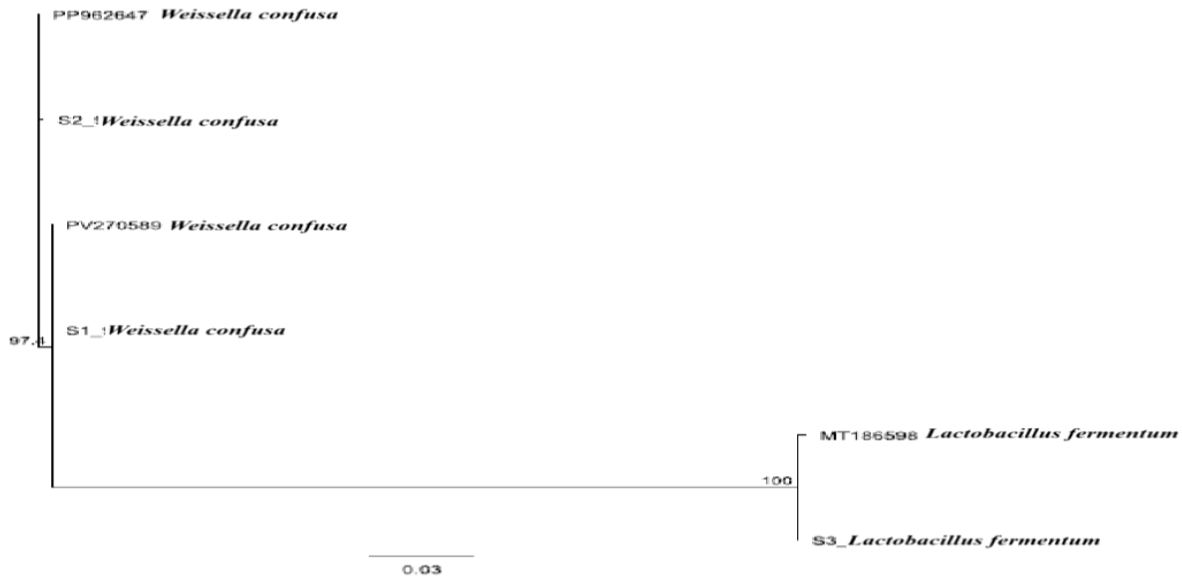


Figure 1: Phylogenetic tree of the evolutionary relationship between the bacterial isolates

### Optimization process and Acceptability of the Fermented Corn/Plantain Pudding

Harmonization of responses in structured questionnaire filled by tasting panels showed that the mean overall acceptability (MOA) of the produced corn/plantain pudding (Epiti) ranged from  $2.83 \pm 0.52$  to  $4.0 \pm 0.55$  on a 5 point scale rating. The matrix of the MOA and set of values of the three parameters (Probiotic concentration, fermentation duration, and milk concentration) used in the optimization experiment as fitted using generalized polynomial model for 3-factor design ( $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{1,2} X_1 X_2 + \beta_{1,3} X_1 X_3 + \beta_{2,3} X_2 X_3 + \beta_{1,1} X_1^2 + \beta_{2,2} X_2^2 + \beta_{3,3} X_3^2$ ) is presented in Table 3. Resolving the 13+2 polynomial equations derived from the information in Table 3 through matrix

### Results

The obtained 16s rRNA sequence from the probiotic isolates produced an exact match during the megablast search for highly similar sequences from the NCBI non-redundant nucleotide (nr/nt) database. The 16S rRNA of the isolates showed a percentage similarity to other species at 100%. The evolutionary distances computed using the Jukes-Cantor method were in agreement with the phylogenetic placement of the 16S rRNA of the isolates within the *Weissella* and *Lactobacillus* sp and revealed a closely relatedness to (Figure 1).

Calculations revealed the values of the coefficients  $\beta_0$ ,  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ ,  $\beta_{1,2}$ ,  $\beta_{1,3}$ ,  $\beta_{2,3}$ ,  $\beta_{1,1}$ ,  $\beta_{2,2}$ , and  $\beta_{3,3}$  to be 2.812, -0.005, 0.431, 0.162, -0.038, -0.005, 0.085, 0.011, -0.093, and -0.041 respectively. The single derived polynomial equation is thus given as:

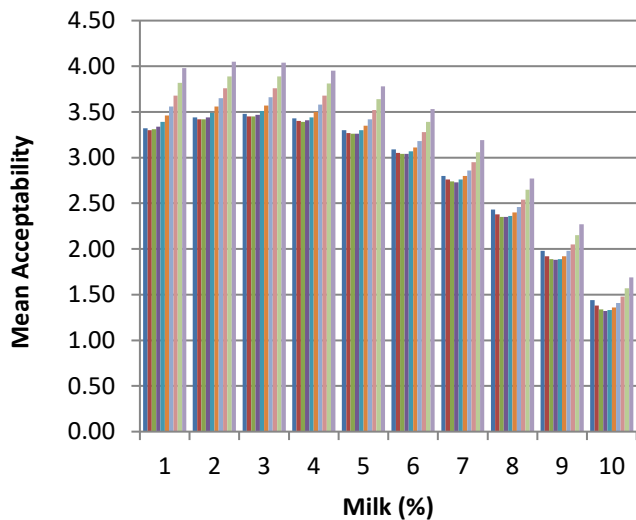
$$Y = 2.812 - 0.005X_1 + 0.431X_2 + 0.162X_3 - 0.038X_1X_2 - 0.005X_1X_3 + 0.085X_2X_3 + 0.011X_1^2 - 0.093X_2^2 - 0.041X_3^2$$

The Response surface graph (RSG) derived from the prediction profile of the MOA obtainable from different theoretical sets of the three parameters is presented in Figure 2a to Figure 2c. From the RSG, it can be seen that the theoretical highest MOA (Table 3) is achievable at Probiotic concentration = 1 %, fermentation duration = 3 days, and milk concentration = 5 %.

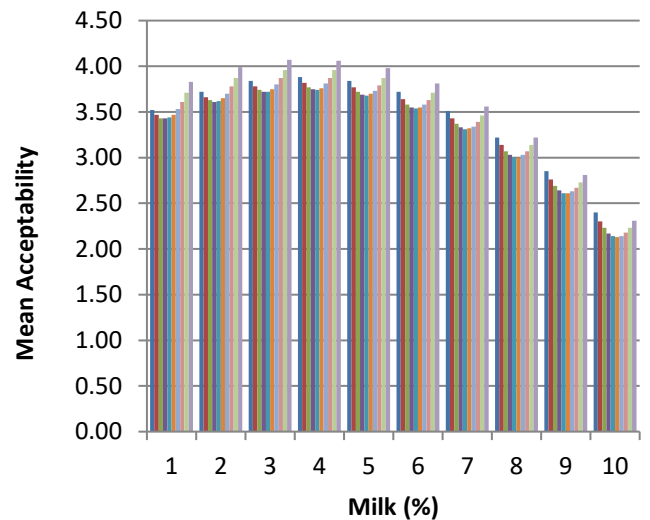
**Table 3: Matrix of the Mean Overall Acceptability and Sets of the Optimization Parameters**

EN	Y MOA	$\beta_0$	$\beta_1$ $X_1$	$\beta_2$ $X_2$	$\beta_3$ $X_3$	$\beta_{1,2}$ $X_1 X_2$	$\beta_{1,3}$ $X_1 X_3$	$\beta_{2,3}$ $X_2 X_3$	$\beta_{1,1}$ $X_1^2$	$\beta_{2,2}$ $X_2^2$	$\beta_{3,3}$ $X_3^2$
1	3.62	1	1	1	4	1	4	4	1	1	16
2	4.00	1	1	3	4	3	4	12	1	9	16
3	3.93	1	9	1	4	9	36	4	81	1	16
4	3.70	1	9	3	4	27	36	12	81	9	16
5	3.65	1	1	2	2	2	2	4	1	4	4
6	3.73	1	1	2	6	2	6	12	1	4	36
7	3.83	1	9	2	2	18	18	4	81	4	4
8	3.75	1	9	2	6	18	54	12	81	4	36
9	3.36	1	5	1	2	5	10	2	25	1	4
10	2.83	1	5	1	6	5	30	6	25	1	36
11	3.78	1	5	3	2	15	10	6	25	9	4
12	3.93	1	5	3	6	15	30	18	25	9	36
13	3.70	1	5	2	4	10	20	8	25	4	16
14	3.80	1	5	2	4	10	20	8	25	4	16
15	3.70	1	5	2	4	10	20	8	25	4	16

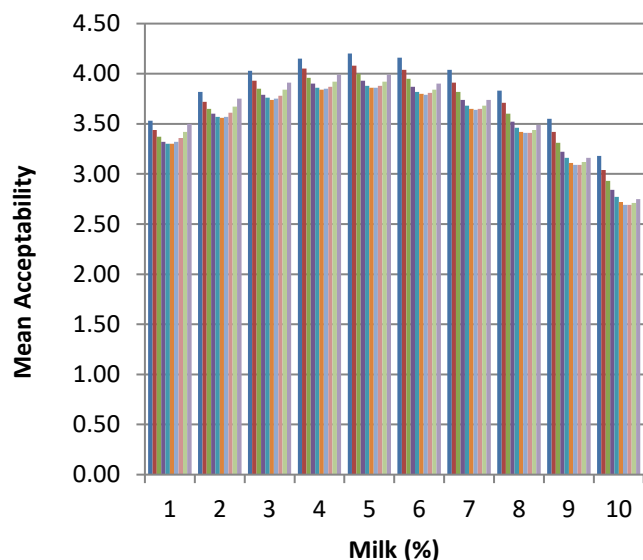
**Note:** EN = Experimental number, MOA = Mean Overall Acceptability,  $X_1$ =LC: Probiotic Concentration (%),  $X_2$  =FD: Fermentation Duration (days),  $X_3$  =MC: Milk Concentration (%), Shaded box = Matrix [X].



**Fig. 2a: Response Surface Graph of theoretical Sets of Probiotic and Milk Concentration at Fermentation Duration of 1 day**



**Fig. 2b: Response Surface Graph of theoretical Sets of Probiotic and Milk Concentration at Fermentation Duration of 2 days**



**Fig. 2c: Response Surface Graph of theoretical Sets of Probiotic and Milk Concentration at Fermentation Duration of 3 days Preparation of Epiti.**

## Discussion

The use of molecularly identified probiotic strains as defined starter cultures ensures consistent fermentation outcomes. This contrasts with traditional spontaneous fermentation, which is prone to contamination. Optimizing the process using *Weissella* and *Lactobacillus* ensures controlled acidification, predictable microbial succession, and improved sensory qualities of the final product (Martín *et al.*, 2013). Both genera are known to contribute to phytate degradation, increase bioavailability of micronutrients like iron and zinc, and enhance the digestibility of plant-based substrates such as corn and plantain (Owusu-Kwarteng, 2015). Their enzymatic activities (e.g., amylases, proteases) also help to improve the texture and flavor profile of fermented foods (Martín *et al.*, 2013).

The results on sensory evaluation obtained from the panelists indicate that the mean overall acceptability (MOA) of the produced corn/plantain pudding (Epiti) ranged from  $2.83 \pm 0.52$  to  $4.0 \pm 0.55$  on a 5-point hedonic scale. This initial finding suggests that consumer perception of the product was influenced by variations in the formulation factors, such as probiotics, fermentation time, and milk concentration.

These three parameters were systematically optimized using a generalized polynomial model in a 3-factor design, which aligns with the principles of response surface methodology (RSM) commonly applied in food product development to identify optimal processing conditions (Bezerra *et al.*, 2008, Montgomery, 2017).

The response surface graphs (RSGs) derived from the prediction profiles demonstrated that the highest theoretical MOA (4.2) could be achieved at probiotic concentration = 1 %, fermentation duration = 3 days, and milk concentration = 5 %. These optimal conditions suggest a synergistic effect between microbial fermentation and milk supplementation, both of which are known to improve texture, aroma, and flavor of fermented foods (Granato *et al.*, 2010; Olagunju *et al.*, 2018). Probiotic addition not only enhances sensory quality but also adds functional value by improving gut health (FAO/WHO, 2002; Ouwehand *et al.*, 2002).

When tested in practice, the optimized Epiti achieved a significantly higher mean overall acceptability ranging from 4.25 to 4.75, compared with 1.50 to 3.25 for commercially produced Epiti. The wide margin indicates that the optimization process successfully aligned with product attributes and consumer safety. Sensory acceptability is a critical determinant of consumer purchase intention, and scores above 4.0 on a 5-point scale generally denote “like very much” (Meilgaard *et al.*, 2007).

Thus, the optimized Epiti not only achieved functional improvement but also attained high consumer desirability. This means the product is not just traditional food but now has added functional value, potentially supporting digestion or overall health due to probiotics.

The statistical analysis confirmed that the differences in mean overall acceptability between the optimized and commercial samples were highly significant ( $P = 0.000000002$ ,  $\alpha = 0.05$ ). Such a low p-value suggests that the probability of the observed differences occurring by chance is virtually negligible. This aligns with findings from similar studies, where the incorporation of probiotics and controlled fermentation process significantly improved the sensory appeal of traditional fermented foods (Sharma *et al.*, 2020, Adepoju *et al.*, 2017).

## Conclusion

The optimization and probiotic fortification of fermented corn–plantain pudding (Epiti) yielded notable improvements in both nutritional value and microbial safety. Molecular characterization of the isolated probiotic strains confirmed their identification as belonging to the genera *Weissella* and *Lactobacillus*, both of which are known for their beneficial health effects and fermentative capabilities. The combined effect of the three processing variables demonstrates that consumer acceptance of Epiti is largely influenced by fermentation time and milk concentration, alongside the beneficial role of probiotics. Optimization using response surface methodology (RSM) offers a dependable foundation for scaling up the production of probiotic-enriched Epiti as a functional African pudding with enhanced market appeal.

## References

- Adepoju, A. O., Oladimeji, O. R., & Akinmoladun, F. O. (2017). Optimization of fermentation conditions for improved quality of traditional African fermented foods. *Journal of Food Research*, 6(2), 45–55.
- Akusu, O. M. and Kiin-Kabari, D. B. (2012). Protein Quality and Sensory Evaluation of Moin-Moin Prepared from Cowpea/Maize Flour Blends. *African Journal of Food Science*, 6(3), 47-51.
- Barrow, G. I., & Feltham, R. K. A. (2003). *Cowan and Steel's manual for the identification of medical bacteria* (3rd ed.). Cambridge University Press.
- Bell, C., Neaves, P., & King, K. (1998). Microbiological safety of food. Aspen Publishers.
- Bezerra, M. A., Santelli, R. E., Oliveira, E. P., Villar, L. S., & Escaleira, L. A. (2008). Response surface methodology (RSM) as a tool for optimization in analytical chemistry. *Talanta*, 76(5), 965–977.
- Box, G. E. P. and Behnken, D. W. (1960). “Some New Three Level Designs for the Study of Quantitative Variables.” *Technometrics*, 2(4): 455–475.
- Cunningham, M., Azcarate-Peril, M. A., Barnard, A., Benoit, V., Grimaldi, R., Guyonnet, D., Holscher, H. D., Hunter, K., Manurung, S. and Obis, D. (2021). Shaping the Future of Probiotics and Prebiotics. *Trends Microbiology*, 29, 667–685.
- Falana, M. B., Bankole, M. O., Omemu, A. M., & Oyewole, O. B. (2011). Microorganisms associated with supernatant solution of fermented maize mash (omidum) from two varieties of maize grains. *The Researcher*, 3(7), 1-7.
- FAO/WHO (2002). Guidelines for the Evaluation of Probiotics in Food. Food and Agriculture Organization of the United Nations/World Health Organization, London, Ontario, Canada.
- Granato, D., Branco, G. F., Cruz, A. G., Faria, J. A. F., & Shah, N. P. (2010). Probiotic dairy products as functional foods. *Comprehensive Reviews in Food Science and Food Safety*, 9(5), 455–470.
- Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., & Sanders, M. E. (2014). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature Reviews Gastroenterology & Hepatology*, 11(8), 506–514.
- Kumar, A. P., Janardhan, A, Radha, S, Viswanath, B, & Narasimha G. (2015). Statistical approach to optimize production of biosurfactant by *Pseudomonas aeruginosa* 2297. *3 Biotech*. 5, 71-79.
- Maftei, N.-M., Raileanu, C. R., Balta, A. A., Ambrose, L., Boev, M., Marin, D. B., & Lisa, E. L. (2024). The potential impact of probiotics on human health: An update on their health-promoting properties. *Microorganisms*, 12(2), 234.
- Marco, M. L., Heeney, D., Binda, S., Cifelli, C. J., Cotter, P. D., Foligné, B., & Hutkins, R. (2017). Health benefits of fermented foods: Microbiota and beyond. *Current Opinion in Biotechnology*, 44, 94–102.
- Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2007). *Sensory Evaluation Techniques* (4th ed.). CRC Press.
- Montemurro, M., Pontonio, E., & Rizzello, C. G. (2019). Design of a fermentation process for the valorization of wheat milling by-products. *Frontiers in Microbiology*, 10, 542.
- Montgomery, D. C. (2017). *Design and Analysis of Experiments* (9th ed.). John Wiley & Sons.
- Olagunju, A. I., Olaniran, A. F., & Akinola, S. A. (2018). Effect of probiotic fortification on the sensory quality of fermented cereal foods. *African Journal of Food Science*, 12(3), 67–74.

- Oranusi S., Okereke I. J., Wesley, B. and Okorundu, I. S. (2014). Evaluation of Microbial and Nutritional Qualities of Aniga and EpitiMoin: Prestige Foods of South Eastern Nigeria. *American Journal of Life Science*, 3(1), 43-55.
- Ouwehand, A. C., Salminen, S., & Isolauri, E. (2002). Probiotics: an overview of beneficial effects. *Antonie van Leeuwenhoek*, 82(1–4), 279–289.
- Owusu-Kwarteng, J., Tano-Debrah, K., Glover, R. L. K., & Jespersen, L. (2015). Technological properties and probiotic potential of *Weissella* and *Lactobacillus* isolates from West African fermented cereal dough. *Journal of Applied Microbiology*, 119(3), 872–883.
- Peekate, L. P. (2022). *Deciphering the identity of bacterial isolates through conventional means: A practical guide*. Edese Printing and Publishing Company, Port Harcourt, Nigeria, 21-48.
- Ranadheera, C. S., Baines, S. K., & Adams, M. C. (2010). Importance of food in probiotic efficacy. *Food Research International*, 43(1), 1–7.
- Sharma, P., Kumari, M., & Mishra, V. (2020). Probiotic enrichment and sensory improvement of traditional fermented foods: A review. *Food Research International*, 136, 109479.
- Vantsawa, P. A., Maryah, U. T., & Bulus, T. (2017). Isolation and identification of lactic acid bacteria with probiotic potential from fermented cow milk (nono) in Unguwar Rimi, Kaduna State, Nigeria. *American Journal of Molecular Biology*, 7(2), 99–106.
- Zhang, X., & Dequan, L. (2013). Response surface analyses of rhamnolipid production by *Pseudomonas aeruginosa* strain with two response values. *African Journal of Microbiology Research*, 7(22), 2757-2763.