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PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERIZATION OF SHRIMP AND ANCHOVY PASTE FROM WEST NUSA TENGGARA

[Karakterisasi Fisikokimia dan Mikrobiologis Terasi dari Nusa Tenggara Barat]

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ABSTRACT

Shrimp anchovy paste is a traditional fermented condiment widely consumed in Asia. Regional variation in raw material selection and processing practice may affect physicochemical composition and microbial ecology, with implications for quality and safety. This study characterized the physicochemical and microbiological properties of shrimp anchovy paste produced in Sumbawa, East Lombok, and Central Lombok. Samples were analysed for proximate composition, texture, colour, amino acid profile, total plate count, lactic acid bacteria enumeration, and cell morphology. Statistical differences were evaluated by one way analysis of variance and Duncan multiple range test using SPSS version 26. Moisture content increased from Sumbawa (37.83%) to East Lombok (43.25%) and Central Lombok (46.17%). Ash content was highest in Sumbawa (28.09%) and lowest in Central Lombok (18.27%). Protein was substantially lower in East Lombok (12.96%) compared with Sumbawa (23.23%) and Central Lombok (23.05%). Fat and instrumental hardness did not differ significantly among regions. Amino acid analysis identified glutamic acid as the dominant free amino acid, most abundant in Central Lombok (25685 ppm) and Sumbawa (23560 ppm). Microbiological profiling indicated the highest total plate count in Sumbawa (2.79 log CFU/mL) and the highest lactic acid bacteria count in East Lombok (2.57 log CFU/mL). Cell morphology revealed Gram negative bacilli in Sumbawa and Gram positive bacilli in East and Central Lombok. Regional differences in raw material ratio, salt application, drying regime, and microbial succession drive variation in composition and microbiology of shrimp anchovy paste.

Keywords: Lactic acid bacteria, microbiological profile, physicochemical properties, shrimp anchovy paste

ABSTRAK

Terasi merupakan bumbu fermentasi tradisional yang banyak dikonsumsi di kawasan Asia. Variasi regional dalam pemilihan bahan baku dan praktik pengolahan dapat memengaruhi komposisi fisikokimia serta ekologi mikroba, yang pada akhirnya berdampak pada mutu dan keamanan produk. Penelitian ini melihat karakterisasi sifat fisikokimia dan mikrobiologis terasi yang diproduksi di Sumbawa, Lombok Timur, dan Lombok Tengah. Analisis yang dilakukan adalah analisis proksimat terhadap komposisi, tekstur, warna, profil asam amino, total plate count, enumerasi bakteri asam laktat, serta morfologi sel. Kadar air meningkat dari Sumbawa (37,83%), Lombok Timur (43,25%), dan Lombok Tengah (46,17%). Kadar abu tertinggi ditemukan pada sampel dari Sumbawa (28,09%) dan terendah dari Lombok Tengah (18,27%). Kadar protein jauh lebih rendah pada Lombok Timur (12,96%) dibandingkan Sumbawa (23,23%) dan Lombok Tengah (23,05%). Kadar lemak dan kekerasan tekstur tidak menunjukkan perbedaan nyata antar daerah. Analisis asam amino mengidentifikasi asam glutamat sebagai asam amino bebas dominan, dengan konsentrasi tertinggi pada Lombok Tengah (25.685 ppm) dan Sumbawa (23.560 ppm). Profil mikrobiologis menunjukkan total plate count tertinggi pada Sumbawa (2,79 log CFU/mL) dan jumlah bakteri asam laktat tertinggi pada Lombok Timur (2,57 log CFU/mL). Morfologi sel menunjukkan terdapat bakteri berbentuk batang gram negatif pada sampel yang berasal dari Sumbawa, serta bakteri berbentuk batang gram positif pada sampel Lombok Timur dan Lombok Tengah. Perbedaan regional dalam proporsi bahan baku, aplikasi garam, pengeringan, dan suksesi mikroba menjadi faktor utama penyebab variasi komposisi dan karakter mikrobiologi terasi.

Kata Kunci: *Bakteri asam laktat, profil mikrobiologis, sifat fisikokimia, terasi*

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INTRODUCTION

Shrimp-anchovy paste is one of the most widely recognized fermented products in Asia, traditionally prepared from crushed shrimp or small fish that undergo fermentation (Amalia et al., 2018; Hudayati et al., 2021; Wahono et al., 2022). The fermentation process extends shelf life, enhances flavor, and contributes to color development (Rahman et al., 2023). This paste functions as a seasoning with a distinctive strong aroma and dense texture and is commonly used in Indonesian cuisine as both a cooking condiment and a source of umami taste (Parvaneh & Jinap, 2013). Similar products are known across Asia, including belacan in Malaysia, bagoong-alamang in the Philippines, ka-pi in Thailand, nga-pi in Myanmar, mam-ruoc in Vietnam, xia-jiang in China, and sae woo-jeot in Korea (Herlina & Setiarto, 2024; Parvaneh & Jinap, 2013; Thanh & Anh, 2016).

Although production methods are generally similar throughout Asia, practices in Indonesia show distinctive regional adaptations, particularly in Lombok and Sumbawa. The production process generally involves washing, sun-drying, pounding, mixing with additives, molding, and fermentation, though methods vary across Indonesia. In Sumbawa, raw materials are not washed and drying is performed only after fermentation, while in Lombok they are washed with brine and drying occurs both before and after fermentation (Handayani et al., 2021; Helmi et al., 2022; Surya et al., 2024; Wahono et al., 2022). In some regions, mixtures of shrimp and anchovies are incorporated, producing shrimp–anchovy paste. Its characteristics are shaped by raw material type, salt concentration, microbial communities, and processing variations. Wahono et al. (2022) reported that salt type strongly influences color, taste, and lactic acid bacteria development. Helmi et al. (2022) further showed that drying frequency has greater impact on quality than raw material type. For instance, shrimp–anchovy paste from Sumbawa, with a single drying stage, has higher salt levels and a stronger salty taste, while pastes from Java and Kalimantan, which undergo two drying stages, tend to develop a slightly bitter taste. Surya et al. (2024) found that a 50:50 shrimp–anchovy mixture yields superior aroma, flavor, and texture compared to pastes made solely from shrimp or fish. Handayani et al. (2021), studying six small-scale producers in Lombok, also identified significant variations in texture, color, and moisture content. These studies collectively show that the composition of raw materials and processing stages have a strong influence on the physicochemical and sensory properties of shrimp paste, but little is known about the combined effects of both in shrimp-anchovy mixed products.

Despite its popularity in West Nusa Tenggara, studies on shrimp–anchovy paste remain limited, particularly concerning the relationship between raw material composition, processing methods, and product quality. Therefore, this research aims to characterize the microbial and physicochemical properties of shrimp–anchovy paste produced in West Nusa Tenggara.

MATERIAL AND METHOD

Materials

Shrimp–anchovy paste samples were obtained directly from traditional producers in three major producing regions of West Nusa Tenggara: East Lombok, Central Lombok, and Sumbawa. Each sample weighed approximately 300 grams and reflected the distinctive local formulations and processing practices. Specifically, samples were collected from Dusun Jor, Jeroaru Village, Jeroaru Subdistrict, East Lombok Regency; Telok, Mangkung Village, Praya Barat Subdistrict, Central Lombok Regency; and Labuhan Bontong Village, Empang Subdistrict, Sumbawa Regency. Additional materials included sodium chloride solution (0.85%), Plate Count Agar (PCA), De Man Rogosa Sharpe Agar (MRSA), De Man Rogosa Sharpe Broth (MRSB) with sodium chloride concentrations of 4% and 6.5%, buffer solutions, Gram staining reagents such as crystal violet and safranin, physiological solution, distilled water, and standard buffer solutions with pH values of 4.00 and 7.00. Reagents for amino acid analysis using HPLC consisted of hydrochloric acid (6 N), sodium hydroxide (6 N), orthophthalaldehyde (OPA), methanol, sodium acetate (50 mM, pH 6.8), tetrahydrofuran, and Whatman 0.2 μm filter paper.

The equipment employed included a Texture Analyzer TA-XT2i with probe P75, a Chromameter CR 300 (Minolta, Japan), a High Performance Liquid Chromatography (HPLC) system equipped with an injector, a LiChrospher 100 RP-18 (5 µm) column, and a Thermo Dionex UltiMate 3000 RS Fluorescence Detector (excitation at 300 nm and emission at 500 nm). Additional instruments comprised a calibrated pH meter, mortar and pestle, vortex mixer, incubators maintained at 35 °C and 37 °C, a compound microscope with 1000× magnification, micropipettes, glass slides, test tubes with serial dilution apparatus, a colony counter, and general laboratory glassware.

Texture Profile Analysis

Texture profile analysis (TPA) was conducted using a Texture Analyzer TA-XT2i following the procedure of Khiari et al., (2013). Each sample was cut into uniform dimensions of 1.5 cm × 1 cm × 1.2 cm. A cylindrical probe P75 was used to compress the sample twice. The measurement settings were: pre-speed 2 mm s^{-1}, test speed 1 mm s^{-1}, post-speed 2 mm s^{-1}, compression time 3.00 s, compression distance 30%, and trigger force 0.067 N. Each analysis was carried out with five replications.

Color Analysis

Color measurement was performed using a Chromameter CR-300 (Minolta, Japan). The Hunter L*, a*, and b* values were recorded to determine the lightness, redness–greenness, and yellowness–blueness of the samples. Three readings were taken from different points of each sample to ensure representativeness (Konzen & Tsai, 2014)

Proximate Composition

Proximate analysis was conducted according to the methods of the Association of Official Analytical Chemists ([AOAC] Association of Official Analytical Chemist, 2005). The analyses included moisture (oven drying), protein (Kjeldahl), fat (soxhlet), and ash content. Each determination was performed in duplicate.

Total Plate Count (TPC)

The total plate count was determined following the method of Maturin & Peeler (2001) with modifications in sample preparation. One gram of shrimp-anchovy paste was homogenized in 9 mL of 0.85% NaCl solution using a mortar and vortex mixer. Serial dilutions were prepared up to 10^{-5}. From each dilution (10^{-1} to 10^{-5}), 0.1 mL aliquots were spread on Plate Count Agar (PCA). The inoculated plates were incubated at 35 °C for 48 h, and the colonies that developed were enumerated. Only plates containing 25–250 colonies were considered valid for counting. All analyses were performed in triplicate.

Isolation of Lactic Acid Bacteria (LAB)

Lactic acid bacteria were isolated according to (Amalia et al., 2018) with modifications. Twenty-five grams of shrimp-anchovy paste were homogenized in 225 mL of buffer solution using a vortex mixer. Serial dilutions up to 10^{-5} were prepared, and aliquots from the last three dilutions were pour-plated on de Man Rogosa and Sharpe Agar (MRSA). Plates were incubated at 37 °C for 48 h.

Gram Staining

Gram staining was conducted to characterize bacterial isolates (Giyatno & Retnaningrum, 2020). Pure isolates were smeared on glass slides, heat-fixed, and stained with crystal violet. Slides were rinsed, counterstained with safranin, washed, air-dried, and observed under a light microscope at 1000× magnification. Gram-positive bacteria were identified by purple coloration.

Data Analysis

A one-way analysis of variance (ANOVA) at a 95 percent confidence level was employed to evaluate differences in physical, chemical, and total microbial parameters. When significant effects were detected, Duncan's multiple range test (DMRT) was applied as a post hoc comparison. All statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Illinois, USA).

RESULT AND DISCUSSION

Moisture Content of Shrimp–Anchovy Paste

The variation in moisture content of shrimp–anchovy paste (Figure 1) across the three districts Sumbawa (37.83%), East Lombok (43.25%), and Central Lombok (46.17%) is statistically significant ($p < 0.05$). Although all producers employed traditional open-air sun-drying, regional variations in ambient temperature, relative humidity, and wind speed can still influence the rate of water loss. Previous studies on fermented shrimp-anchovy paste have shown that even under similar drying methods, higher ambient humidity and lower wind velocity can slow evaporation, resulting in higher residual moisture (Agustini et al., 2021; Lamsyehe et al., 2021; Wahdayani et al., 2021; Wiskito, 2022). In this context, the relatively drier and windier conditions in Sumbawa may have facilitated faster dehydration compared to the more humid environments of East and Central Lombok, The relative humidity in Sumbawa Island ranges from 39% to 98%, which is generally lower than the national average for Indonesia (typically around 75–85%). In contrast, Lombok Island records consistently higher relative humidity, ranging from 52% to 100%, with an annual mean of approximately 78–79% (Stasiun Meteorologi NTB, 2025). Notably, the Indonesian National Standard (SNI 2716:2016) specifies a maximum moisture content of 35% for solid block shrimp paste, indicating that the products from all three regions exceeded the recommended threshold (BSN, 2016).

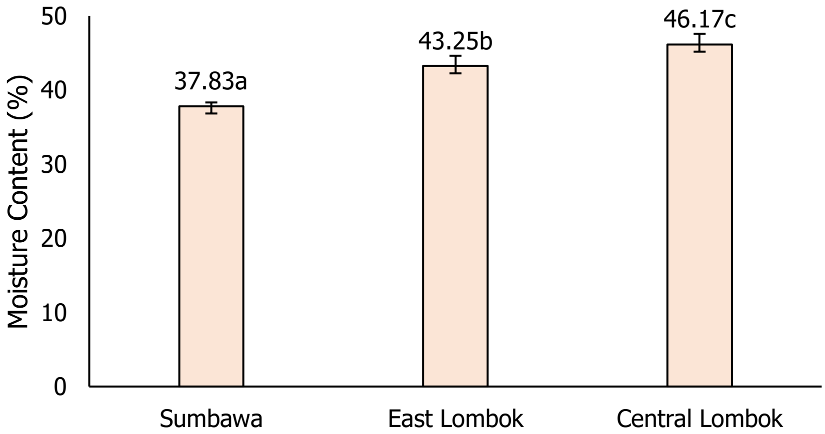

Figure 1. Moisture Content of Shrimp-Anchovy Paste

Beyond environmental factors, differences in the composition of the shrimp–fish mixture, initial moisture content of the raw materials, and salt concentration during fermentation may also contribute to the observed variation. The ratio of shrimp to fish affects muscle structure and water-binding capacity, while higher salt levels promote osmotic dehydration, reducing final moisture content (Anggo et al., 2014). Metabolite and microbial studies on salted shrimp and mixed shrimp fish pastes showed that raw material composition and fermentation regime influence proteolysis and water retention, which in turn affect moisture and quality outcomes (Lim et al., 2023; Surya et al., 2024).

Ash Content of Shrimp–Anchovy Paste

The ash content of shrimp–fish paste differed significantly among the three districts (Figure 2), with the highest value in Sumbawa (28.09%), followed by East Lombok (22.41%), and the lowest in Central Lombok (18.27%) ($p < 0.05$). As all producers used traditional open-air drying, the variation is more likely linked to differences in raw material characteristics and environmental conditions during processing. Ash quantifies the inorganic residue remaining after combustion and increases with greater salt addition and higher proportions of mineral-rich fractions such as bones and whole anchovy tissue; conversely, intensive washing, decalcification, or selective use of shrimp muscle reduce the mineral fraction retained (Chan et al., 2023; Herlina & Setiarto, 2024; Surya et al., 2024). Compared with previous reports, the ash content observed in this study is markedly higher. For instance Anggo et al., (2014) reported ash levels of 6–12% in Indonesian shrimp paste, while Wahono et al., (2022) found values ranging from 8–15% depending on salt concentration and raw material type. These values are also far above the maximum limit of 1.5% specified by the Indonesian National Standard (SNI 2716:2016), demonstrating that all products analyzed in this study exceeded the regulatory threshold. Possible drivers of variation include differences in raw material composition and processing practices; however, the shrimp–fish ratio and salt concentration were not recorded in this study and therefore cannot be confirmed. Environmental factors such as salinity, water chemistry, and feeding ecology may also influence mineral composition (Wahdayani et al., 2021), while regional differences in traditional formulations such as the inclusion of mineral rich additives like palm sugar or seaweed have been reported to alter ash content (Wiskito, 2022).

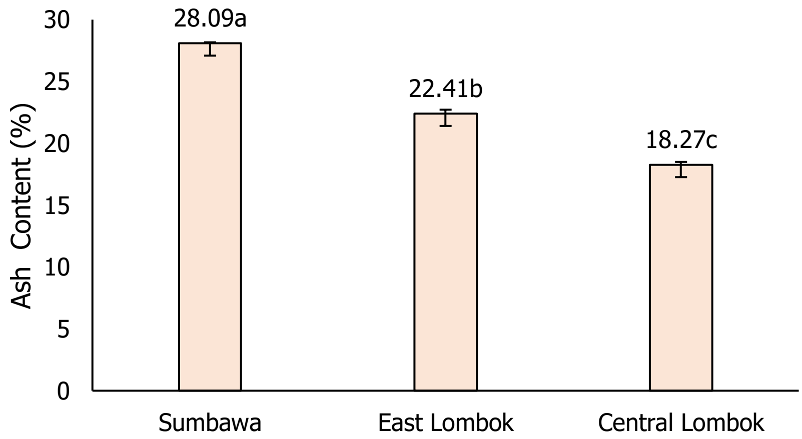

Figure 2. Ash Contentof Shrimp-Ancovy Paste

Fat Content of Shrimp–Anchovy Paste

The fat content of shrimp–anchovy paste showed no significant variation among the three districts (Figure 3), with values of 9.89% in Sumbawa, 9.82% in East Lombok, and 10.45% in Central Lombok ($p > 0.05$). This uniformity indicates that lipid levels are largely determined by the intrinsic composition of shrimp and anchovy rather than by regional environmental or processing differences. In fermented seafood products, lipids are generally retained during fermentation and drying, although some hydrolysis into free fatty acids may occur due to endogenous and microbial lipases, influencing flavor and oxidative stability. Minor fluctuations may arise from differences in species composition, the proportion of lipid-rich tissues such as viscera or skin, and handling practices like washing or trimming, which can remove surface oils. The aquatic environment where raw materials are harvested particularly water temperature, salinity, and diet can also influence lipid profiles, but such effects are typically less pronounced than those on moisture or ash content. Existing studies confirm that fat levels in shrimp-based pastes remain relatively stable when similar raw materials and drying methods are used (Chan et al., 2023; Herlina & Setiarto, 2024; Lim et al., 2023; Surya et al., 2024).

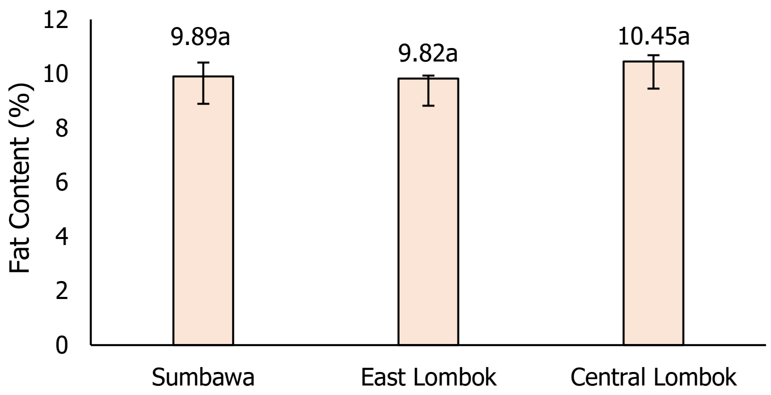

Figure 3. Fat Content of Shrimp-Ancovy Paste

Protein Content of Shrimp-Anchovy paste

The protein content of shrimp–fish paste varied significantly among the three districts (Figure 4), with Sumbawa (23.23%) and Central Lombok (23.05%) forming the higher group, while East Lombok recorded a markedly lower value of 12.96% ($p < 0.05$). This substantial variation reflects the influence of raw material composition and fermentation practices on nutritional quality. The relatively high protein levels in Sumbawa and Central Lombok are likely linked to a greater predominance of shrimp as the primary raw material, as shrimp is recognized for its high-quality protein rich in essential amino acids, contributing both to flavor development and nutritional value (Bhatti et al., 2025; Lopetcharat & Park, 2002). The variation in protein content among regions appears to be closely related to the raw materials used by local producers. Field observations indicated that producers in Sumbawa and Central Lombok predominantly relied on shrimp, while those in East Lombok more frequently incorporated anchovy or other small fish species. Shrimp generally contains around 20–24% protein and is recognized as a high-quality source of essential amino acids (Bhatti et al., 2025; Lopetcharat & Park, 2002), whereas anchovy typically contains about 17–20% protein in fresh form (Anggo et al., 2014; Swastawati et al., 2020; USDA FoodData Central, 2025). These differences in raw material composition are consistent with the observed regional variation in protein levels.

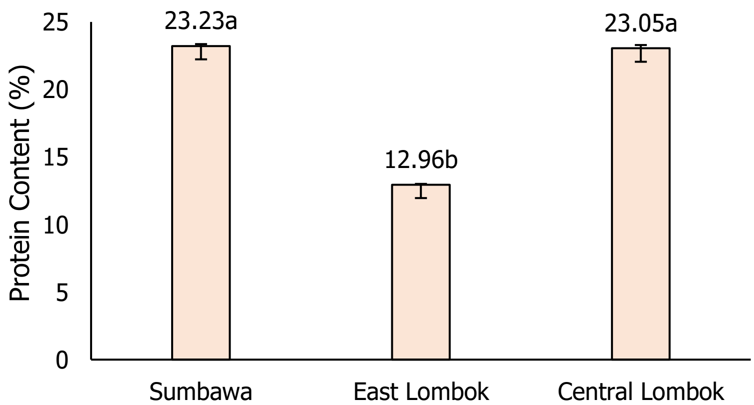

Figure 4. Protein Content of Shrimp-Ancovy Paste

In addition, fermentation conditions may also contribute to protein degradation through proteolysis, while the proportion of muscle versus non-muscle fractions and the presence of carbohydrate- or mineral-rich additives can further influence the final protein content (H. Li et al., 2024; Zhao et al., 2016). Protein levels are also influenced by the proportion of muscle tissue versus non-muscle fractions and by dilution from carbohydrate- or mineral-rich additives. These patterns are consistent with compositional studies of Southeast Asian fermented seafoods, which report that shrimp-based pastes such as terasi and belacan typically contain 20–25% protein, higher than mixed-fish products like bagoong or fish sauces, with variability driven by species composition, salt content, and fermentation duration (Julmohammad et al., 2025). Notably, according to the Indonesian National Standard (SNI 2716:2016), shrimp paste must contain a minimum of 15% protein; thus, the products from Sumbawa and Central Lombok complied with this requirement, whereas the East Lombok samples fell below the standard threshold.

Texture (Hardness) of Shrimp–Anchovy Paste

The hardness of shrimp–anchovy paste produced in Sumbawa (4.40 N), East Lombok (4.15 N), and Central Lombok (4.26 N) did not differ significantly among regions (Figure 5) , as evidenced by overlapping error bars and identical superscript letters ($p > 0.05$). This uniformity in texture suggests that artisanal production methods such as fermentation duration, drying intensity, and manual grinding are relatively consistent across locations, leading to similar development of the protein network that governs hardness. In fermented fish products, texture is strongly influenced by moisture content, protein denaturation, and the extent of proteolysis, all of which modulate structural integrity and firmness (Benjakul et al., 2005; Pongsetkul et al., 2015; Zhang et al., 2015). Because samples were collected as produced, without control of shrimp-to-anchovy ratio or fermentation parameters, variation in raw materials may be masked by overarching process similarity. Additionally, similar moisture contents and protein profiles among regions likely contribute to the homogeneity of hardness (Herlina & Setiarto, 2024).

When related to compositional data, this finding appears somewhat contradictory. Moisture content differed significantly among regions (37.83% in Sumbawa, 43.25% in East Lombok, and 46.17% in Central Lombok), and protein content also varied (higher in Sumbawa and Central Lombok, lower in East Lombok). Generally, higher water content is expected to soften texture, while higher protein levels enhance firmness. However, the hardness values remained statistically similar. This may be explained by the balancing effect of raw materials: anchovy, which is more fragile and structurally softer than shrimp, was more frequently used in East Lombok, while shrimp predominated in Sumbawa and Central Lombok. Thus, the higher moisture in Lombok samples may have been offset by compositional differences, resulting in comparable hardness values across regions. Previous studies have likewise shown that when raw materials, fermentation duration, and drying conditions are consistent, hardness values remain stable across production sites, while sensory traits such as flavor, aroma, and color are more sensitive to regional variation (Handayani et al., 2021; Haris et al., 2024; Helmi et al., 2022; Prihanto et al., 2021).

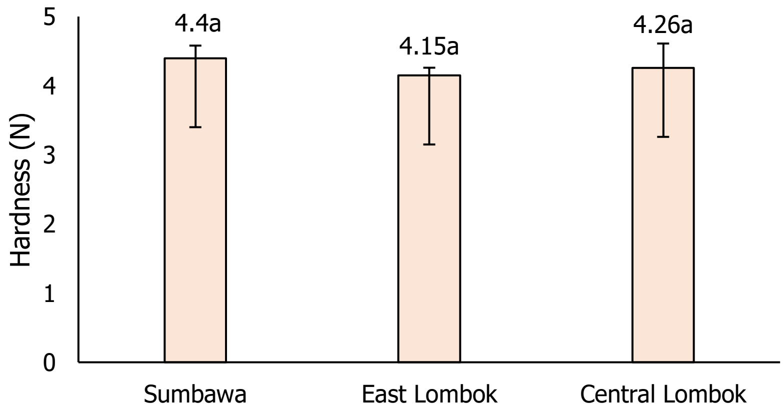

Figure 5. Texture (Hardness) of Shrimp-Ancovy Paste

Amino Acid content of Shrimp–Anchovy Paste

The amino acid profile of shrimp–anchovy (Table 1) paste provides valuable insight into its nutritional quality and flavour potential, as well as the biochemical changes occurring during fermentation. In this study, glutamic acid was the most abundant amino acid across all regions, with concentrations of 235,60 ppm in Sumbawa, 185,40 ppm in East Lombok, and 256,85 ppm in Central Lombok. This predominance is consistent with its role as a major contributor to umami taste, enhancing the savoury flavour characteristic of fermented seafood products (Diani et al., 2025; Pongsetkul et al., 2022). Aspartic acid, another umami-enhancing amino acid, was also present at high levels, ranging from 139,34 ppm in East Lombok to 190,37 ppm in Sumbawa.

Several essential amino acids were detected in appreciable amounts. Lysine, important for protein synthesis and growth, was highest in Sumbawa (182,55 ppm) and Central Lombok (175,40 ppm), but markedly lower in East Lombok (76,31 ppm). Leucine ranged from 105,83 ppm in East Lombok to 146,34 ppm in Central Lombok, while valine varied between 79.11 ppm and 103,85 ppm. Isoleucine followed a similar pattern, with the lowest concentration in East Lombok (57,69 ppm) and the highest in Sumbawa (78,50 ppm). These branched-chain amino acids (BCAAs) contribute to both nutritional value and flavour complexity (Julmohammad et al., 2025).

Table 1. Amino Acids Content of Shrimp–Anchovy Paste

Amino Acids	Shrimp-Anchovy paste (ppm)		
	Sumbawa	East Lombok	Central Lombok
Aspartic acid	190.37	139.34	183.33
Glutamic acid	235.60	185.40	256.85
Serine	64.35	53.60	55.17
Histidine	36.96	34.46	34.22
Glycine	91.79	60.95	71.20
Threonine	70.65	57.40	59.39
Arginine	50.94	55.26	49.68
Alanine	98.93	88.80	102.24
Tyrosine	204.99	144.75	204.59
Methionine	39.56	39.15	39.46
Valine	96.84	79.11	103.85
Phenylalanine	88.73	71.41	83.62
Isoleucine	78.50	57.69	76.51
Leucine	137.21	105.83	146.34
Lysine	182.55	76.31	175.40

Among aromatic amino acids, tyrosine was notably high in Sumbawa (204.99 ppm) and Central Lombok (204,59 ppm) compared to East Lombok (144,75 ppm), while phenylalanine ranged from 714.1 ppm to 887.3 ppm. Non-essential amino acids such as alanine (88,80–102,24 ppm), glycine (60,95–91,79 ppm), and serine (53,60–64,35 ppm) were present in moderate amounts and are known to impart sweet taste notes, balancing the umami profile (Nareswari et al., 2023). Arginine levels were relatively consistent (49,68–55,26 ppm), while methionine content was low but uniform (39,15–39,56 ppm), consistent with its susceptibility to oxidative degradation during processing (Pongsetkul et al., 2022), methionine appears to be a limiting amino acid, consistent with the tendency of sulfur-containing amino acids to be degraded during processing. The regional differences observed may be attributed to variations in shrimp-to-anchovy ratio, raw material freshness, salt concentration, and fermentation duration. East Lombok's generally lower amino acid concentrations this trend is consistent with the significantly lower crude protein content observed in East Lombok samples. Proteolysis, driven by endogenous enzymes and fermentative microbiota, hydrolyses muscle proteins into peptides and free amino acids, enhancing digestibility and flavour (Diani et al., 2025) Salt levels influence microbial succession and enzyme activity, thereby affecting the accumulation of specific amino acids (Pongsetkul et al., 2015, 2022). Overall, the amino acid composition confirms that shrimp–anchovy paste is both a nutrient-dense food and a potent flavour enhancer. The dominance of glutamic and aspartic acids underpins its umami-rich character, while the balanced essential amino acid profile supports its dietary value. These amino acid characteristics indicate that shrimp and anchovy paste can serve not only as a protein-rich seasoning, but also as a natural umami flavor enhancer in food formulations.

Color Characteristics (CIE L^* a^* b^*) of Shrimp–Anchovy Paste

The color characteristics of shrimp–fish paste, expressed as CIE L^* a^* b^* values (Table 2), provide objective indicators of pigment composition, browning reactions, and overall visual quality (Handayani et al., 2021; Markovic et al., 2013)). In this study, L values (lightness) ranged from 36.49 ± 0.98 in Sumbawa to 38.59 ± 0.03 in East Lombok and 41.84 ± 0.46 in Central Lombok, with significant differences among all regions ($p < 0.05$). Higher L^* values indicate a lighter appearance, while lower values are associated with darker tones, often resulting from Maillard browning, pigment degradation, or extended fermentation (Pongsetkul et al., 2022). The a^* values (red–green axis) were highest in East Lombok (13.80 ± 0.29), followed by Sumbawa (11.62 ± 0.29), and lowest in Central Lombok (1.77 ± 0.42), reflecting the influence of astaxanthin and other carotenoids from shrimp; reductions in a^* may indicate pigment oxidation or dilution by fish tissue with lower carotenoid content (Yanar et al., 2004). The b^* values (yellow–blue axis) were highest in Sumbawa (9.99 ± 0.44), followed by East Lombok (6.92 ± 0.16) and Central Lombok (6.23 ± 0.26), representing yellowish hues from carotenoids, Maillard reaction products, and certain additives (Song et al., 2024). These variations likely reflect differences in shrimp-to-fish ratio, raw material freshness, fermentation duration, salt concentration, and drying conditions, consistent with previous findings that shrimp-based pastes generally exhibit higher a^* and b^* values than fish-only products (Pongsetkul et al., 2022; Song et al., 2024; Yanar et al., 2004). The relatively higher L value in Central Lombok suggests a lighter product, which may be linked to shorter fermentation duration and more intensive drying practices. Field observations indicated that producers in Central Lombok often apply sun-drying both before and after fermentation, which accelerates moisture loss and reduces the extent of browning reactions. In contrast, Sumbawa producers typically dry only after fermentation, allowing more time for Maillard reactions and pigment degradation, resulting in darker pastes. East Lombok, with intermediate practices, showed intermediate L values.

Table 2 Color Characteristics (CIE L* a* b*) of Shrimp–Anchovy Paste

Sample	L^*	a^*	b^*	Color convertion
Sumbawa	36,49 ± 0,98^{a}	11,62 ± 0,29^{a}	9,99 ± 0,44^{a}	
East Lombok	38,59 ± 0,03^{b}	13,80 ± 0,29^{b}	6,92 ± 0,16^{b}	
Central Lombok	41,84 ± 0,46^{c}	1,77 ± 0,42^{c}	6,23 ± 0,26^{c}	

Microbiological Characteristics of Shrimp-Anchovy Paste

The microbiological analysis of shrimp-anchovy paste samples from different regions demonstrated notable variation in bacterial populations (Table 3), both in terms of lactic acid bacteria (LAB) and total plate counts (TPC). The data indicate that Sumbawa, East Lombok, and Central Lombok exhibited distinct microbial profiles, which may reflect differences in raw materials, environmental conditions, and processing practices. Such variations are common in fermented fishery products and have been previously associated with region-specific microbial communities (Riebroy et al., 2008; Zaman et al., 2010).

Table 3. Microbiological Characteristics of Shrimp-Anchovy Paste

Sample	Total BAL (Log Cfu/ml)	Total Plate Count (Log Cfu/ml)	Cell Morphology	
			Gram	Shape
Sumbawa	1.85±0,02[a]	2.79± 0,07[a]	-	Basil
East Lombok	2.57±0,13[b]	2.34± 0,03[b]	+	Basil
Central Lombok	1.20±0,14[c]	2.28± 0,06[b]	+	Basil

The LAB population ranged from 1.20 to 2.57 log CFU/ml across the three sampling regions. The highest LAB count was recorded in East Lombok (2.57±0.13 log CFU/ml), while the lowest was observed in Central Lombok (1.20±0.14 log CFU/ml). These findings highlight the selective proliferation of LAB, which play a crucial role in fermentation by producing lactic acid, lowering pH, and contributing to the development of desirable flavor and texture (Marshall & Mejia, 2012). The relatively higher LAB population in East Lombok suggests a more favorable environment for LAB growth, possibly due to intrinsic factors such as raw material composition or extrinsic factors such as temperature and salt concentration during fermentation. Conversely, the lower LAB count in Central Lombok may reflect less optimal fermentation conditions or competitive microbial dynamics.

The TPC values further illustrate the microbial load of the samples, ranging between 2.28 and 2.79 log CFU/ml. The highest count was found in the Sumbawa sample (2.79 ± 0.07 log CFU/ml), indicating a relatively dense microbial population. Interestingly, although Sumbawa presented the highest TPC, its LAB count was intermediate (1.85 ± 0.02 log CFU/ml), suggesting the presence of a diverse microbial community beyond LAB. In contrast, East Lombok exhibited a higher LAB proportion relative to its TPC, which may imply dominance of LAB over other bacterial groups. Such dominance of LAB is generally considered beneficial for the safety and quality of fermented products (Marshall & Mejia, 2012). Central Lombok, with lower LAB and TPC values, may indicate either slower microbial activity or effective inhibitory conditions that suppress microbial proliferation.

Morphological and staining characteristics further revealed that most isolates were bacilli, consistent with the general prevalence of rod-shaped LAB in fermented fish products. Gram-positive bacilli were dominant in East and Central Lombok, aligning with typical LAB profiles such as *Lactobacillus* and *Pediococcus* species, which are known to enhance flavor development and improve product safety (R. Li et al., 2013). Notably, the presence of Gram-negative bacilli in the Sumbawa sample aligns with earlier findings in rebon shrimp terasi from Bontang, which reported isolates such as Pseudomonas sp., Neisseria sp., and Erysipelothrix sp. These microorganisms exhibit Gram negative rod-shaped morphology and display fermentative or oxidative characteristics, while also being salt-intolerant (Setiawan et al., 2015)

CONCLUSION

This study characterized Physicochemical and microbial profiles of shrimp anchovy paste from Sumbawa, East Lombok and Central Lombok. Significant differences were observed in moisture, ash and protein: moisture increased from 37.83 percent in Sumbawa to 46.17 percent in Central Lombok; ash was highest in Sumbawa (28.09 percent) and lowest in Central Lombok (18.27 percent); protein was lower in East Lombok (12.96 percent) than in Sumbawa and Central Lombok. Fat and hardness were similar across regions. Glutamic acid predominated in amino acid profiles, highest in Central Lombok. Microbiological analysis showed highest total plate count in Sumbawa and highest lactic acid bacteria in East Lombok; Gram negative bacilli dominated in Sumbawa while Gram positive bacilli were prevalent in Lombok. Standardize salt ratio, material blending and controlled drying.

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