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Article

Cultural and Nutritional Enhancement of Flatbreads (Piaya) Fortified with Indigenous Fruits and Herbs: A Biochemical, Microbiological, and Ethnobotanical Analysis

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Abstract

Six specially designed flatbreads (piaya) with local fruits and herbs were identified for scale-up development from eighteen initial prototypes. These selected models enhanced with puree and powder mixtures of mango, strawberry, muscovado, pineapple, screw pine, and purple yam were thoroughly tested by expert panels employing a 6x3 factorial Design of Experiments (DoE). Each sample was subjected to intense testing for microbiological safety, biochemical composition, nutrient level, and stability of shelf life. Findings indicated that all six fortified piaya samples, as well as the commercial type, passed the biological safety standards of the Food and Drug Administration (FDA). The commercial type, however, had a significantly higher Aerobic Plate Count (APC), probably because it had a greater moisture level, making its environment more conducive to bacterial growth. Biochemical testing showed the fortified flatbreads had much better nutritional profiles. Most significantly, their sugar levels were decreased by almost fivefold from the commercial product, a critical improvement considering the World Health Organization's (WHO) guidelines for daily consumption of sugar. This decrease makes the fortified piaya a better choice for those watching their sugar intake. Notably, the incorporation of fruit and herb powders played a significant role in increasing the product's shelf-life. However, this benefit came with a slight compromise: the more powder added, the more the organic compounds like natural sugars and flavor elements tended to decrease. Nonetheless, this trade-off reflects a thoughtful balance between nutrition, safety, and cultural preservation, proving that innovation can honor tradition while promoting health.

Keywords: *Piaya fortification, food innovation, cultural food heritage, nutritional enhancement, traditional delicacy*

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Introduction

By the year 2045, the Western Pacific region of the world is estimated to have the most significant number of diabetes patients, at 212 million people in the age group 20-79 (Elfien & John, 2020). The trend will significantly affect the Philippines as a nation with high culinary culture and carbohydrate and sugar-rich diets. Flatbreads like piaya, a sweet Negros Occidental delicacy, are favored across the country but make a significant contribution to excessive sugar intake. Made from flour and muscovado sugar in the old days, piaya is packed with as much as 50 grams of sugar per serving, twice the amount of recommended daily sugar for adults, according to the World Health Organization (WHO) and the Philippine Food and Drug Administration (FDA). Addressing the world's increasing number of non-communicable diseases and local reliance on sugary food, this research aims to respond by redefining piaya as a culture-rooted yet health-promoting food item. The study creatively fortified piaya with nutrient-rich local fruits and herbs like Indian mango, pineapple, purple yam, strawberry, and screw pine from different barangays in Sagay and Cadiz City, Negros Occidental. Adding these native ingredients is intended to lower free sugar levels, extend shelf life, and enhance the product's nutritional quality without detracting from its sensory and cultural attractiveness.

Culturally, piaya is not just a snack but a heritage food embedded deeply within Negrense culture. It is eaten at family reunions, celebrations, and daily meals. It signifies the convergence of gastronomic tradition, regional identity, and local economic enterprise. Production using locally available ingredients encourages sustainable foodways and solidifies cultural continuity and regional food sovereignty. Through strengthening a classic food instead of replacing it, the study preserves the country's culinary heritage while responding to contemporary health issues.

Despite continued food innovation endeavors in the Philippines, a critical gap in research in culturally relevant product formulation that addresses both public health, cultural heritage, and financial viability is very much present. Existing food fortification studies have mainly targeted commercial breads or foreign models and are irrelevant to local ways or locally desired foods. Additionally, few have investigated the biochemical, microbiological, proximate, and nutrient alterations when traditional food products such as piaya are fortified with fruit and herb derivatives.

This research thus addresses an urgent need by blending cultural heritage with nutritional innovation. It presents a scientific and socially pertinent paradigm for reframing traditional Filipino dishes to address the urgent health needs of the future yet remains grounded in local culture and community identity. Rooted in the values

of sustainability, food justice, and the United Nations Sustainable Development Goals, this study illustrates that food innovation based on heritage can be a health intervention and a celebration of culture.

Methodology

It utilized a descriptive-quantitative design to assess the composition of ingredients and the nutritional enrichment of flatbreads (piaya) with indigenous local fruits and herbs. The descriptive approach was suitable since it enabled the researcher to describe the differences and characteristics of each fortified piaya sample according to their biochemical, microbiological, proximate, and nutrient content and shelf-life. As Creswell (1994) proposed, descriptive research is efficient in describing existing situations, and herein it was applied to record the exact ingredient blends in every formula. On the other hand, the quantitative aspect entailed gathering and analyzing data in the form of figures, such as ingredient quantity, nutritional value, microbial counts, and shelf life, as advocated for by Bhandari (2022). The research also applied GIS mapping to determine and map the local sources of fruits and herbs utilized in the fortification process.

The experiment was carried out at the Food Technology Research and Development Center of Northern Negros State College of Science and Technology (NONESCOST), Sagay City, Negros Occidental. The raw materials were obtained from local barangays: pineapple from Bug-ang and Makiling barangays, Indian mango from Paraiso and Old Sagay barangays, strawberry and purple yam from Cadiz City, and pandan leaves from Paraiso barangay. Laboratory tests were conducted at Negros Prawn Producers Cooperative Analytical and Diagnostic Laboratory, Bacolod City.

The main ingredients used were monosaccharides and disaccharides flour, drinking water, lard, muscovado sugar, and sesame seeds, supplemented with fruit and herb purees and powder from Indian mango, pineapple, strawberry, purple yam, and screw pine. Equipment like rolling pins, griddling surfaces, mixing basins, electric mixers, and temperature-controlled containers was used to prepare and bake the enriched piaya.

A 6×3 factorial design of experiments (DoE) was utilized to generate eighteen unique treatment combinations with six fruit and herb variables at three levels of concentration: puree alone, a blend of puree and powder, and powder alone. Three fixed levels of flour, lard, and muscovado-sesame mixtures were incorporated for each treatment. Six of these eighteen treatments were chosen for biochemical,

microbiological, proximate, and toxicity studies, each involving a distinct fruit or herb variant in its optimal formulation.

The ingredients were weighed, sifted, and mixed in steps for every treatment. The dough was made with flour, lard, and water, rolled, and filled with the ready fruit- and herb-infused fillings. Each filled dough was flattened, baked on a griddle, cooled, and packed for testing. The stepwise procedures helped standardize the preparation to reliably examine differences in nutritional content, microbial action, and shelf-life among treatments.

The research design intermeshed classical culinary practice and scientific method to assess how locally accessible, high-nutrient fruits and herbs could be incorporated into a culturally renowned Filipino dish to enhance its health content without diminishing its sensory quality or cultural identity.

Results and Findings

Table 1: Analytical Results of the Assessment of the Microbiological Content of Flatbread (Piaya) Fortified with Fruits and Herbs

(500 grams)

PARAMETER	FOOD SAFETY LIMIT	PIAYA FORTIFIED WITH HERBS TREATMENT/SAMPLE 1 (Mango)	2 (Strawberry)	3 (Regulated Muscovado)	4 (Pineapple)	5 (Screwpine)	6 (Purple Yam)	CONTROL A
Aerobic Plate Count (CFU/g) (Pour Plate Method)	$\leq 10^4$ or less than 100,000	25	30	25	10	10	15	35
Escherichia Coli (CFU/g) (Compact Dry Media)	≤ 20	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1
Total Coliform (CFU/g) (Compact Dry Media)	10^2 Or 100 Of 100	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1
Salmonella	≤ 20	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1
Staphylococcus Aureus (CFU/g) (Compact Dry Media)	Should not be detected at 10^1 In 25g Sample	Not Detected at 10^1	Absent in 25g	Absent in 25g	Absent in 25g	Absent in 25g	Absent in 25g	Absent in 25g
Listeria (Reveal 2.0 For Listeria)	10 Or 1000g	Negative	Negative	Negative	Negative	Negative	Absent in 25g	Negative
Yeasts (CFU/g) (Pour Plate Method For 2 Hours)	10^3 or 1000g	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1
Molds CFU/ (Pour Plate Method For 2 Hours	10^3 or 1000g	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1	Not Detected at 10^1

Source: Negros Prawn Producers Cooperative Analytical and Diagnostic Center

Table 1: Microbiological Content and Cultural Implications of Fortified Flatbreads (Piaya)

Table 1 shows the microbiological analysis of fruit- and herb-enriched flatbreads (piaya) in Treatments 1 to 6 and a control sample in the form of a commercial

piaya product. The analysis, which was performed by the Negros Prawn Producers Cooperative Analytical and Diagnostic Center, aimed to determine microbial presence, specifically the Aerobic Plate Count (APC), which is a general measure of bacterial load in food. The findings indicated that all seven samples, including the commercial control, were within the acceptable range for safe consumption based on national and international food safety standards.

However, it was noted that the control sample (commercial piaya) had the highest APC among all the treatments, yet below the critical limit. This indicates that while commercially made piaya is still safe to consume, its relatively higher bacterial content may be a factor towards its shorter shelf-life and higher risk of spoilage in the long term. On the other hand, some of the fortified samples, especially those with ingredients like pineapple, screw pine, and purple yam, had lower APC values. The results indicate that adding fruit and herb extracts, most of which have naturally occurring antimicrobial compounds, could have helped suppress bacterial growth and improve the product's shelf stability.

Culturally, this result affirms the long-established indigenous knowledge of Filipino communities in which native fruits and herbs are prized for their aroma, nutrients, and preservation capabilities. Pandan (screw pine) and mangga (mango), for example, have long been used in household preparation not only to add aroma and taste but also for their preservation properties. In incorporating these native ingredients in a widely popular treat such as piaya, this research responds to contemporary health issues like microbial contamination and food safety. It enforces the cultural knowledge infused in Filipino food culture.

This science-based validation of heritage ingredients repositions piaya from being only a sweet cultural delicacy to a functional food that bridges health and heritage. As such, the findings of Table 1 indicate that culturally derived food

innovation based on local tradition and scientific capability can uplift products and contribute to safer, healthier, and more sustainable local food systems.

Table 2: Analytical Results of the Assessment of Biochemical Content of Flatbread (Piaya) Fortified with Fruits and Herbs

(60 grams Serving Size)

PARAMETER	RECOMMENDED DIETARY ALLOWANCE (9-18 Years)	PIAYA FORTIFIED WITH FRUITS AND HERBS TREATMENT/SAMPLE						
		1 (Mango)	2 (Strawberry)	3 (Muscovado)	4 (Pineapple)	5 (Screwpine)	6 (Purple Yam)	CONTROL A
Calories	88% or 1760 (of 2000 Calories)	188	198	193	198	193	195	205
Calories due to Fat	35% (of Total Daily Calories)	25	35	30	35	29	26	40
Total Fat	160g M/90gW (10% SFA/1%TF)	3g	4g	3g	4g	3g	3g	6g
Protein	0.36g (Per Kg of Body Weight)	1g	1g	1g	1g	1g	1g	0.003g
Total Carbohydrates	130g	40g	40g	40g	40g	40g	41g	75g
Dietary Fiber	25g (Per 2000 Calorie/Day Diet)	≤1g	≤1g	≤1g	≤1g	≤1g	≤1g	≤1g
Sugar	25g (Sugar from Fruits and Vegetables)	9g	7g	3g	7g	6g	7g	50g
Calcium	1300* mg	50mg	48mg	44mg	47mg	42mg	48mg	10mg
Potassium	4.7* g	132mg	131mg	139mg	134mg	144mg	141mg	120mg
Magnesium	360 mg	20mg	20mg	31mg	19mg	24mg	27mg	31mg
Iron	15 mg	7mg	10mg	5mg	10mg	9mg	8.5mg	6mg
Zinc	9 mg	0.01mg	0.022mg	0.022mg	0.032mg	0.027mg	0.02mg	0. 02mg

Source: Negros Prawn Producers Cooperative Analytical and Diagnostic Center

Table 2: Biochemical Content of Flatbread (Piaya) Fortified with Fruits and Herbs and Its Cultural Implications

Table 2 illustrates the biochemical analysis of the biofortification content of piaya using locally available fruits and herbs. A sample analysis was done on Treatments 1 to 6, with each treatment consisting of various fruit and herb fortifications contrasted against a control sample of the standard commercially sold piaya. Each sample was quantified according to a 60-gram serving size, compliant with functional consumption standards. The study's main goal was to decrease the free

sugar content of the classic piaya, a flatbread with high muscovado sugar content, without detracting from its sensory attractiveness or cultural importance.

The findings demonstrated a significant decrease in total sugar content between the fortified treatments and the commercial control. While the commercial piaya exceeded the World Health Organization's (WHO) suggestion for daily sugar intake at 25 grams by almost doubling that threshold in a single serving, the fortified versions dramatically decreased sugar content. This was done by substituting partially muscovado with fruit and herb purees and powders, acting as natural sweeteners and adding other nutritional advantages like dietary fiber, vitamins, antioxidants, and phytochemicals. For instance, pineapple and mango use added natural sugars, vitamin C, and enzymes such as bromelain, which are beneficial for digestion and immunity.

Culturally, this biochemical development honors and maintains the integrity of piaya as a valued Negros Occidental delicacy. With its dense muscovado filling and firm connection to the sugarcane economy, piaya has long been tied to festivals, welcome, and local pride. However, with increasing diabetes and lifestyle diseases in the province and nationwide, remaking old recipes is now unavoidable. This research presents a culturally appropriate strategy by adapting, rather than substituting, the conventional formula. Ingredients like ube (purple yam), mangga (mango), pinya (pineapple), pandan (screw pine), and preskong presa (strawberry), which are utilized, are not only ubiquitous in communities but also rooted in Philippine food tradition.

The cultural factor goes beyond. These ingredients are commonly used in traditional Filipino snack foods, desserts, and medicinal applications, and their presence in piaya is a testament to the matching of health and heritage. By utilizing known, culturally significant ingredients, the research increases the acceptability of the modified piaya among Filipino consumers, especially those in rural and semi-urban areas where traditional foods remain strongly favored.

The implications of the discoveries are far-reaching. Biochemically, the fortified piaya variants provide a less glycemic replacement for the commercial variety that can become part of diabetes prevention in sugar-dependent areas. Culturally, the research confirms that traditional Filipino cuisine can adapt to the requirements of the modern era without losing its identity. This supports the worth of culturally embedded food

innovation as a public health nutrition approach, especially in populations where food is closely associated with social memory, place identity, and livelihood economy.

Table 3: Analytical Results of the Proximate Analysis Assessment of Piaya Fortified with Fruits and Herbs

PROXIMATE ANALYSIS OF PIAYA FORTIFIED WITH FRUITS AND HERBS PUREE /PIAYA FORTIFIED WITH FRUIT AND HERBS PUREE & POWDER/ PIAYA FORTIFIED WITH FRUITS AND HERBS POWDER ONLY

PARAMETER % (500g)	1 (Mango)	2 (Strawberry)	3 (Muscovado)	4 (Pineapple)	5 (Screwpine)	6 (Purple Yam)	CONTROL A
PROTEIN	6.77 / 6.75/6.70	9.78 /6.74/ 6.61	9.64/9.58/9.48	4.78/4.70/ 4.63	9.37/9.30/9.23	5.01/ 4.91/4.75	4.68
FAT	6.92 /6.82/ 6.58	8.93/ 8.85/8.71	7.16/7.10/6.81	4.19/4.07/ 3.98	9.91/9.84/9.70	11.42/11.01/10.82	8.01
MOISTURE	9.22/9.10/8.93	9.63/9.50/9.31	9. 54/9.32/9.12	6.86/6.71/6.50	9.65/9.49/9.21	9.78/9.53/9.29	57.08
Water Activity	0.6960/0.6670	0.75/0.68/0.54	0.71 /0.60/0.47	0.51/0.43/0.33	0.78/0.61/0.47	0.81/0.69/0.47	1.37
ASH	0.85/0.79/0.60	0.89/0.71/0.49	0.97/0.81/0.58	0.54/0.43/ 0.21	0.96/0.80/0.67	0.98/0.79/0.60	1.01
CARBOHYDRATES	72.01/72.00/70.00	78.03/77.00/75.00	86.02 /86.01/85.00	63.02/62.00/61.00	77.01/77.00/76.88	88.02/88.00/86.00	98.08
FIBER	1.13/0.98/0.81	1.93/1.80/1.50	1.82 /1.71/1.50	1.15/0.98/0.61	2.0/1.77/1.48	2.01/1.88/1.61	1.83

Source: Negros Prawn Producers Cooperative Analytical and Diagnostic Center

Table 3: Proximate Analysis of Piaya Fortified with Fruits and Herbs and Its Cultural Relevance

Table 3 presents a comprehensive outline of the proximate composition of piaya enriched with a mixture of indigenous fruits and herbs, utilizing eighteen treatment combinations. The treatments were grouped according to the type of fortification used: (1) puree only of fruits and herbs, (2) mixed puree and powder, and (3) powder only. The parameters examined were protein, fat, moisture, water activity, ash, and fiber determinants of nutritional quality and product stability.

The outcome indicated the dominant pattern: piaya fortified only with fruit and herb puree contained the highest protein, moisture, and total organic content, the richest in macronutrients, but with a relatively shorter shelf-life of 14 days. In comparison, piaya fortified with puree and powder showed moderate nutrient content and had the most extended shelf-life of 60 days. The shelf-stable form with a duration of up to 95 days was the one that was fortified with fruit and herb powders only. Nonetheless, this variant had lesser moisture, protein, and fat content due to the

dehydrating process, which, despite restricting microbial growth, also lowered the content of bioavailable nutrients.

The study has a cultural aspect. Piaya is a historically and culturally rooted delicacy in Negros Occidental, deeply linked with the region's economy of sugarcane and cuisine. Classically taken as a newly prepared pastry filled with sweet muscovado syrup, piaya is frequently served during family reunions, fiestas, and as pasalubong (homecoming treat) for tourists. Traditional piaya has always had a short shelf life, constraining its dissemination and availability outside local markets.

This research redesigns piaya using culturally embedded food innovation. Introducing indigenous fruits like mangga (Indian mango), ube (purple yam), pandan (screw pine), pinya (pineapple), and presa (strawberry), which are all known and culturally relevant in Filipino food practice, the process of fortification not only enhances the health value of piaya but also widens its market reach with enhanced shelf stability.

Notably, the fortification using powders indicates the customary food preservation techniques practiced by Filipinos. Drying fruits and herbs has been a common practice in rural areas to guarantee year-round produce availability, particularly during off-season months or periods of low supply. In contemporary times, adopting this ancient technique not only upholds sustainable food processing but also serves to maintain cultural food knowledge systems.

In addition, the extended shelf-life of powdered-fortified piaya opens possibilities for small-scale producers and local businesses in rural areas to expand their scales of production and commercialization without losing their cultural identity. It also complements public health goals, enabling nutrient-fortified foods capable of being shipped across regions with acceptable safety and nutritional attributes.

Finally, Table 3 measures the functional benefits of various fortification technologies and shows how traditional foods like piaya can be transformed through respectful, scientific approaches into healthier, more sustainable, and cost-effective innovations. This balance of tradition, nutrition, and shelf-life benefits enhances the cultural and commercial appeal of piaya as a heritage food suitable for contemporary Filipino consumption.

Discussion

In this research, the eighteen initially developed piaya treatments with a blend of different local fruits and herbs were reduced to six formulations by scientific investigation and expert panel ratings. The six chosen treatments used blends of purees and powders of culturally important Philippine fruits, namely Indian mango,

strawberry, muscovado, pineapple, screwpine (pandan), and purple yam (ube). These ingredients are nutritionally valuable and firmly rooted in Filipino culinary traditions, signifying bounty, celebration, and identity in many regional cuisines.

Microbiological testing of the six fortified samples and the commercial control revealed that all were within the Food and Drug Administration (FDA) acceptable safety limits. While a significant disparity was noted, the commercialized piaya had the highest Aerobic Plate Count (APC), whose source can be traced to its greater moisture content. High moisture is conducive to microbial growth, thereby reducing shelf life. Conversely, the presence of dried fruit and herb powder in the fortified variants added to low water activity, which inherently inhibited the growth of microorganisms. This result not only assured the safety of the fortified products but also aligned with the conventional methods of Filipino food preservation, like drying and fermenting, which extend the shelf life of ingredients without using synthetic preservatives.

Biochemically, the six chosen fortified piaya samples showed better nutrition profiles. The samples obtained a considerable reduction in the content of sugars, up to five times lower than the commercially sold counterpart. From the World Health Organization (WHO), the daily recommended intake (RDI) of free sugar is 25 grams or roughly six teaspoons. The market pie usually crossed this threshold in one serving, raising a public health issue, considering the rising incidence of diabetes and metabolic disease in the Philippines. The fruit- and herb-enriched versions proved that one can preserve the cultural flavor and popularity of piaya without deviating from nutritional standards.

Culturally, this innovation is a significant development of a classic delicacy. Piaya, more especially from Negros Occidental, is not just a snack; it is a cultural icon associated with the region's sugarcane tradition and food identity. Historically crafted using rich muscovado syrup, piaya has long been a symbol of Filipino sweetness, both figuratively and literally. However, when left unbridled, this very sweetness is also a health hazard. The research strategy was not to eliminate this cultural icon but to rejuvenate it so that it could be applicable and health-promoting in today's era.

In addition, the selected ingredients mirror the biodiversity and agro-culture of several Philippine communities. Mangoes and pineapples are local fruits commonly cultivated in backyards; ube and strawberries are linked to upland cultivation; pandan is utilized in ritual preparation and everyday rice cooking. Their incorporation into a

popular local snack celebrates regional resources and indigenous knowledge systems in food construction.

This study discusses how scientific, microbiological, biochemical, and nutritional evaluations can be reconciled with cultural appropriateness. The fortified piaya is an exemplary new food product and an exemplar of healthy, sustainable, culturally based nutrition that connects heritage and wellness. This confirms that cooking traditions can be reconfigured to answer contemporary dietary requirements without sacrificing historical and cultural authenticity, enhancing scholarly discourse and local cuisine practice.

Conclusion

In summary, the fortification of piaya, a native Filipino flatbread, with a mixture of macro and micronutrients yielded a nutritionally improved product with minimal free sugar levels. The fortification, especially using fruit and herb powders, led to healthier nutritional consequences and helped improve the product's shelf life. The inclusion of powders like mango, pineapple, purple yam, screw pine, and strawberry contributed to the reduction of moisture and water activity levels, which are imperative in retarding microbial growth and spoilage. This concurs with conventional Filipino food preservation processes, wherein drying ingredients has long been done to provide food durability without resorting to chemical preservatives.

A noted trade-off, however, followed this improvement. As the fruit and herb powder concentration level increased in all three treatment groups, the only puree group, the puree and powder combined group, and the only powder group, the organic chemical content, including natural sugars, volatile flavor components, and some phytonutrients, increased. This decline is due to the drying process, which, although effective in minimizing perishability, also hinders the availability of specific heat-sensitive or water-soluble nutrients in fresh produce.

Nevertheless, this outcome underscores the delicate balance between nutritional density, flavor retention, and shelf life in food innovation. From a cultural perspective, this approach respects the essence of piaya as a cherished heritage delicacy while modernizing it to respond to evolving health and food security concerns. Thus, the study not only presents a viable solution to nutritional and preservation challenges but also contributes to the revitalization of traditional Filipino foodways in a health-conscious and sustainable manner.

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Conflict of Interest

The author declares no conflict of interest.

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