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FORMULATION AND EVALUATION OF INSTANT FRIED RICE SEASONING ENRICHED WITH BLUE SWIMMER CRAB LEMI POWDER

Indrati Kusumaningrum*, Khusnul Khotimah, Rahadina Praba Melati, Rahmania Nur Afiah, Dian Rachmawanti Affandi
Agricultural Product Technology Study Program, Faculty of Vocational School, Sebelas Maret University
Kolonel Sutarto St 150 K, Jebres, Surakarta, Central Java, Indonesia 57126

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*Correspondence: inkusuma81@staff.uns.ac.id

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Abstract

Fried rice is one of Indonesia's most popular dishes, creating a demand for practical seasoning alternatives such as instant seasoning made from crab lemi powder (LP), which provides a distinctive seafood flavor. This study aimed to evaluate the chemical, physical, and sensory characteristics of instant fried rice seasoning with varying proportions of LP and MSG. Four formulations (P0–P3) were developed using a completely randomized design. Chemical analyses included moisture, ash, protein, fat, carbohydrate, NaCl, and glutamate content. The physical analyses comprised measurements of bulk density, flowability, angle of repose, and color (L*, a*, and b*). Sensory evaluation was conducted using a hedonic test to assess color, aroma, taste, texture, and overall acceptability. Formulas P1 (34% LP : 3% MSG) and P2 (31% LP : 6% MSG) met the SNI standards for protein and fat content, with sodium levels significantly below the maximum limit, despite water content exceeds the standard (≤4%). Physically, all formulations showed densities of 0.71 to 0.74 g·mL^{-1}, flow times of 7.88 and 8.95 g·s^{-1}, and angles of repose below 30° (27.88°-28.61°), indicating excellent flowability and consistent color. Hedonic testing revealed that MSG addition had no significant impact on color, aroma, and texture but significantly improved taste and overall acceptability (p<0.05). Consequently, formulation P1, which had a lower MSG level, was identified as optimal, providing the best balance of physical stability, chemical quality, and sensory acceptability. This suggests its potential for development as a practical and safe instant fried rice seasoning product that is aligned with consumer preferences

Keywords: low sodium, natural flavor enhancer, *Portunus pelagicus*, seafood, seasoning

Formulasi dan Evaluasi Bumbu Instan Nasi Goreng yang Diperkaya dengan Bubuk Lemi Rajungan

Abstrak

Nasi goreng merupakan salah satu makanan khas Indonesia yang banyak diminati sehingga perlu dikembangkan bumbu praktis, salah satunya bumbu instan berbahan dasar bubuk lemi rajungan atau lemi powder (LP) yang memberikan cita rasa *seafood*. Penelitian ini bertujuan untuk mengevaluasi karakteristik kimia, fisik, dan sensori bumbu instan nasi goreng dengan variasi proporsi bubuk lemi (LP) dan MSG. Formulasi dikembangkan menggunakan desain penelitian rancangan acak lengkap (RAL). Analisis kimia meliputi kadar air, abu, protein, lemak, karbohidrat, kadar garam (NaCl), dan kadar glutamat. Analisis fisik mencakup densitas kamba, laju alir (*flowability*), sudut diam (*angle of repose*), dan warna (L*, a*, b*). Sedangkan uji sensori dilakukan secara hedonik terhadap warna, aroma, rasa, tekstur, dan penerimaan keseluruhan. Formula P1 (34% LP : 3% MSG) dan P2 (31% LP : 6% MSG) menunjukkan mutu kimia yang sesuai SNI untuk kadar protein dan lemak dengan kadar natrium jauh di bawah batas maksimum meskipun kadar air melebihi standar (≤4%). Secara fisik, seluruh formula memiliki densitas kamba 0,71-0,74, laju alir

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7,88-8,95 g.s-1, dan sudut diam <30° (27,88°-28,61°) yang tergolong kategori *excellent flowability*, serta warna seragam antar formula. Hasil uji hedonik menunjukkan bahwa penambahan MSG tidak memengaruhi secara signifikan parameter warna, aroma, dan tekstur, namun meningkatkan skor rasa dan penerimaan keseluruhan secara nyata (p<0,05). Berdasarkan hasil tersebut, formulasi P1 dengan penggunaan MSG lebih rendah diidentifikasi sebagai formula paling optimal karena memberikan keseimbangan terbaik antara kestabilan fisik, mutu kimia, dan penerimaan sensori sehingga berpotensi dikembangkan sebagai produk bumbu nasi goreng instan yang praktis, aman, dan sesuai preferensi konsumen.

Kata kunci: bumbu rasa, penyedap alami, *Portunus pelagicus*, rendah natrium, *seafood*

INTRODUCTION

Instant seasoning is a food innovation that provides convenience for consumers in preparing dishes quickly and practically. Fried rice seasoning is one of the most popular because it suits local tastes and is flexible in its use (Fitriana *et al.*, 2021). Most commercial instant seasoning products still rely on synthetic flavorings, such as monosodium glutamate (MSG), to provide a savory or umami taste. The use of MSG is currently the most effective method for enhancing the flavor of cooked products. In Indonesia, the use of MSG is regulated under the Indonesian National Agency of Drug and Food Control (BPOM) Regulation No. 11 of 2009, which stipulates that its application must adhere to the principles of Good Manufacturing Practices (GMP), meaning it may be used as needed, provided that the amount is technologically justified and does not pose a health risk. However, its use often raises consumer concerns regarding its potential health effects when consumed in excess. Persistent public concerns, often referred to as Chinese Restaurant Syndrome, include perceived symptoms such as headaches, flushing, and nausea, although consistent scientific evidence to support these claims is lacking (Chung *et al.*, 2022; Katrancı *et al.*, 2024). Although regulations consider MSG safe, social stigma against it remains strong among consumers. This highlights the need to find natural alternatives that can partially replace MSG without reducing sensory quality.

The trend of using natural flavorings has recently increased in the food industry, along with consumer preference for clean-label products (Grant *et al.*, 2021). Consumer awareness of health and policies promoting sodium reduction present new challenges in developing seasoning formulations that maintain sensory quality while reducing the MSG content. Efforts to replace or reduce MSG require a scientific approach, as these changes may affect both the sensory attributes and chemical characteristics of products (Shaltout, 2022; Tonnis *et al.*, 2019; Zhang *et al.*, 2019). Therefore, research on alternative flavor enhancers is highly relevant to the food industry.

Several studies have shown that fishery-based powders can enhance the sensory profile of food, particularly its taste and aroma. Some reports have highlighted that using fishery by-products can improve savory taste and be accepted by panelists, such as shrimp head powder in cilok products (Azizah *et al.*, 2020), shrimp head mixed with mulberry leaves (Fajriyah & Winarti, 2022), and yellowfin tuna tail powder as a natural flavoring (Fadila, 2021). One potential material is lemi, a by-product of crab processing that contains beneficial nutrients. Crab lemi refers to the remaining cavity of the crab body after the main meat has been removed from it. It is generally considered waste but still contains approximately 14.40% protein in its fresh form (Kusumaningrum *et al.*, 2025). Lemi is rich in protein, umami-forming amino acids such as glutamate, and distinctive volatile compounds that contribute to its aroma and flavor (Gunawan *et al.*, 2020; Suparmi *et al.*, 2021). Using fishery by-products as flavoring powders not only increases the value of the by-products but also supports sustainable food processing principles (Adachi *et al.*, 2019; Gonçalves & dos Santos, 2019).

Fajri *et al.* (2021) reported that crab lemi powder can be used as a flavoring material after drying, and the addition of anti-caking agents can improve solubility and product stability. Kusumaningrum *et al.* (2025) studied variations in maltodextrin concentration to optimize the physicochemical characteristics

of crab lemi powder, making it suitable as a flavoring powder that can be applied to various food products. These studies demonstrate the potential of crab lemi as a natural umami source. However, its use has been limited to processed products such as crackers (Jumiati & Suprapti, 2023) or general flavoring powders and not specifically for instant seasoning. Although the use of MSG as a flavor enhancer has been widely studied in various food products, research exploring the use of crab lemi powder specifically as a natural substitute for synthetic flavorings such as MSG in instant fried rice seasoning remains limited. Therefore, it is important to develop instant seasoning products using this material, in line with food industry trends toward clean-label formulations and utilization of fishery by-products.

The extent to which the substitution or addition of crab lemi powder in instant seasoning formulations can be accepted both organoleptically and chemically needs to be determined (Kleinschmidt *et al.*, 2024; Koohathong & Khajarern, 2021; Śmiechowska *et al.*, 2021). This study aimed to evaluate the chemical, physical, and sensory characteristics of instant fried rice seasoning formulated with varying ratios of crab lemi powder and MSG. Proximate parameters, salt content (NaCl), moisture, glutamate levels, and hedonic tests were used to assess consumer preference. The results are expected to contribute to the development of instant seasoning products made from local materials while reducing the use of synthetic additives. In addition, the use of crab by-products is expected to support the sustainable management of fishery resources.

MATERIALS AND METHODS

Preparation of Crab Lemi Powder

Crab lemi powder (LP) was prepared following the method described by Kusumaningrum *et al.* (2025). The crab lemi were first washed with clean water to remove dirt and unwanted tissue residues. The material was then steamed for 10 min, starting from the boiling point of the water. After steaming, the lemi was cooled for 10 min and then ground while adding 10% maltodextrin and 1% salt. Both percentages were calculated based on the weight of the steamed lemi. The mixture was subsequently dried in an oven at 65–70°C for approximately four hours until completely dry. The dried sample was then ground into a fine powder and sieved using a 60-mesh sieve. These steps aimed to produce lemi powder with consistent physical quality, easy application in instant seasoning formulations, and good stability during storage. The chemical composition of the lemi powder (LP) produced using this method is presented in Table 1.

Formulation of Instant Fried Rice Seasoning

Instant fried rice seasoning was formulated in four treatments with varying ratios of crab lemi powder (LP) and monosodium glutamate (MSG), while the proportions of other ingredients remained constant. The formulation was determined by referring to the general composition of commercial instant fried rice seasonings available in the market, which typically consist of salt, sugar, spices, an anti-caking agent, maltodextrin, and a flavor enhancer (MSG). Based on this reference, the formula was modified by adjusting the proportions of LP and MSG while keeping the other components constant to specifically evaluate the effects of the LP and MSG ratios on the chemical and sensory characteristics of the seasoning. The formulations were arranged based on their total weight percentages (Table 2). Treatment P0 did not contain MSG and had the highest

Table 1 Chemical composition of fresh lemi and lemi powder (LP)*

Material	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
Fresh lemi	78.26	2.40	14.40	0.02	4.95
Lemi powder	3.14	11.60	42.20	11.69	31.18

*Kusumaningrum *et al.* (2025)

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Table 2 Formulation of fried rice instant seasoning with different ratio of lemi powder and MSG

Ingredients	Lemi powder (LP) and MSG ratio (LP: MSG)			
	P0 (37: 0)	P1(34: 3)	P2 (31: 6)	P3 (28: 9)
Lemi powder	37.00	34.00	31.00	28.00
MSG	0.00	3.00	6.00	9.00
Salt	35.00	35.00	35.00	35.00
Sugar	7.50	7.50	7.50	7.50
Chili powder	5.00	5.00	5.00	5.00
Candlenut powder	2.00	2.00	2.00	2.00
Garlic powder	2.00	2.00	2.00	2.00
Anti-caking agent	1.50	1.50	1.50	1.50
Maltodextrin	10.00	10.00	10.00	10.00
Total	100.00	100.00	100.00	100.00

proportion of Lemi powder (37%), whereas P1, P2, and P3 contained 3%, 6%, and 9% MSG, respectively, with the proportion of Lemi powder gradually reduced to 34%, 31%, and 28%, respectively. The other components included salt (35%), granulated sugar (7.5%), chili powder (5%), candlenut powder (2%), garlic powder (2%), anti-caking agent (1.5%), and maltodextrin (10%).

Proximate Analysis

Proximate analysis included the determination of moisture, protein, ash, fat, and carbohydrate content. Moisture was analyzed using the oven-drying (thermogravimetric) method, and protein content was determined using the Kjeldahl method. The ash content was measured through combustion in a muffle furnace, and the fat content was analyzed using the Soxhlet extraction method. The carbohydrate content was calculated using the by-difference method by subtracting the total amounts of moisture, ash, protein, and fat from 100%. All proximate analysis procedures followed the AOAC (2005) method.

Salt Content (NaCl)

Salt content was determined using the Mohr method (argentometric titration) in accordance with the AOAC (2005) procedure. A 5 g sample was placed in a 100 mL Erlenmeyer flask, and 100 mL of distilled water was added using a volumetric flask. The solution was shaken until homogeneous, after which 25 mL was taken and 3 mL of a 5% potassium chromate (K_2CrO_4) indicator was added. Titration was then carried out using a 0.1 N standard silver nitrate ($AgNO_3$) solution until a brick-red color appeared.

Glutamic Acid Content

Glutamic acid content was analyzed using the ninhydrin spectrophotometry method. The sample was homogenized, then approximately 1 g was weighed and placed into a 100 mL Erlenmeyer flask. Distilled water was added to reach a total volume of 100 mL, and the mixture was filtered through filter paper or separated by centrifugation. A clear filtrate (1 mL) was transferred into a test tube, followed by the addition of 2 mL ninhydrin reagent. The tube was then heated in a water bath at 50°C for 15 minutes. After heating, the sample was cooled, and 96% ethanol was added to a final volume of 10 mL before homogenization with a vortex. The reaction mixture was quantitatively analyzed using a spectrophotometer at a wavelength of 520 nm. Glutamic acid concentration was determined using a standard calibration curve with concentrations of 0, 0.1, 0.2, 0.3, 0.4, and 0.5 mg/mL. Glutamic acid content (%) was calculated by multiplying the absorbance value by 100 and the dilution factor, then dividing by the sample weight (Rachma & Saptawati, 2021)2021.

Physical Test (Bulk Density, Flow Time, Angle of Repose, Color)

Bulk density, flow time, and angle of repose were measured following the method described by Han *et al.* (2026). Bulk density was determined by measuring the mass of powder occupying a known volume and expressed in grams per milliliter ($g \cdot mL^{-1}$). Flow time was measured by weighing a certain amount of powder sample, pouring it through a funnel, and recording the time required for the powder to flow completely. The result was expressed as $g \cdot s^{-1}$ (mass/time). Angle of repose was determined by placing a specific amount of powder into a funnel with its outlet initially closed. The powder was then allowed to flow freely to form a stable cone on a flat surface. The height (h) and base radius (r) of the cone were measured, and the angle of repose (θ) was calculated using the equation $\theta = \arctan(h/r)$. Color measurement was performed using a Chromameter (Konica Minolta CR-400) based on the Hunter Lab color system, which measures three parameters: L* (lightness), a* (red-green), and b* (yellow-blue) (Senphan *et al.*, 2025).

Organoleptic Test

The organoleptic test was conducted using the hedonic method with five levels of preference (1 = strongly dislike, 5 = strongly like), involving 30 untrained panelists. Before the evaluation, the panelists were given a brief explanation of the assessment procedure and the criteria for each attribute, including color, aroma, taste, texture, and overall acceptance. For the taste attribute, panelists were asked to sample fried rice prepared with the instant seasoning according to each treatment group. Each seasoning sample was randomly coded to ensure evaluation without direct comparison among the samples (Khotimah *et al.*, 2024).

Data Analysis

This study used a completely randomized design (CRD) with four treatment ratios of crab lemi powder and monosodium glutamate (Table 2). Differences in chemical and physical parameters among treatments were analyzed using analysis of variance (ANOVA), based on triplicate data, followed by Tukey's test ($\alpha = 0.05$). Hedonic test data were analyzed using the nonparametric Kruskal–Wallis test to determine the differences in preference levels among treatments for color, aroma, taste, texture, and overall acceptance. If significant differences ($p < 0.05$) were found, the Mann–Whitney U test was used for post-hoc comparisons between treatment pairs. Data analysis was performed using SPSS software version 27.

RESULTS AND DISCUSSION

Chemical Characteristics of Instant Fried Rice Seasoning

The moisture content of the instant fried rice seasoning in this study ranged from 4.39% to 6.22% (Table 3). The highest value was found in treatment P0 (37% LP: 0% MSG), whereas the lowest value was observed in treatment P3 (28% LP: 9% MSG). Statistical analysis showed that variations in the proportions of lemi powder (LP) and MSG had a significant effect on moisture content ($p<0.05$), with P0 being significantly different from P2 and P3, whereas P1 did not differ significantly from P0 and P2. A decreasing trend in moisture content was observed with increasing MSG concentration and decreasing lemi powder content, which can be attributed to the hygroscopic properties and composition differences between the two ingredients. Lemi powder is a protein-rich ingredient that contains hydrophilic functional groups with a strong affinity for water and tends to retain more moisture. In contrast, MSG is a crystalline, low-moisture compound that does not readily bind to water and may even reduce the overall water-holding capacity of the mixture. Therefore, formulations with higher proportions of lemon myrtle powder tended to exhibit higher moisture content owing to greater water retention, whereas increasing MSG levels diluted this effect, resulting in lower overall moisture content.

The maximum moisture content limit for powdered seasoning products, according to SNI 01-4273-1996 for beef flavor seasoning and SNI 01-4281-1996 for chicken flavor seasoning, is 4% (Badan Standardisasi Nasional [BSN], 1996a; BSN, 1996b). The results of this study showed that

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Table 3 Chemical composition of instant fried rice seasoning with different ratio of lemi powder and MSG

Parameters (%)	Lemi powder (LP) and MSG ratio (LP: MSG)			
	P0 (37: 0)	P1(34: 3)	P2 (31: 6)	P3 (28: 9)
Moisture	6.22±0.85^{b}	5.03±0.20^{ab}	4.64±0.41^{a}	4.39±0.26^{a}
Ash	38.55±0.18^{a}	38.33±0.10^{a}	41.33±0.28^{c}	39.82±0.15^{b}
Protein	15.04±0.39^{a}	14.50±0.46^{a}	14.31±1.05^{a}	15.52±0.32^{a}
Fat	5.42±0.17^{c}	5.51±0.11^{c}	4.90±0.03^{b}	4.16±0.16^{a}
Carbohydrate	34.76±0.66^{a}	36.63±0.69^{a}	34.82±1.21^{a}	36.12±0.37^{a}
NaCl	12.87±0.21^{a}	14.49±0.25^{b}	15.22±0.21^{c}	15.61±0.28^{c}
Glutamate	6.79±0.60^{a}	14.43±1.16^{b}	21.27±2.46^{c}	32.34±1.05^{d}

Different letters on the same row indicate significant differences (p<0.05)

the moisture content in treatments P2 (4.64%) and P3 (4.39%) was close to the standard, whereas those in P0 (6.22%) and P1 (5.03%) exceeded the specified limits. This indicates that formulations with higher proportions of lemi powder (>31%) tended to produce products with higher moisture content. These findings suggest that although crab lemi has the potential to improve the nutritional value and flavor of the product, formulation adjustments are necessary to achieve moisture levels that meet the SNI quality standards, thereby ensuring an optimal product shelf life. Low moisture content is crucial for instant seasoning products because it effectively inhibits microbial growth and prevents deteriorative chemical reactions, such as lipid oxidation Poo *et al.* (2025).

A previous study by Kusumaningrum *et al.* (2025) reported that flavor powder derived from crab lemi with maltodextrin addition had a moisture content ranging from 3.14% to 5.02%. This difference may be attributed to the type and concentration of filler material used. MSG, a crystalline salt, has different hygroscopic properties than crab lemi powder or other ingredients in the formulation; therefore, its presence can reduce the overall moisture content. Lemi powder, which contains protein and minerals, tends to bind water more effectively than crystalline MSG, which has low hygroscopicity (Wang *et al.*, 2021). Thus, the higher the concentration of lemi powder, the greater the mixture's ability to retain water, whereas higher MSG addition resulted in lower moisture content.

The ash content of instant fried rice seasoning in this study ranged from 38.33% to 41.33%, with the highest value observed in treatment P2 (31% LP : 6% MSG) and the lowest in P1 (34% LP : 3% MSG). Statistical analysis revealed significant differences among the treatments ($p < 0.05$). Treatments P0 and P1 did not differ significantly, but both were significantly different from the P2 and P3 treatments. This indicates that the proportions of lemi powder (LP) and MSG used in P0 (37% LP: 0% MSG) and P1 (34% LP: 3% MSG) did not affect the ash content. However, increasing the proportion of MSG to 6% and 9%, accompanied by a reduction in Lemi powder, significantly increased the ash content. According to SNI 01-4273-1996 for beef-flavored seasoning and SNI 01-4281-1996 for chicken-flavored seasoning, no specific limit is set for the ash content in seasoning products (BSN, 1996a; BSN, 1996b).

The increase in ash content observed in this study may be attributed to the use of MSG, which is a sodium salt of glutamic acid. Salts contribute significantly to the total ash content of food products, reflecting their inorganic mineral content (Shaltout, 2022). The ash content of a material is influenced by its composition. In this study, the crab lemi powder used had an ash content ranging from 10.52% to 13.47% (Kusumaningrum *et al.*, 2025).

The analysis showed that the protein content of instant fried rice seasoning made from crab lemi ranged from 14.31% to 15.52%. The highest value was found in treatment P3 (28% LP: 9% MSG), whereas the lowest was observed in treatment P2 (31% LP: 6% MSG). This relatively uniform range indicates that even though the proportion of lemi powder was reduced from 37% in P0 to 28% in P3, the protein levels remained high. This is because crab lemi is an animal protein source, and MSG, which is added to the formulation, is the sodium salt of glutamic acid, one of the amino acids that make up proteins (Hajhasani *et al.,* 2020). The main raw material, lemi powder, used in this formulation is an animal protein source that contributes to the nutritional value and functional quality of the instant seasoning, with a protein content ranging from 36.54% to 46.67% (Kusumaningrum *et al.*, 2025).

The protein content obtained in this study far exceeded the minimum protein standards set by SNI 01-4273-1996 for beef-flavored seasoning (≥7%) and SNI 01-4281-1996 for chicken-flavored seasoning (≥6%) (BSN, 1996a; BSN, 1996b). These findings indicate that all treatments (P0–P3) surpassed the SNI minimum limits by more than two-fold. This confirms that instant fried rice seasoning made from crab lemi not only meets national quality standards but also has the potential to provide added nutritional value in the form of protein content far exceeding the minimum required.

The fat content of instant fried rice seasoning made from crab lemi in this study ranged from 4.16% to 5.51%. The highest value was observed in treatment P1 (34% LP: 3% MSG) at 5.51%, whereas the lowest value was observed in P3 (28% LP: 9% MSG) at 4.16%. Statistical analysis revealed significant differences between the seasoning formulations. The fat contents in treatments P0 (5.42%) and P1 (5.51%) did not differ significantly, indicating that changing the proportion of crab lemi powder from no MSG to 3% MSG did not significantly affect the fat content. However, a significant decrease was observed in P2 (4.90%), which was different from that observed in P0 and P1. This decline continued in formula P3 (4.16%), which had the lowest fat content and was significantly different from all other formulas.

The reduction in fat content from P0 to P3 indicates that as the proportion of crab lemi powder decreased and the MSG proportion increased in the formulation, the total fat content of the product decreased significantly. The differences in fat content among the treatments were related to the proportion of lemi powder used: the higher the proportion of lemi in the formulation, the higher was the fat content of the product. This may be influenced by the fat content of lemi powder itself, which, according to Kusumaningrum *et al.* (2025), was 11.69%. Based on SNI 01-4273-1996 for beef-flavored seasoning and SNI 01-4281-1996 for chicken-flavored seasoning, the minimum fat content required is 2% (BSN, 1996a; BSN, 1996b). The results of this study indicate that all treatments had fat contents above the minimum standard.

The carbohydrate content (by difference method) of instant fried rice seasoning in this study ranged from 34.76% to 36.63%. Statistical analysis revealed no significant differences among the seasoning formulations (p>0.05). This indicates that variations in the proportions of crab lemi powder and MSG did not significantly affect the total carbohydrate content of the products. This can be explained by considering the composition of the ingredients that influence the carbohydrates in the formulations. The lemi powder used in this study followed the method of Kusumaningrum *et al.* (2025), which included the addition of 10% maltodextrin during the preparation of lemi powder. The carbohydrate content of lemi powder obtained using this method was 31.18%.

The carbohydrate content of these formulations was largely influenced by the main raw material, namely lemi powder. MSG, the sodium salt of glutamic acid, is an amino acid that constitutes proteins (Hajhasani *et al.,* 2020). Therefore, although changes were made to the proportions of crab lemi powder and MSG, the overall carbohydrate content did not change significantly because the primary carbohydrate contribution came from constant ingredients, and the substitution of lemi powder with MSG was insufficient to

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produce a statistically significant difference in the total carbohydrate levels. Similarly, chili powder, candlenut powder, and garlic powder may contain carbohydrates, but their contributions are relatively small, and their proportions are constant.

The salt content of instant fried rice seasoning with varying proportions of lemi powder and MSG in this study ranged from 12.87% to 15.61%. The lowest value was found in P0 (37% LP: 0% MSG), whereas the highest was obtained in P3 (28% LP: 9% MSG). In this study, all formulations contained a fixed amount of table salt (NaCl) of 35%. However, the additional sodium contribution from MSG caused the total sodium content to increase with higher MSG proportions in treatments P1, P2 and P3. This difference was directly influenced by the formulation, where increasing the proportion of MSG not only functioned as a flavor enhancer but also increased sodium levels, as MSG is the sodium salt of glutamic acid (Wang *et al.*, 2021).

When compared with the SNI 01-4273-1996 standard for beef-flavored seasoning and SNI 01-4281-1996 for chicken-flavored seasoning, which set the maximum permissible NaCl content at 65% (BSN, 1996a; BSN, 1996b), the sodium levels observed in this study, ranging between 12 and 16%, were far below the established threshold. This demonstrates that instant fried rice seasoning made from crab lemi is safe in terms of salt content, according to national quality standards. Moreover, the use of MSG can also contribute to overall sodium reduction strategies, as MSG contains less sodium than table salt while still enhancing the perception of saltiness and umami (Halim *et al.*, 2020).

The glutamic acid content of instant fried rice seasoning with varying proportions of lemi powder and MSG in this study showed a significant increasing trend, rising from 6.79% in treatment P0 (without MSG) to 32.34% in treatment P3 (9% MSG). Treatment P0, which contained the highest proportion of lemi powder (37%), had a glutamic acid content of 6.79% despite the absence of MSG. This result indicates that crab lemi powder naturally contains glutamic acid, an amino acid that contributes to the umami taste. Kusumaningrum *et al.* (2025) also reported that crab lemi has a high protein content, which contributes to the basic flavor profile of food products.

The statistically significant differences among the treatments demonstrated that as the proportion of lemi powder was gradually reduced and replaced with MSG, the glutamic acid levels increased markedly. Although crab lemi naturally contains glutamate, MSG is the main factor driving the increase in total glutamic acid content in the instant seasoning. This finding is consistent with the nature of MSG as the sodium salt of glutamic acid, which is abundant in nature (Sugimoto *et al.*, 2019). Glutamate is a key component responsible for the umami or savory taste sensation, which has been recognized as the fifth basic taste (Kawai *et al.*, 2009).

According to the Indonesian National Agency of Drug and Food Control (BPOM) Regulation No. 11 of 2009, MSG is classified as a food additive (BTP) used as a flavor enhancer, with the allowable limit set as "sufficient" according to technological need or good manufacturing practices (GMP). This means that MSG may be added as long as it fulfills its technological function in food without posing health risks, as regulatory authorities have confirmed its safety at normal consumption levels. These findings show that the instant fried rice seasoning formulations in this study remain within safe limits for MSG use, particularly regarding its role in enhancing the umami taste. Therefore, the observed increase in glutamic acid levels with specific MSG ratios is expected to improve the sensory quality of the products.

Physical Characteristics of Instant Fried Rice Seasoning

Bulk density

The results showed that the bulk density values ranged from 0.71 to 0.74 g·mL^{-1} (Table 4), with a slight increasing trend as the proportion of lemi powder (LP) decreased and MSG increased. However, statistical analysis indicated that the differences among the treatments were not significant (p>0.05). This

Table 4 Physical composition of instant fried rice seasoning with different ratio of lemi powder and MSG

Parameters	Lemi powder (LP) and MSG ratio (LP: MSG)			
	P0 (37: 0)	P1(34: 3)	P2 (31: 6)	P3 (28: 9)
Bulk density (gmL^{-1})	0.71±0.01[a]	0.72±0.01[a]	0.72±0.02[a]	0.74±0.02[a]
Flow time (gs^{-1})	7.88±0.29[a]	8.54±0.32[a]	8.39±0.54[a]	8.95±0.54[a]
Angle of repose (o)	28.61±0.40[a]	28.45±0.65[a]	27.95±0.79[a]	27.88±0.51[a]
L*	74.46±0.24[a]	74.24±0.26[a]	72.62±0.71[a]	73.97±1.37[a]
a*	13.17±0.28[a]	13.61±0.10[a]	13.36±0.36[a]	13.74±0.52[a]
b*	27.81±0.28[a]	27.69±0.45[a]	26.51±1.07[a]	27.24±1.39[a]

Different letters on the same row indicate significant differences ($p<0.05$)

finding suggests that variations in the crab LP-to-MSG powder (LP) and MSG did not significantly affect the product bulk density.

The relatively high and stable bulk density, particularly in treatment P3, may offer advantages in terms of packaging and transportation efficiency, as powders with higher compactness and homogeneity tend to occupy less volume and are easier to manage. These results are consistent with a study on turmeric powder, in which different drying treatments produced relatively stable bulk density values (0.42–0.45 $g{\cdot}mL^{-1}$) without significant differences among treatments (Purbasari & Pujiana, 2022). The bulk density of food powders is influenced by the particle size, shape, porosity, and moisture content. Crystalline materials, such as MSG, tend to increase the bulk density by filling the interparticle voids, whereas fibrous or porous materials can decrease it (Camacho *et al.*, 2022; Suhag *et al.*, 2024).

Flow time

The flow time of the instant fried rice seasoning in this study ranged from 7.88 to 8.95 $g{\cdot}s^{-1}$. Analysis of variance showed no significant difference among the treatments ($p>0.05$), indicating that variations in LP and MSG had only a minimal influence on the powder flow characteristics. This suggests that the proportions of crab lemi powder and MSG used in the formulations were compatible and did not interfere with each other's flow behavior. Powdered food products are generally susceptible to flow problems and caking, which can lead to handling and economic issues (Kleinschmidt *et al.*, 2024; Suhag *et al.*, 2024).

The observed trend of slightly increased flow time corresponded with an increase in bulk density, implying that formulations with higher MSG content tended to flow more easily. This finding aligns with that of Han *et al.* (2025), who reported that chicken powder with smaller and smoother particles exhibited significantly reduced shear angles and improved flowability. Shah *et al.* (2023) further explained that finer, smoother particles possess lower frictional resistance, thereby enhancing flow. Optimal flowability ensures ease of handling and consistency in product distribution. The inclusion of anti-caking agents and maltodextrin in the powder formulations also contributed to preventing aggregation and maintaining stable flow properties across the treatments (Suhag *et al.*, 2024).

Angle of repose

The angle of repose values for the instant fried rice seasoning ranged from 27.88° to 28.61°, with all treatments showing values below 30° (Table 4). According to the flowability classification proposed by Shah *et al.* (2023), angles between 25°and 30° are categorized as excellent flowability, 31°–35° as good, 36°–40° as fair, and >45° as poor to very poor flowability. Thus, all the formulations in this study fell under the excellent flowability category. ANOVA results indicated no significant differences among the treatments

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(p>0.05), suggesting that variations in LP and MSG ratios did not significantly affect the angle of repose.

The consistently low angle of repose indicates that all formulations exhibited excellent flow properties, an essential characteristic for instant powder products, facilitating mixing, packaging, and distribution. Physically, a lower angle of repose is generally associated with reduced interparticle cohesion and increased packing uniformity (Suhag *et al.*, 2024). Although the compositional variations in LP and MSG were not statistically significant, the uniformly low angles of repose demonstrated that all instant fried rice seasoning formulations possessed good physical stability and optimal flow characteristics suitable for industrial powdered food applications.

Color (L*, a*, b*)

The color parameters of the instant fried rice seasoning showed ranges of L = 72.62–74.46*, a = 13.17–13.74*, and b = 26.51–27.81*, with all treatments sharing the same superscript letter (a), indicating no significant differences among them ($p > 0.05$). The relatively high L* values indicated good brightness across all formulations, whereas the stable a* and b* values reflected consistent reddish-yellow tones. This suggests that variations in the LP and MSG ratios did not significantly affect the visual appearance of the product.

Color stability is important because it ensures that changes in the formulation do not alter consumers' visual perception of the characteristic reddish-brown color of the fried rice seasoning, which results from the combination of crab lemi powder and added chilli powder. The consistent brightness (L*) among the treatments aligns with the fact that MSG is a white crystalline compound without noticeable coloration, indicating that its addition did not substantially alter the product's physical appearance. The most dominant factors influencing brightness are the base materials or fillers used (Nitipong *et al.*, 2020). Therefore, the uniform color results indicate that all formulations maintained desirable and stable visual characteristics suitable for commercial powdered seasoning applications.

Sensory Characteristics of Instant Fried Rice Seasoning

For taste assessment, the panelists were provided with fried rice samples prepared using the formulated instant seasonings. A total of 20 g of instant seasoning was used to fry 400 g of rice. The panelists were also asked to provide an overall evaluation of the instant seasonings tested in this study. The hedonic test results for the instant fried rice seasoning are presented in Table 5.

The hedonic scores for color ranged from 3.6 to 4.0, with the highest values in formulations P2 and P4 (4.0) and the lowest in P0 (3.6). The Kruskal–Wallis test results indicated no significant differences among the treatments (p>0.05), suggesting that the proportion of MSG used to replace part of the lemon powder did not affect the visual perception of the product color. This is because MSG is a white crystalline compound without distinct coloration and, therefore, does not alter the physical appearance of the product based on the composition of the ingredients used. The color was mainly influenced by the base materials, such as lemi powder, chili powder, and other components in the formulation, which remained relatively stable despite variations in lemi powder and MSG proportions (Shaltout, 2022).

Aroma

The hedonic scores for aroma ranged from 3.2 (P3) to 3.6 (P2). Although there were slight differences in the average scores, statistical analysis showed no significant differences among the treatments. This indicates that variations in the proportions of lemi powder and MSG did not significantly affect the panelists' perception of aroma in the instant seasoning. The consistency in aroma scores may be attributed to the volatile compounds from crab lemi powder and the base spices used in the formulations, such as garlic and chili powders, as well as other ingredients kept constant across treatments. Although lemi powder contains distinctive volatile compounds, differences in

Table 5 Mean hedonic scores of instant fried rice seasoning with different ratio of lemi powder and MSG

Parameters	Lemi powder (LP) and MSG ratio (LP: MSG)			
	P0 (37: 0)	P1(34: 3)	P2 (31: 6)	P3 (28: 9)
Color	3.6±0.99[a]	3.8±0.86[a]	4.0±0.80[a]	3.7±1.03[a]
Aroma	3.4±1.03[a]	3.3±0.97[a]	3.6±0.92[a]	3.2±0.99[a]
Taste	3.1±1.12[a]	4.1±0.90[b]	4.0±1.08[b]	3.7±1.22[b]
Texture	3.6±1.08[a]	4.0±0.68[a]	4.1±0.89[a]	3.8±0.92[a]
Overall	3.3±1.11[a]	3.9±0.81[b]	3.9±0.93[b]	3.7±1.06[b]

Different letters on the same row indicate significant differences ($p<0.05$) based on the Mann-Whitney U test

its proportion combined with MSG did not influence overall aroma acceptance, a finding consistent with Sasongko *et al.* (2018).

Flavor

Taste was the attribute that showed the most significant differences among all the sensory parameters tested. Hedonic scores for taste ranged from 3.1 to 4.1, with the lowest score in treatment P0 (3.1, no MSG) and the highest in P1 (4.1, 3% MSG) and P2 (4.0, 6% MSG). Statistical tests clearly showed that P0 differed significantly from P1, P2, and P3. This finding indicates that the addition of MSG significantly influenced the panelists' taste acceptance, as MSG served as an umami enhancer that amplified the perception of palatability.

Glutamic acid, the main component of MSG, is known as one of the key amino acids responsible for providing savory or umami taste (Katrancı *et al.*, 2024). However, the hedonic test results did not show statistically significant differences among P1, P2, and P3. This suggests that adding MSG in proportions ranging from 3% to 9% did not significantly increase taste scores, although the scores tended to decline at higher MSG concentrations. This finding can be interpreted as higher MSG proportions potentially reducing consumer preference because of an excessively strong or unbalanced taste (Halim *et al.*, 2020). Therefore, MSG usage at levels of 3–6% (P1 and P2) can be considered optimal, as it significantly improves taste compared to no MSG, but without the risk of excessive addition that could reduce the acceptance.

Texture

The hedonic scores for texture ranged from 3.6 (P0) to 4.1 (P2). Although variations in scores were observed, statistical analysis revealed no significant differences between the treatments. This indicates that variations in the proportions of crab lemi powder and MSG did not significantly affect the panelists' perception of the texture of the instant seasoning. The combination of ingredients used in the formulations resulted in a texture that dissolved easily when preparing fried rice. Although not statistically significant, the observed trend suggests that the composition of lemi powder and additional ingredients, such as maltodextrin and anti-caking agents, influenced texture perception. Maltodextrin improves powder density and flowability while reducing hygroscopicity (Sasongko *et al.*, 2018).

Overall

Overall evaluation showed that P1 and P2 achieved the highest scores (3.9), with significant differences compared to P0 (3.3), whereas P3 (3.7) did not differ significantly from P1 and P2. Although not statistically different, the trend indicated that the panellists preferred products with an optimal balance between lemi powder and MSG. This was evident in the optimal combination of 3–6% MSG with 31–34% lemi powder, which

enhanced the overall sensory acceptance. MSG addition within this range improved consumer preference for umami taste, whereas the low score for P0 (without MSG) emphasized the importance of MSG's contribution to sensory acceptance, particularly for taste and aroma. Thus, formulations with 31–34% lemi powder and 3–6% MSG (P1 and P2) can be considered as providing the most optimal sensory characteristics overall.

CONCLUSION

The addition of MSG to instant fried rice seasoning formulations significantly enhanced the taste and overall acceptance. The formulation containing 34% lemi powder and 3% MSG (P1) was identified as the most preferred based on sensory evaluation. All formulations met the Indonesian National Standard (SNI) requirements for protein and fat content, although their moisture levels slightly exceeded the specified limit (≤4%). In terms of physical properties, all formulations exhibited comparable bulk density values, excellent flow characteristics (angle of repose <30°), and uniform color, indicating stable powder performance and ease of handling. Therefore, P1 can be considered the optimal formulation, offering the best balance between chemical quality, physical stability, and sensory properties.

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