Research Article

Indigenous Flavors: The Development of Liposu Sauce for Modern Culinary Use

Khai Ming Tang[1]; Hasmadi Mamat[1]; Wolyna Pindi[1,2]; Aizul Azri Azizan[1]; Dynatalie Delicious[1]; Adilah Md Ramli[1]; Dk Rafidzah Ak Mohiddin[1]; Leoneeta Rozween Hassan[1]; Shalawati Ibrahim[1]; Dian Widya Ningtyas[3] Sylvester Mantihal [1,2*]

[1]Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia.
[2]Food Security Research Laboratory, Faculty of Food Science and Nutrition, Universiti of Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia.
[3]Laboratory of Food Microbiology, Faculty of Agriculture Technology, University Brawijaya, Jl. Veteran No.10-11, Ketawanggede, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

*s.mantihal@ums.edu.my

ABSTRACT

Liposu (*Baccaurea lanceolata*) is an endemic fruit native to the Borneo region, particularly valued by the Dusun community of Sabah. This study explores the potential of Liposu fruit in the development of a novel sauce formulation. Three formulations were prepared and evaluated through sensory analysis involving 52 semi-trained panelists, utilizing both ranking and hedonic scoring methods. Based on the sensory data, Formulation III (9.2% Liposu) was identified as the most preferred variant. Subsequent proximate analysis revealed that the major components of the optimized formulation included water (39.0% w/w), vegetable oil (10.1% w/w), and carbohydrates derived from gum Arabic (8.5% w/w), carboxymethyl cellulose (0.4% w/w), and pectin released during processing. Literature-supported interpretation of ash content (3.60% ± 0.00) indicated the presence of essential minerals such as potassium, magnesium, zinc, calcium, and phosphorus. Furthermore, the intrinsic acidity of the Liposu fruit, attributed primarily to acetic acid, contributed to a final product pH of 4.32 ± 0.01. These findings highlight the potential of Liposu fruit as a functional and sensory-appealing base for sauce development, with favorable physicochemical and nutritional properties.

Received: 9 April 2025
Accepted: 6 August 2025
Published: 30 September 2025
DOI: https://10.51200/ijf.v2i2.6308

Keywords: liposu; proximate; sambal; sensory

1. Introduction

Baccaurea lanceolata, commonly known as Liposu among the Dusun ethnic group in Sabah, is a tropical plant native to the rainforests of Borneo, Peninsular Malaysia, the Philippines, Thailand, and Sumatra (Mojulat & Surugau, 2021). Traditionally valued for its edible fruit and timber, Liposu has also been used by the Dayak community as a hunting indicator (Mojulat & Surugau, 2021). Despite its ability to fruit year-round, the species is largely under-cultivated, with most occurrences found growing wild near homes rather than in formal agricultural settings (Awang *et al.*, 2018). The fruit's pericarp is typically consumed raw with sugar or salt to counterbalance its intense sourness (Walter, 2004), and it is occasionally processed into traditional products such as sun-dried slices, juice, or sambal (Mojulat & Surugau, 2021).

Recent studies have drawn attention to Liposu's phytochemical and antioxidative potential, suggesting its value not only in traditional diets but also in pharmaceutical and nutraceutical applications (Abu Bakar *et al.*, 2014; Gruère *et al.*, 2006). Members of the *Baccaurea* genus are notably rich in phenolic compounds and antioxidants, particularly in their rind, pericarp, and pulp (Abu Bakar *et al.*, 2014; Astuti *et al.*, 2020; Ismanto *et al.*, 2022). Bioactive constituents such as saponins, tannins, flavonoids, and alkaloids present in the fruit exhibit antimicrobial properties, which, when combined with its naturally low pH (ranging from 4.2 to 4.38), position Liposu as a promising candidate for use in food preservation (Fitriansyah *et al.*, 2018; Galappathie *et al.*, 2014).

In the culinary context, sauces play an essential role in enhancing sensory attributes such as taste, aroma, and texture. Typically composed of plant- or animal-derived ingredients, sauces can take the form of liquids, pastes, emulsions, or suspensions (da Silva *et al.*, 2021), and are commonly used to complement dishes ranging from meats to vegetables (Cárdenas-Castro *et al.*, 2019). The Malaysian Food Regulations (1985) define a sauce as a liquid or semi-liquid savory preparation that may or may not contain spices and is intended to be consumed with food, including products such as soy sauce, fish sauce, mayonnaise, and hydrolyzed vegetable protein-based condiments. More recently, fruit-based sauces have been recognized as functional foods, owing to their high content of bioactive compounds including antioxidants, vitamins, and minerals (Csapó *et al.*, 2019). Studies have demonstrated that fruit incorporation into sauces can enhance the nutritional profile of the final product. For instance, the addition of strawberry pulp in ketchup formulations increased phenolic and flavonoid content without negatively affecting sensory acceptability (Ahouagi *et al.*, 2021), while macauba pulp sauces showed improved antioxidant activity and shelf life through the inclusion of gum arabic and xanthan gum (Fonseca *et al.*, 2021). Similarly, persimmon-based cake formulations exhibited high levels of total phenolics and antioxidant activity while offering a low-fat alternative to traditional baking ingredients (Dipti *et al.*, 2023).

Although Liposu is recognized as a culturally significant and potentially valuable fruit, its market presence remains limited due to a lack of public awareness and minimal commercial development (Gunawan *et al.*, 2023). Its consumption is largely restricted to indigenous communities, particularly the Dusun of Sabah, who traditionally use it in fermented or acidic preparations such as sambal (Mojulat & Surugau, 2021). Given the widespread Malaysian preference for sour and spicy flavors—evident in dishes such as tempoyak, asam laksa, and jeruk—the development of Liposu-based condiments aligns well with national taste preferences (Ajibola *et al.*, 2023).

Moreover, traditional preparations such as sambal Liposu often include local ingredients such as dried anchovies (ikan bilis) and tuhau (*Etlingera coccinea),* a wild ginger herb endemic to Borneo (Mahdavi *et al.*, 2017). This highlights Liposu's potential for value-added product development, particularly in the form of packaged condiments or souvenirs that can promote local culinary heritage. Despite its promising attributes, current innovations involving Liposu remain scarce. Most studies focus on the conservation of the species due to ecological threats such as deforestation, rather than exploring its potential for commercialization and economic sustainability among local communities. Traditional processing methods and small-scale production further limit its scalability and competitiveness in broader food markets.

This study aims to formulate and develop a sauce derived from Liposu fruit, with sambal Liposu serving as the conceptual foundation. The objective is to create a commercially viable product that reflects familiar Malaysian flavor profiles while harnessing the functional and nutritional benefits of the fruit. The most acceptable formulation, based on sensory analysis, will be further analyzed to determine its physicochemical properties and potential for commercial application.

2. Materials and Methods

2.1 Sauce Formulation

The wild Liposu fruit (acquired from supplier - unripe) was washed, peeled, and deseeded, with the pulp diced and weighed into required batches. The same batches were used throughout this study and kept in refrigeration about 7ºC until further usage. Other ingredients such as ginger, garlic, onion, and red chili were also diced and weighed according to the formulations. Seasonings (salt and sugar) and additives (carboxymethyl cellulose, gum Arabic, and soy lecithin) were measured and prepared.

To begin the cooking process, anchovies (*ikan bilis*) were toasted until golden brown and set aside. The Liposu fruit, bird's-eye chili, onion, garlic, and ginger were sautéed to enhance flavor through caramelization and the Maillard reaction. Salt and sugar were gradually added to balance the flavor. After 10 minutes, the mixture was allowed to cool for homogenization.

For homogenization, the sautéed mixture and toasted anchovies were blended with the remaining seasoning and soy lecithin until smooth. The mixture was then sieved to remove plant fibers. Carboxymethyl cellulose (0.4% w/w) and gum Arabic (8.6% w/w) were added gradually, and the sauce was blended until fully emulsified. The final product was transferred into heat-treated glass bottles (boiled for 15 minutes between 95ºC to 100ºC) and stored for further analysis.

Table 1. Ingredients of liposu sauce formulation according to weightage in percentage

Type of Ingredient	Weightage (w/w)				
	I (Control)	II	III	IV	V
Liposu fruit	0.0%	4.6%	9.2%	11.4%	15.6%
Onion	8.7%	8.7%	8.8%	8.7%	8.7%
Garlic	1.4%	1.4%	1.4%	1.4%	1.4%
Ginger	1.4%	1.4%	1.4%	1.4%	1.4%
Red Chilli	15.6%	11.4%	6.0%	4.6%	0.0%
Bird's eye chilli	4.6%	4.6%	4.6%	4.6%	4.6%
Vegetable oil	10.1%	10.1%	10.1%	10.1%	10.1%
Ikan bilis	4.6%	4.6%	4.6%	4.6%	4.6%
Potable water	39.0%	38.8%	39.2%	38.8%	39.0%
Salt	1.7%	1.7%	1.7%	1.7%	1.7%
Sugar	3.4%	3.4%	3.4%	3.4%	3.4%
Gum Arabic	8.5%	8.6%	8.5%	8.6%	8.5%
Soy lecithin	0.5%	0.5%	0.5%	0.5%	0.5%
Carboxy Methyl Cellulose	0.4%	0.4%	0.4%	0.4%	0.4%

2.2 Sensory Analysis

A completely randomized design (CRD) was employed following Dipti *et al.* (2023). The study was conducted in two stages: the first assessed the acceptability of Liposu sauce formulation, and the second identified the preferred formulation. Five formulations (including one control with 0% Liposu juice) were used for the acceptability test, while three formulations were tested for preference. Fifty semi-trained panelists from the Faculty of Food Science and Nutrition at UMS evaluated one control formulation and four Liposu sauce formulations in each stage. Each 5-gram sample was presented in a plastic cup with a three-digit random code. A nine-point hedonic scale (1 = "extremely dislike", 9 = "extremely like") was used to assess attributes including color, taste, aroma, texture, and overall acceptability. Cucumber strips served as the sauce carrier to reduce bias.

2.3 Proximate Analysis

The proximate analysis of the Liposu sauce was conducted to determine its nutritional composition, including the content of ash, moisture, protein, fat, crude fiber, carbohydrates, and pH value. The analysis followed the AOAC (2000) standard methods. The energy value of each sample was calculated based on the caloric contribution of carbohydrates, proteins, and fats. The total carbohydrate content was derived by subtracting the sum of all other macronutrients from 100%. Each analysis was performed in triplicate to minimize instrumental errors and ensure the reliability of the results. The pH value of the Liposu sauce was measured with a pH meter (Model 340, Mettler-Toledo, Switzerland) with a dilution ratio of 1:1 of Liposu sauce to distilled water.

2.4 Statistical Analysis

Statistical analyses were performed using the Real Statistics add-in for Microsoft Excel 2020. All data were reported as mean ± standard deviation, with a significance level set at $p=0.05$. A one-way ANOVA was used to analyze the proximate data. If the null hypothesis was rejected, post-hoc comparisons were conducted using the Tukey HSD test. To determine the optimal Liposu sauce formulation, the Kruskal-Wallis ANOVA was employed to analyze the ranking data from the sensory evaluation. If the null hypothesis was rejected, pairwise comparisons were made using the Dunn-Bonferroni test at a 95% confidence level. The Friedman nonparametric ANOVA was applied to the sensory evaluation data from the 9-point hedonic scale, followed by the Friedman-Nemenyi post-hoc test to identify significant differences between sample groups, with $p=0.05$ used to evaluate significance.

3. Results and Discussion

In this study, five Liposu sauce formulations were developed for sensory evaluation. During the initial phase, various combinations of sambal-based Liposu sauces were tested to identify the optimal base formulation. The objective of this study was to determine the best Liposu sauce formulation through sensory analysis. The weight of Liposu fruit and red chili in each variation served as the manipulated variables, aiming to identify the most preferred formulation based on panelist feedback, as detailed in the following section. The ingredients used in the final sauce production are listed in Table 1.

Table 2 presents the results of the ranking test conducted during the sensory evaluation of Liposu sauce. This test aimed to identify the most preferred formulation, with the sample showing the lowest average ± standard deviation value being selected as the "best formulation." Among the five samples, Sample III had the lowest value (2.13 ± 1.60), indicating it was the most preferred, followed by Sample IV (2.25 ± 1.56), Sample II (2.29 ± 1.60), Sample I (2.48 ± 1.92), and Sample V (2.96 ± 1.92).

However, it is important to note that despite the clear preference for Sample III, the Kruskal-Wallis ANOVA revealed no statistically significant differences between the samples at a 95% confidence level ($\alpha=0.05$). This suggests that while panelists showed a slight preference for Sample III, the differences between formulations may not be substantial enough to warrant a definitive conclusion. The perceived difference in preference could be attributed to sensory fatigue, as all formulations contained similar levels of chili-based spice (red chili and bird’s eye chili). Capsaicin, the compound responsible for the spiciness, stimulates the TRPV-1 receptor, which can lead to desensitization of the sensory neurons, thereby influencing panelists' ability to distinguish between subtle differences in formulation (Ringkamp & Meyer, 2008).

Table 2. Statistical results of ranking of liposu sauce samples according to rank in average ± standard deviation.

Sample Type	Liposu content	Ranking
I	0%	2.48 ± 1.92
II	4.6%	2.29 ± 1.60
III	9.2%	2.13 ± 1.60
IV	11.4%	2.25 ± 1.56
V	15.6%	2.96 ± 1.92

Note: All ranking results were analyzed with the Kruskal-Wallis ANOVA at confidence level of 95%, $\alpha=0.05$. All sample types were found to be statistically insignificant, the Dunn-Bonferonni Post Hoc test was not performed.

Despite the statistical insignificance found, the feedback consistently identified Sample III as the most preferred formulation, suggesting that the overall flavor profile, despite being perceived as "spicy" or "very spicy," resonated better with the panelists. Therefore, while statistical analysis did not reveal strong differentiation, the clear preference for Sample III in the ranking test justifies its selection for further laboratory analysis, alongside Sample I as the control.

Table 3 presents the results of the hedonic scoring for each Liposu sauce sample, including average ± standard deviation, Friedman's nonparametric ANOVA, and statistical significance interpretation. Statistical significance was found between all Liposu sauce samples ($pcal$ < 0.05), leading to the rejection of the null hypothesis. To further investigate these results, the Friedman-Nemenyi Post Hoc test was conducted to assess the significance between sample groups at a 95% confidence level (α=0.05). Among all samples, the control sample (Sample I) and Sample II received the highest scores for color (7.83 ± 1.44), aroma (7.27 ± 1.43), taste (7.00 ± 1.57), and overall acceptance (7.17 ± 1.41), suggesting that panelists preferred a Liposu sauce with more intense color and milder spiciness.

The color attribute exhibited statistical significance between sample groups, as detailed in Table 3. Variations in the concentration of red chili (*Capsicum sp*.), rich in carotenoids such as capsanthin and capsorubin, contributed to the observed red-orange pigmentation in the sauces (Schieber & Weber, 2016). Decreased red chili content in formulations I, III, and V resulted in a significant difference in perceived color. Red color, associated with sweetness, is naturally preferred by humans (Drewnowski *et al*., 2012; Velasco *et al*., 2023). Panelists showed a preference for formulations with higher red chili content (Formulation I), followed by Formulation III, confirming that the intensity of the red hue influenced their preferences.

The aroma attribute also showed statistical significance between the samples (Table 3). This result was unexpected, as similar ingredients were used across all formulations (Table 8). One plausible explanation could be the influence of visual cues, as color can impact the perception of aroma (Spence, 2015). Formulation V, which had the least red chili content and a more orange hue, may have contributed to the differences in aroma perception, as the reduced red pigmentation led to lower sensory scores in this formulation. For the overall acceptance attribute, statistical significance was observed, particularly for Formulation V, which received the lowest scores for color (5.29 ± 1.87), taste (6.21 ± 1.91), aroma (5.96 ± 1.83), and texture (6.58 ± 1.80). These findings align with previous studies suggesting that the red color, associated with sweetness, is inherently favored by consumers (Drewnowski *et al*., 2012; Spence, 2015; Velasco *et al*., 2023). The reduced redness in Formulation V likely contributed to its lower acceptance among panelists.

Table 3. Scores of hedonic attributes from panelists in average ± standard deviation.

Sample	Color	Taste	Aroma	Texture	Overall Acceptance
I	$7.83 \pm 1.44^{III,V}$	6.69 ± 1.82	7.27 ± 1.56^{V}	6.96 ± 1.73	6.88 ± 1.72^{V}
II	7.69 ± 0.98^{V}	7.00 ± 1.57	7.21 ± 1.43^{V}	7.19 ± 1.48	7.17 ± 1.41^{V}
III	$7.12 \pm 1.37^{I,V}$	6.60 ± 1.86	7.06 ± 1.32	7.13 ± 1.43	7.00 ± 1.71
IV	7.19 ± 1.47^{V}	6.88 ± 1.75	6.96 ± 1.67^{V}	7.25 ± 1.33	7.13 ± 1.57^{V}
V	$5.29 \pm 1.87^{I,II,III,IV}$	6.21 ± 1.91	$5.96 \pm 1.83^{I,II,IV}$	6.58 ± 1.80	$6.19 \pm 1.78^{I,II,IV}$

Superscripted sample group: Significance found between sample groups of Liposu sauce via Freidman-Nemenyi test.

In conclusion, the hedonic attribute scores were analyzed using Friedman's nonparametric ANOVA, with further examination through the Friedman-Nemenyi Post Hoc test. Statistical significance was found for color, aroma, and overall acceptance between Liposu sauce formulations. The contribution of capsanthin and capsorubin from red chili was critical in shaping the perceived taste, aroma, and overall profile of the sauces. Given that formulations I, II, and IV exhibited similar sensory attributes with statistical insignificance, and considering the ranking results, Formulation III emerged as the best Liposu sauce due to its favorable red hue and comparable taste, aroma, and texture to other top formulations.

Table 4 presents the results of the proximate analysis, which aimed to determine the physicochemical properties of the best Liposu sauce formulation identified in the previous sensory evaluation. In this study, Sample III, containing 9.2% w/w Liposu fruit, was selected as the best formulation and was compared to Sample I (control), which contained 0% Liposu fruit, for comparative analysis.

Table 4. Results of proximate analysis in average ± standard deviation between sample I and sample III.

Type of Analysis	I	III
Carbohydrate content	$14.32\% \pm 0.02$	$10.47\% \pm 0.08$
Protein content	$3.36\% \pm 0.00$	$3.26\% \pm 0.00$
Fat content	$16.65\% \pm 0.02$	$17.03\% \pm 0.08$
Crude fiber content	$0.78\% \pm 0.00^{a,b}$	$1.98\% \pm 0.01^{a,b}$
Ash content	$3.66\% \pm 0.00^{a,b}$	$3.60\% \pm 0.00^{a,b}$
Moisture content	$61.23\% \pm 0.01$	$63.66\% \pm 0.04$
Total energy (kcal/5g)	11.03 ± 0.63	10.41 ± 2.17
pH value	$4.88 \pm 0.03^{a,b}$	$4.32 \pm 0.01^{a,b}$

[a] : Statistical significance was found between sample types.
[b] : Statistical significance was found between sample groups.
All results tabulated were analyzed with ANOVA at confidence level of 95%, α = 0.05.
Tukey's Post Hoc test was conducted if null hypothesis was rejected

Table 4 present the three major constituents in both Liposu sauce formulations were moisture (61.23% ± 0.01 for Sample I, 63.66% ± 0.04 for Sample III), fats (16.65% ± 0.02 for Sample I, 17.03% ± 0.08 for Sample III), and carbohydrates (14.32% ± 0.02 for Sample I, 10.47% ± 0.08 for Sample III).

These findings align with the ingredient composition, as the sauce is an oil-in-water emulsion, where oil droplets from vegetable oil are dispersed in the continuous water phase (Ren *et al.*, 2022). The primary source of carbohydrates in the sauce is derived from polysaccharides such as gum Arabic (Tiamiyu *et al.*, 2023), carboxymethyl cellulose (Huang *et al.*, 2024), and pectin released from the cell walls of fruits, including chilies and Liposu fruit, during the cooking process (Gunter *et al.*, 2023).

The ash content of Liposu sauce Sample I and Sample III showed statistical significance between sample types (Table 11), likely due to the inclusion of Liposu fruit and red chili in Sample III. This finding is consistent with previous proximate analyses of Liposu fruit, which reported high mineral content, particularly potassium (126 mg/100g), followed by calcium, magnesium, zinc, and phosphorus (Mojulat & Surugau, 2021). Similarly, a study on red chilies also reported significant levels of phosphorus, magnesium, and calcium (Ananthan *et al.,* 2014).

The crude fiber content of Liposu sauce formulations I and III also exhibited statistical significance. While the results were lower than those reported in previous studies, formulation III still had significantly higher fiber content than formulation I, despite the straining process used during production to remove plant fibers. This discrepancy may be explained by the kitchen sieve used in production, where smaller plant fiber particles could pass through the mesh due to inconsistent blending during homogenization. For reference, Liposu fruit contains 2.2% fiber per 100g of edible portion, while chilies range from 4.65% to 6.15% (Ananthan *et al.*, 2014; Mojulat & Surugau, 2021).

The pH value of Liposu sauce Sample I and III also showed statistical significance (Table 11), which can be attributed to the presence of Liposu fruit in Sample III. Previous studies report that Liposu fruit has a pH ranging from 3 (Liposu extract) to 4 (Liposu fruit) (Purnomo *et al.*, 2014). Additionally, Liposu fruit contains 2.739% acetic acid, which contributes to its acidity. Acetic acid, a weak organic acid, dissociates in water, increasing the concentration of acetate ions as the amount of acetic acid rises in Sample III, explaining the observed pH difference.

The three primary constituents of both Liposu sauce formulations were water (potable water), oil (vegetable oil), and carbohydrates (gum Arabic, carboxymethyl cellulose (CMC), and released pectin). The ash content of Liposu sauce formulation III was predominantly composed of essential elements such as potassium (K), zinc (Zn), magnesium (Mg), calcium (Ca), and phosphorus (P). The crude fiber content in formulation III exhibited variability, potentially due to technical factors such as prolonged blending, which may have reduced the particle size of plant fiber, allowing them to pass through the sieve during filtration. The lower pH value of Sample III was attributed to the presence of acetic acid in the Liposu fruit, which, upon the sauce mixture, undergoes partial dissociation in water, thereby lowering the pH.

4. Conclusion

This study demonstrated the potential of Liposu fruit in the development of a novel fruit-based condiment, with Formulation III identified as the most preferred based on sensory evaluation, nutritional content, and physicochemical properties. The formulation's appealing red color, natural acidity from acetic acid, and rich mineral composition—including potassium, phosphorus, magnesium, and calcium—contribute to both its sensory quality and nutritional value. Compared to similar fruit-based sauces such as tamarind chutneys or mango relishes, Liposu sauce shows competitive advantages and promising commercial potential, particularly as a unique, locally sourced product. Nevertheless, challenges such as emulsion instability, microbial safety, and limited technical data on the Liposu fruit must be addressed. Future research should explore the use of natural preservatives, improved homogenization techniques, and expanded sensory testing involving a wider consumer base. Additionally, microbiological studies could determine the sauce's shelf stability and potential antimicrobial effects. Despite these limitations, the findings suggest that Liposu-based products could support food innovation, promote the use of underutilized local fruits, and offer economic benefits to rural communities while introducing this exotic ingredient to broader markets.

Acknowledgment

The authors would like to express their appreciation to the Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, for facilitating this study. Special thanks are extended to the researchers for their cooperation and valuable contributions to this work.

References

Abdul Karim, S. M., Abdul Rashid, S. S., Adzahan, N., & Camillo, A. A. (2011). Consumers' perspective towards malaysian traditional food: Journal of Agribusiness Marketing, 4, 68–92. http://psasir.upm.edu.my/id/eprint/24150

Abu Bakar, M. F., Ahmad, N. E., Karim, F. A., & Saib, S. (2014). Phytochemicals and antioxidative properties of borneo indigenous liposu (Baccaurea lanceolata) and tampoi (Baccaurea macrocarpa) fruits. Antioxidants, 3(3), 516–525. https://doi.org/10.3390/antiox3030516

Ahouagi, V. B., Mequelino, D. B., Tavano, O. L., Garcia, J. A. D., Nachtigall, A. M., & Vilas Boas, B. M. (2021a). Physicochemical characteristics, antioxidant activity, and acceptability of strawberry-enriched ketchup sauces. In Food Chemistry (Vol. 340). https://doi.org/10.1016/j.foodchem.2020.127925

Ajibola, O. O., Thomas, R., & Bakare, B. F. (2023). Selected fermented indigenous vegetables and fruits from Malaysia as potential sources of natural probiotics for improving gut health. In Food Science and Human Wellness (Vol. 12, Issue 5, pp. 1493–1509). https://doi.org/10.1016/j.fshw.2023.02.011

Ananthan, R., Subash, K., & Longvah, T. (2014). Assessment of Nutrient Composition and Capsaicinoid Content of Some Red Chilies R. International Conference on Food and Nutrition Technology, 72(1), 2–5. https://doi.org/10.7763/IPCBEE. 2014. V72.1

AOAC International. (2000). Official methods of analysis of AOAC International (Vol. 17, No. 1-2). AOAC international.

Astuti, M. D., Ana, W. F., Rosyidah, K., & Rodiansono. (2020). The antioxidant activity of white kapul (Baccaurea macrocarpa) fruit rinds. IOP Conference Series: Materials Science and Engineering, 980(1). https://doi.org/10.1088/1757- 899X/980/1/012040

Awang, K., Shukri, M., & Ali, M. (2018). Diversity, distribution and conservation of Baccaurea species in the home gardens and orchards in Malaysia. September.

Belović, M., Torbica, A., Pajić Lijaković, I., Tomić, J., Lončarević, I., & Petrović, J. (2018). Tomato pomace powder as a raw material for ketchup production. In Food Bioscience (Vol. 26, pp. 193–199). https://doi.org/10.1016/j.fbio.2018.10.013

Cárdenas-Castro, A. P., Perales-Vázquez, G. del C., De la Rosa, L. A., Zamora-Gasga, V. M., Ruiz-Valdiviezo, V. M., Alvarez-Parrilla, E., & Sáyago-Ayerdi, S. G. (2019). Sauces: An undiscovered healthy complement in Mexican cuisine. International Journal of Gastronomy and Food Science, 17(February). https://doi.org/10.1016/j.ijgfs.2019.100154

Csapó, J., Albert, C., & Szigeti, T. J. (2019). Functional foods. Elelmiszervizsgalati Kozlemenyek, 65(1), 2349–2360. https://doi.org/10.14302/issn.2379-7835.ijn-19-2615

Cushnie, T. P. T., Cushnie, B., & Lamb, A. J. (2014). Alkaloids: An overview of their antibacterial, antibiotic-enhancing and antivirulence activities. International Journal of Antimicrobial Agents, 44(5), 377–386. https://doi.org/10.1016/j.ijantimicag.2014.06.001

da Silva, M. M., Lemos, T. de O., Rodrigues, M. do C. P., de Araújo, A. M. S., Gomes, A.M. M., Pereira, A. L. F., Abreu, V. K. G., Araújo, E. dos S., & Andrade, D. de S. (2021). Sweet-and-sour sauce of assai and unconventional food plants with functional properties: An innovation in fruit sauces. International Journal of Gastronomy and Food Science, 25. https://doi.org/10.1016/j.ijgfs.2021.100372

Dipti, S., Kumari, A., Kaur, N., Tripathi, A. D., & Agarwal, A. (2023). Development of cake by using persimmon fruit (Diospyros kaki) as a fat replacer and its chemical and structural profile analysis. Lwt, 178. https://doi.org/10.1016/j.lwt.2023.114601

Drewnowski, A., Mennella, J. A., Johnson, S. L., & Bellisle, F. (2012). Sweetness and food preference. Journal of Nutrition, 142(6), 1142–1148. https://doi.org/10.3945/jn.111.149575

Fitriansyah, S. N., Putri, Y. D., Haris, M., & Ferdiansyah, R. (2018). Aktivitas Antibakteri Ekstrak Etanol Buah, Daun, Dan Kulit Batang Limpasu (Baccaurea lanceolata (Miq.) Müll.Arg.) dari Kalimantan Selatan. In PHARMACY: Jurnal Farmasi Indonesia (Pharmaceutical Journal of Indonesia) (Vol. 15, Issue 2, p. 111). https://doi.org/10.30595/pharmacy.v15i2.3062

Fonseca, J. V. dos S., Batista, J. D. F., de Oliveira, M. C., Diniz, N. C. M., Lima, M. dos S., Madruga, M. S., Magnani, M., & Borges, G. da S. C. (2021a). Low-fat and rich- fibers macauba (Acrocomia spp.) sauces: Physical and oxidative stability, nutritional quality and sensory characteristics. In Food Bioscience (Vol. 43). https://doi.org/10.1016/j.fbio.2021.101272

Food Regulations 1985 (Regulation 339 Rev. 2020), Malaysia. https://hq.moh.gov.my/fsq/peraturanperaturan-makanan-1985

Füchtbauer, S., Mousavi, S., Bereswill, S., & Heimesaat, M. M. (2021). Antibacterial properties of capsaicin and its derivatives and their potential to fight antibiotic resistance – A literature survey. European Journal of Microbiology and Immunology, 11(1), 10–17. https://doi.org/10.1556/1886.2021.00003

Galappathie, S., Palombo, E. A., Yeo, T. C., Ley, D. L. S., Tu, C. L., Malherbe, F. M., & Mahon, P. J. (2014). Comparative antimicrobial activity of South East Asian plants used in Bornean folkloric medicine. In Journal of Herbal Medicine (Vol. 4, Issue 2, pp. 96–105). https://doi.org/10.1016/j.hermed.2014.03.001

Gharibzahedi, S. M. T., Mousavi, S. M., Hamedi, M., Khodaiyan, F., & Razavi, S. H. (2012). Development of an optimal formulation for oxidative stability of walnut- beverage emulsions based on gum arabic and xanthan gum using response surface methodology. In Carbohydrate Polymers (Vol. 87, Issue 2, pp. 1611–1619). https://doi.org/10.1016/j.carbpol.2011.09.067

Gruère, G. P., Giuliani, A., & Smale, M. (2011). Marketing Underutilized Plant Species for the Benefit of the Poor: A Conceptual Framework. In SSRN Electronic Journal. https://doi.org/10.2139/ssrn.916572

Gruère, G., Giuliani, A., & Smale, M. (2006). Marketing Underutilized Plant Species for the Benefit of the Poor : A Conceptual Framework. June. https://doi.org/10.2139/ssrn.916572

Gunawan, Anwar, K., Gafur, A., Hilaliyah, R., Waro, A. A., Hikmah, N., Sakinah, Erwansyah, M., Susilawati, D., Lestari, R. D., & Triana, D. (2023). Predicting the current potential geographical distribution of Baccaurea (B. lanceolata and B. motleyana) in South Kalimantan, Indonesia. Biodiversitas, 24(2), 930–939. https://doi.org/10.13057/biodiv/d240232

Gunter, E. A., Melekhin, A. K., Belozerov, V. S., Martinson, E. A., & Litvinets, S. G. (2023). Preparation, physicochemical characterization and swelling properties of composite hydrogel microparticles based on gelatin and pectins with different structure. International Journal of Biological Macromolecules, 258(December 2023), 128935. https://doi.org/10.1016/j.ijbiomac.2023.128935

Huang, L., Chen, Y., Ding, S., Qu, L., He, R., & Dai, C. (2024). Emulsification and encapsulation properties of conjugates formed between whey protein isolate and carboxymethyl cellulose under acidic conditions. Food Chemistry, 430(July 2023). https://doi.org/10.1016/j.foodchem.2023.136995

Ismanto, A., Khizanatusani, L., Haris, Muh. I., Indana, K., & Wibowo, A. (2022). The Effect of Addition Lempahong (Baccaurea lanceolata) Fruit Extract on pH, Organoleptic, and Antioxidants of the Making Yoghurt . Proceedings of the International Conference on Tropical Agrifood, Feed and Fuel (ICTAFF 2021), 17(Ictaff 2021), 224–228. https://doi.org/10.2991/absr.k.220102.033

Purnomo, L. J., Nuryati, N., & Fatimah, F. (2014). Pemanfaatan Buah Limpasu (Baccaurea lanceolata) Sebagai Pengental Lateks Alami. Jurnal Teknologi Agro-Industri, 1(1), 24-32. https://doi.org/10.34128/jtai.v1i1.27

Jinap, S., Ilya-Nur, A. R., Tang, S. C., Hajeb, P., Shahrim, K., & Khairunnisak, M. (2010). Sensory attributes of dishes containing shrimp paste with different concentrations of glutamate and 5′-nucleotides. In Appetite (Vol. 55, Issue 2, pp. 238–244). https://doi.org/10.1016/j.appet.2010.06.007

S., Roh, S. W., & Lee, S. H. (2018). Role of jeotgal, a Korean traditional fermented fish sauce, in microbial dynamics and metabolite profiles during kimchi fermentation. In Food Chemistry (Vol. 265, pp. 135–143). https://doi.org/10.1016/j.foodchem.2018.05.093

Kamerow, D. (2004). Food, functional food. Bmj, 328(7440), E277. https://doi.org/10.1136/bmj.328.7440.E277

Kim, K. H., Chun, B. H., Kim, J., & Jeon, C. O. (2021). Identification of biogenic amine- producing microbes during fermentation of ganjang, a Korean traditional soy sauce, through metagenomic and metatranscriptomic analyses. In Food Control (Vol. 121). https://doi.org/10.1016/j.foodcont.2020.107681

Li, C., Li, W., Li, L., Chen, S., Wu, Y., & Qi, B. (2022). Microbial community changes induced by a newly isolated salt-tolerant Tetragenococcus muriaticus improve the volatile flavor formation in low-salt fish sauce. In Food Research International (Vol. 156). https://doi.org/10.1016/j.foodres.2022.111153

Mahdavi, B., Yaacob, W. A., & Din, L. B. (2017). Chemical composition, antioxidant, and antibacterial activity of essential oils from Etlingera sayapensis A.D. Poulsen & Ibrahim. In Asian Pacific Journal of Tropical Medicine (Vol. 10, Issue 8, pp. 819– 826). https://doi.org/10.1016/j.apjtm.2017.08.006

Martínez-Huélamo, M., Tulipani, S., Estruch, R., Escribano, E., Illán, M., Corella, D., & Lamuela-Raventós, R. M. (2015). The tomato sauce making process affects the bioaccessibility and bioavailability of tomato phenolics: A pharmacokinetic study. In Food Chemistry (Vol. 173, pp. 864–872). https://doi.org/10.1016/j.foodchem.2014.09.156

Mojulat, M. B. C., & Surugau, N. (2021). A review on benefits, potential and conservation of Baccaurea lanceolata. IOP Conference

Series: Earth and Environmental Science, 736(1). https://doi.org/10.1088/1755-1315/736/1/012042

Nguyen, A., Sekar, A., Kim, M., Nguyen, L., Le, N., Uh, S., Hong, S., & Kim, K. (2021). Fish sauce fermentation using Marinococcus halotolerans SPQ isolate as a starter culture. Food Science & Nutrition, 9(2), 651–661. https://doi.org/10.1002/fsn3.2024

Ren, Z., Li, X., Ma, F., Zhang, Y., Hu, W., Khan, M. Z. H., & Liu, X. (2022). Oil-in-water emulsions prepared using high-pressure homogenisation with Dioscorea opposita mucilage and food-grade polysaccharides: guar gum, xanthan gum, and pectin. In Lwt (Vol. 162). https://doi.org/10.1016/j.lwt.2022.113468

Ringkamp, M., & Meyer, R. A. (2008). Physiology of Nociceptors. The Senses: A Comprehensive Reference, 5, 97–114. https://doi.org/10.1016/B978-012370880-9.00146-8

Schieber, A., & Weber, F. (2016). Handbook of Natural Pigmentation Food and Beverage. https://doi.org/https://doi.org/10.1016/B978-0-08-100371-8.00005-1

Spence, C. (2015). Visual contributions to taste and flavour perception. Colour Additives for Foods and Beverages, 2011, 190–210. https://doi.org/10.1016/B978-1-78242- 011-8.00007-6

Surya, R., & Tedjakusuma, F. (2022). Diversity of sambals, traditional Indonesian chili pastes. Journal of Ethnic Foods, 9(1). https://doi.org/10.1186/s42779-022-001427

Tiamiyu, Q. O., Adebayo, S. E., & Yusuf, A. A. (2023). Gum Arabic edible coating and its application in preservation of fresh fruits and vegetables: A review. Food Chemistry Advances, 2(September 2022). https://doi.org/10.1016/j.focha.2023.100251

Torbica, A., Belović, M., Mastilović, J., Kevrešan, Ž., Pestorić, M., Škrobot, D., & Dapčević Hadnadev, T. (2016). Nutritional, rheological, and sensory evaluation of tomato ketchup with increased content of natural fibres made from fresh tomato pomace. In Food and Bioproducts Processing (Vol. 98, pp. 299–309). https://doi.org/10.1016/j.fbp.2016.02.007

Uribe-Wandurraga, Z. N., Igual, M., Rufino, R. G. de, Savall, C., García-Segovia, P., & Martínez-Monzó, J. (2021). Physicochemical and rheological characterisation of microalgae-enriched ketchups and their sensory acceptability. In International Journal of Gastronomy and Food Science (Vol. 26). https://doi.org/10.1016/j.ijgfs.2021.100424

Walter, H. S. (2004). The mismeasure of islands: implications for biogeographical theory and the conservation of nature. Journal of Biogeography, 31(2), 177-197. https://doi.org/10.1046/j.0305-0270.2003.00989.x

Velasco, C., Barbosa Escobar, F., Spence, C., & Olier, J. S. (2023). The taste of colours. Food Quality and Preference, 112(July). https://doi.org/10.1016/j.foodqual.2023.105009

Yan, S., Regenstein, J. M., Zhang, S., Huang, Y., Qi, B., & Li, Y. (2023). Edible particle- stabilized water-in-water emulsions: Stabilization mechanisms, particle types, interfacial design, and practical applications. In Food Hydrocolloids (Vol. 140, p. 108665). https://doi.org/10.1016/j.foodhyd.2023.108665

Zhao, G., Ding, L. L., Yao, Y., Cao, Y., Pan, Z. H., & Kong, D. H. (2018). Extracellular proteome analysis and flavor formation during soy sauce fermentation. Frontiers in Microbiology, 9(AUG), 1–7. https://doi.org/10.3389/fmicb.2018.01872

Zhao, Y., Chen, F., & Wang, Y. (2023). Demulsification of peanut emulsion by aqueous enzymatic extraction using a combination of oleic and citric acids. In Lwt (Vol. 180). https://doi.org/10.1016/j.lwt.2023.114658

Zhou, K., Zhang, X., Huang, G. D., Hongsibsong, S., Hao, G., Li, Y. man, Yang, J. yuan, & Xu, Z. L. (2023). Formation of biogenic amines in soy sauce and reduction via simple phytochemical addition. In Lwt (Vol. 176). https://doi.org/10.1016/j.lwt.2023.114542