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# Characteristics of Chicken Liver and Anchovy (*Stolephorus indicus*) Composite Powder to Prevent Stunting

**Nawasari Indah Putri Sejati[1*], Endang Sri Wahyuni[1], Bertalina Bertalina[1], Dina Fithriyani[2]**
[1]Nutrition Department, Poltekkes Kemenkes Tanjung Karang, Bandar Lampung, Indonesia
[2]Faculty of Industrial Technology, Institut Teknologi Sumatera, Bandar Lampung, Indonesia

Corresponding author: nawasari@poltekkes-tjk.ac.id

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**ABSTRACT**

Stunting remains a major public health problem in Indonesia, with prevalence still exceeding national targets. Inadequate intake of high-quality animal protein during the first 1,000 days of life is a key contributing factor. Chicken liver and anchovies are affordable local sources of animal protein; however, their fresh forms are highly perishable. Powdered chicken liver and anchovies offer several advantages, including extended shelf life, greater storage practicality, and easier distribution. This study aimed to evaluate the physical, chemical, and sensory characteristics of chicken liver and anchovy composite powder stored for 4–6 weeks. An experimental study using a completely randomized design was conducted with three composite powder formulations: F1 (75% chicken liver:25% anchovy), F2 (50:50), and F3 (25:75). Physical properties (Hunter L*, a*, b*), proximate composition, and sensory characteristics were analyzed before and after storage. Data were analyzed using two-way repeated-measures ANOVA, LMM, and non-parametric tests ($\alpha$=0.05). Results showed that formulation significantly affected color, texture, and proximate composition. Higher anchovy proportions increased brightness and smoothness. Storage influenced color intensity and aroma in certain formulations but did not affect texture stability. All formulations exhibited low moisture content (<10%) and high protein content (>60%). Protein levels remained stable after storage, while moisture, lipid, and carbohydrate contents were affected. Formula F3 consistently demonstrated superior nutritional and physical stability. With its extended shelf life and favorable nutritional value, the composite powder made from chicken liver and anchovies is expected to serve as a major protein source for stunting intervention, particularly in remote and underserved areas.



## INTRODUCTION

Stunting is a nutritional problem in Indonesia that remains a government concern. The prevalence of stunting in Indonesia remains above the expected target. The prevalence of stunting in 2024 was 19.8%. This number is still above the 2024 national target of 14% (later revised to 20.1% for 2024). The national stunting target of 14.2% was eventually set as the 2029 stunting target. Therefore, various stunting prevention and management efforts must continue to be implemented to reduce the stunting rate by 7.3% over five years (Ministry of Health Republic Indonesia, 2025).

The causes of stunting in Indonesia are quite complex. However, the direct cause is inadequate nutritional intake during the first 1,000 days of life (HPK). To prevent and overcome this, interventions are needed to address its direct causes, such as providing foods containing animal protein and complete nutrients. Research shows that consistent, specific nutritional intervention programs supported by active parental involvement can have a positive impact on preventing and reducing the prevalence of stunting (Bola et al., 2024). Nurpratama et al. (2024) also stated that infant weight gain occurred after receiving local food interventions and nutritional counseling.

Animal protein is one of the essential nutrients required to prevent stunting in children. The results of the Indonesian Nutritional Status Survey (Ministry of Health Republic Indonesia, 2025) indicated that approximately 26,6% of children under two years had not received any animal protein intake at all. Furthermore, according to Alghifari et al. (2025), animal protein intake among families living in rural areas tends to remain lower than the recommended dietary intake established in the Indonesian Recommended Dietary Allowance (RDA). Therefore, educational interventions and improved access to animal protein sources in rural communities are urgently needed to support optimal child growth and reduce the prevalence of stunting.

Chicken liver and anchovies are good sources of animal protein. Chicken liver contains 27.4g of protein, while anchovies contain 10.3g per 100g (Ministry of Health Republic Indonesia, 2018). Both are widely used as food ingredients. Fresh chicken liver cooked at 100°C and Taburia chicken liver have good nutritional value and can be used as food ingredients to prevent stunting (Wardani et al., 2025). Utami et al. (2025) stated that anchovies combined with chicken liver can be a food that prevents stunting due to their very high protein content. Although chicken liver and anchovies are considered excellent sources of protein for stunting prevention and management, their acceptability among the community remains relatively low. This finding is consistent with the study conducted by Putri et al. (2024), which reported that increasing the proportion of chicken liver and anchovies added to rice cake formulations resulted in lower sensory acceptability among consumers.

It is important to note that chicken liver and anchovies are fresh foods that are easily spoiled and therefore have a short shelf life. These two food ingredients only last one day at room temperature. The shelf life of chicken liver and anchovies can be extended by changing the fresh form to a dry form, where there is a fairly high reduction in moisture content. Low moisture content will reduce the availability of free water in food, so that the potential for microbial growth is very small. Pinto et al. (2021) stated that the moisture content of chicken liver powder is relatively low, at 6.1%. Meanwhile, anchovy powder has a moisture content of 8.55% (Windya Kusumaningtyas et al., 2024). Consistent with the findings reported by Putri et al. (2024), the reduction in sensory acceptability is primarily attributed to the intensified fishy or rancid aroma, the development of bitter or excessively salty flavors, a grittier texture, and a darker product appearance as the proportion of chicken liver and anchovies increases in the formulation. Therefore, processing these ingredients into composite powder is expected to enhance consumer acceptability by minimizing unfavorable sensory characteristics while preserving their nutritional value.

Khathir et al. (2021) stated that food ingredients with a moisture content below 10% can have a long shelf life, even up to 32 months. In addition to the type of food ingredient, the type of packaging also affects shelf life. At room temperature, meat packaged in aluminum foil can last for 11 months, while processed fish packaged in aluminum foil can last for 7 months (National Agency of Drug and Food Control, 2024). Another added value resulting from the change in the shape of chicken liver and anchovy from fresh to dried, apart from a longer shelf life, is convenience in distribution. Food ingredients in powder form are lighter and more compact than fresh foods. Sitepu et al. (2022) stated that 250g of chicken liver can be converted into chicken liver powder, weighing between 54.54g to 56.39g, depending on the drying temperature. Meanwhile, Hendrayati et al. (2020) stated that 5,000g of fresh anchovies can be converted into 650–720g of anchovy powder.

The practicality of dried food ingredients and their long shelf life make dried chicken liver and anchovy products a viable source of protein accessible to all groups and regions. The relatively low prices of chicken liver and anchovies make them affordable for a wide range of groups. The prices of chicken liver and anchovies tend to be lower than those of other animal protein sources, such as beef, chicken fillets, or larger sea fish. Chicken liver and anchovy powder, with its better shelf life, affordability (price and region), and easy accessibility, space-saving storing without a refrigerator can be utilized as a food source to prevent and overcome stunting. Therefore, this study aims to identify the physical, chemical, and organoleptic characteristics of chicken liver and anchovy composite powder stored for 4–6 weeks.

## METHOD

This research was an experimental study using a completely randomized design. Three composite chicken liver and anchovy powder formulas were used. These formulations follow research conducted by Wahyuni et al. (2024), which used five combinations of chicken liver and anchovy powder. The other two formulas were not composite powders but were used as individual powders. The ratio of chicken liver and anchovy powder in each formula was as follows: F1 (75:25), F2 (50:50), and F3 (25:75).

Broiler chicken liver (*Gallus gallus domesticus*) and anchovies (*Stolephorus indicus*) were used in their fresh form and obtained from traditional markets. The first stage of this research was the preparation of chicken liver and anchovy powder. The procedure for making both types of powder followed that of Wahyuni et al. (2024), which pretreated fresh chicken liver and anchovy before drying. Fresh chicken liver was thoroughly washed and blanched in boiling water for 5 minutes. After draining, the chicken liver was soaked in lime juice (0.2-0.5% of its initial weight) for one minute. It was then thinly sliced and dried in a tray dryer at 60°C for 24 hours. Fresh anchovies undergo a process of separating the heads and debris, washing, draining, and drying in a tray dryer at 60°C for 24 hours. They are then ground using a hammer mill and then sieved through a 40-mesh sieve.

After the powder is ready, it is blended into a composite powder according to the formula using Philips Blender HR 2115 and packaged in Delcochoice 100-micron-thick laminated aluminum foil packaging. Data collected before storage were analyzed for each characteristic immediately after mixing the powder. Data collected after storage were analyzed for the product that was packaged in laminated aluminum foil, stored at room temperature for 4–6 weeks. The selection of a 4–6 week storage period was based on the susceptibility of dried animal-based products to quality deterioration during storage. Chicken liver contains heme pigments and iron compounds that may accelerate lipid oxidation, while anchovies are rich in unsaturated fatty acids that are prone to oxidative rancidity. It was also observed that microbial counts increased in fish powder stored at room temperature for 30 days in both sealed and non-sealed packaging (Binti et al., 2025).

The chicken liver and anchovy composite powder is then analyzed for its physical characteristics (objective and subjective) and chemical characteristics, both before and after 4–6 weeks of storage. Objective physical characteristics are analyzed using the CIE Lab* (Hunter) method at the Laboratorium Teknologi Pangan of Institut Teknologi Sumatera. Subjective physical (organoleptic) analysis is conducted at the Laboratorium Uji Cita Rasa of the Nutrition Department, Poltekkes Kemenkes Tanjung Karang. Chemical analysis is conducted at the Laboratorium Teknologi Pertanian of the Politeknik Negeri Lampung.

Organoleptic analysis used paired-comparison test and scalar tests. The panelists consisted of 30 individuals who met the inclusion criteria: having passed the panelist selection process, having been exposed to both the paired-comparison test and scalar tests, having previously served as panelists for other research, being in good health, having no known allergies to the product, having the willingness and time to serve as a panelist, not being active smokers, and being adults. A panel size of 30 participants was therefore considered appropriate because it falls within the recommended range for sensory discrimination studies and provides adequate statistical power to detect sensory differences while minimizing random error among panelists. Chemical analysis was performed proximately using methods in accordance with Indonesian National Standards (SNI) for moisture content, ash content, protein content, and fat content. Carbohydrate content was calculated using the by-difference method, where the formula is 100 – (moisture content + ash content + protein content + fat content).

The results were analyzed using a two-way repeated-measures analysis of variance (ANOVA) with a post hoc multiple comparison test (Duncan's Multiple Range Test) at a 95% confidence level for the physical characteristics of color and proximate chemical characteristics due to the normally distributed data. For the organoleptic test, the paired comparison test used a binomial table, while the scalar test used Linear Mixed Effects Model (LMM) with a Bonferroni further test for color and aroma, and non-parametric statistics in the form of a Friedman test with a Wilcoxon further test for texture, because the data were not normally distributed. Data analysis was conducted using statistic application. This research has received approval from the

Research Ethics Commission of Poltekkes Kemenkes Tanjung Karang with ethics code number 477/KEPK-TJK/X/2025.

## RESULTS

In product formulation, the yields obtained differed slightly from those found in the literature. Chicken liver powder had a yield of 15.88%, while anchovy powder had a yield of 7%. This number is significantly lower than the yields of chicken liver powder and anchovy powder, which range between 20.47% (Utami et al., 2025) and 21.73% (Sitepu et al., 2022) at a drying temperature of 50°C.

The type of anchovy used affects the powder yield. Wet anchovies produce a lower yield than dried anchovies. Furthermore, the size of the anchovies and the cleaning process also affect the yield. The cleaning and weeding process, which involves removing the heads and debris from medium to large anchovies, reduces the yield. Differences in drying temperature also affect the yield. Higher temperatures result in a greater reduction in moisture content, thus reducing the product yield. The following is a picture of the two types of powder and the composite powder from the research.


**Figure 1. Chicken liver and anchovy composite powder (A = Chicken Liver Powder, B= Anchovies Powder, C = Composite Powder Formula F1 75:25; F2 50:50; F3 25:75)**

### Physical characteristic

The results of physical characteristics (color) in chicken liver and anchovy composite powder can be seen in Table 1. Color measurement using the Hunter Lab system provides three main parameters, namely L*, which describes the level of brightness, a* (describing the color towards red-green), and b* (describing the color towards yellow-blue). Table 1 shows that Formula F1 demonstrated the lowest brightness level and Formula F3 demonstrated the highest. The brightness levels of each formula were significantly different (p<0,05). This indicates that the composition of the composite powder formula influences the brightness level of the product.

**Table 1. Color properties of chicken liver and anchovy composite powder before and after storage (means ± SD)**

| Formula | | Hunter test | | |
|---|---|---|---|---|
| | | L* | a* | b* |
| F1 | Before | 72.57 ± 0.04$^{a}$ | 2.84 ± 0.05$^{d}$ | 15.79 ± 0.04$^{e}$ |
| | After | 72.71 ± 0.21$^{a}$ | 2.38 ± 0.02$^{c}$ | 15.09 ± 0.08$^{d}$ |
| F2 | Before | 73.28 ± 0.18$^{b}$ | 3.14 ± 0.04$^{e}$ | 16,42 ± 0,06$^{f}$ |
| | After | 73.85 ± 0.08$^{c}$ | 1.28 ± 0.04$^{b}$ | 13.64 ± 0.03$^{c}$ |
| F3 | Before | 76.48 ± 0.03$^{d}$ | 0.83 ± 0.04$^{a}$ | 12.05 ± 0.05$^{b}$ |
| | After | 76.55 ± 0.29$^{d}$ | 0.84 ± 0.03$^{a}$ | 11.88 ± 0.05$^{a}$ |

$^{a, b, c, d, e}$ Means within each column having different superscripts are significantly different (P < 0.05).
L* (Lightness): Represents the intensity of light.
a* (Red/Green Value): Represents the color's position on the red-green axis.
b* (Blue/Yellow Value): Represents the color's position on the yellow-blue axis.
F1, F2, F3: chicken liver and anchovy composite powder formula which F1 (75:25); F2(50:50); F3(25:75)

A positive Hunter a* value indicates a tendency toward red. Table 1 shows that the color of all three samples showed positive results, but with low values. The reddish color of the product tended to be faint. Formulation and storage influenced the a* color of the chicken liver and anchovy composite powder. Only Formula F3 remained stable and did not change. A positive Hunter b* value indicates a tendency toward yellow. It can be seen that formulation and storage also significantly affect the intensity of the b* color in the composite powder of chicken liver and anchovy.

## Sensory evaluation

### Paired comparison test

The paired comparison test is a discriminatory test that aims to determine whether panelists can differentiate between two samples based on specific sensory characteristics, such as color, aroma, or texture (Kusuma et al., 2017). In this test, each panelist is asked to choose one of two samples with the stronger intensity according to the tested characteristic.

Table 2 shows the results of the paired comparison test between composite powder that had been stored for 4 weeks and composite powder without storage. For the paired comparison test, at a confidence level 95% with 30 panelists, the minimum number of answers indicating a significant difference was 20. If more than 20 panelists chose a particular sample, the difference was significant. If the number is below 20, it means the product is considered the same.

**Table 2. Paired comparison test for chicken liver and anchovy composite powder before and after storage**

| Sensory characteristics | Formula (Before and After) | | |
|---|---|---|---|
| | F1 | F2 | F3 |
| Color | 28 | 18 | 12 |
| Aroma | 26 | 22 | 19 |
| Texture | 13 | 11 | 12 |

Storage affected the color and aroma of F1 and the aroma of F2, while no changes were observed in F3. The texture of all formulations remained unchanged after storage. Regarding aroma, F3 was the most stable after storage, as there was no significant change in the aroma of F3 before and after storage. For F1 and F2, there were significant changes in aroma due to storage. The aroma after storage tended to be stronger than before storage.

### Scalar test

The results showed that formulation significantly affected the color of the product ($p<0.05$), while storage had no significant effect on color ($p>0.05$). Formulas F1 and F2 tended to have a brown color, whereas F3 appeared brownish-white. A higher proportion of anchovy powder resulted in a lighter brownish-white color. Formulation did not affect the aroma of the composite powder before storage. However, after storage, Formula F2 showed a more stable aroma compared to the other formulations. Both formulation and storage affected the texture of the chicken liver and anchovy composite powder. Formula F1 had the lowest texture score, while Formula F3 had the highest. Increasing the proportion of anchovy powder produced a smoother texture.

**Table 3. Scalar test for chicken liver and anchovy composite powder before and after storage (Mean ± SD)**

| Sensory characteristics | | Formula | | |
|---|---|---|---|---|
| | | F1 | F2 | F3 |
| Color | Before | 4.39 ± 3.05$^{ab}$ | 5.05 ± 2.99$^{b}$ | 7.34 ± 2.40$^{c}$ |
| | After | 2.04 ± 2.22$^{a}$ | 4.37 ± 3.11$^{ab}$ | 7.55 ± 1.33$^{c}$ |
| Aroma | Before | 6.96 ± 2.15$^{a}$ | 5.77 ± 2.85$^{a}$ | 4.92 ± 3.31$^{a}$ |
| | After | 3.32 ± 2.73$^{b}$ | 4.89 ± 3.21$^{a}$ | 3.83 ± 3.19$^{b}$ |
| Texture | Before | 4.44 ± 3.12$^{a}$ | 5.53 ± 3.04$^{bc}$ | 7.04 ± 2.62$^{e}$ |
| | After | 3.95 ± 2.84$^{a}$ | 4.15 ± 2.98$^{ab}$ | 6.27 ± 2.67$^{cd}$ |

$^{a, b, c, d, e}$ Means within each column having different superscripts are significantly different ($P < 0.05$).
F1, F2, F3: chicken liver and anchovy composite powder formula which F1 (75:25); F2(50:50); F3(25:75)

### Chemical properties

The results of the proximate analysis of the composite powder of chicken liver and anchovies can be seen in Table 4. This table shows that the composite powder has a low moisture content (below 10%), high protein content (above 60%), and moderate fat content (4-5%). Proximate analysis results demonstrated that formulation significantly affected nutritional composition.

Before storage, ANOVA revealed significant differences among formulas for all proximate parameters ($p < 0.05$). Post hoc analysis showed that moisture content decreased significantly from F1 to F3, with F3 (4.50 ± 0.01$^{a}$) having the lowest value. Ash content differed significantly among formulas, with F3 (3.80 ± 0.02$^{e}$) showing the highest mineral content. Protein content increased significantly across formulations, where F3 (62.25 ± 0.32$^{c}$) was significantly higher than F1 and F2. Lipid content followed a similar trend, while carbohydrate content decreased significantly from F1 (25.55 ± 0.04$^{d}$) to F3 (22.35 ± 0.24$^{b}$), indicating a statistically significant inverse relationship with protein and lipid contents.

**Table 4. Chemical properties of chicken liver and anchovy composite powder before and after storage per 100g product (Mean ± SD)**

| Formula | Nutritional composition | | | | |
|---|---|---|---|---|---|
| | Moisture content (g) | Ash content (g) | Protein content (g) | Lipid content (g) | Carbohydrate content (g) |
| Before | | | | | |
| F1 | 4.94 ± 0.00$^{c}$ | 3.20 ± 0.00$^{a}$ | 60.36 ± 0.04$^{a}$ | 5.95 ± 0.01$^{a}$ | 25.55 ± 0.04$^{d}$ |
| F2 | 4.72 ± 0.10$^{b}$ | 3.33 ± 0.02$^{b}$ | 61.40 ± 0.37$^{b}$ | 6.23 ± 0.05$^{b}$ | 24.33 ± 0.40$^{c}$ |
| F3 | 4.50 ± 0.01$^{a}$ | 3.80 ± 0.02$^{e}$ | 62.25 ± 0.32$^{c}$ | 7.11 ± 0.05$^{c}$ | 22.35 ± 0.24$^{b}$ |
| After | | | | | |
| F1 | 5.27 ± 0.07$^{d}$ | 3.45 ± 0.06$^{c}$ | 60.66 ± 0.55$^{ab}$ | 6.17 ± 0.13$^{ab}$ | 24.45 ± 0.82$^{c}$ |
| F2 | 5.38 ± 0.03$^{d}$ | 3.72 ± 0.04$^{d}$ | 62.42 ± 0.09$^{c}$ | 7.32 ± 0.15$^{c}$ | 21.17 ± 0.25$^{a}$ |
| F3 | 5.32 ± 0.06$^{d}$ | 3.75 ± 0.04$^{de}$ | 62.68 ± 0.09$^{c}$ | 7.74 ± 0.15$^{d}$ | 20.51 ± 0.27$^{a}$ |

$^{a, b, c, d, e}$ Means within each column having different superscripts are significantly different ($P < 0.05$).
F1, F2, F3: chicken liver and anchovy composite powder formula which F1 (75:25); F2(50:50); F3(25:75)

After 6 weeks of storage, ANOVA confirmed that storage significantly influenced moisture, ash, lipid, and carbohydrate contents ($p < 0.05$), whereas protein content remained relatively stable. Post hoc comparisons indicated no significant difference in moisture content among formulas after storage, as all treatments shared the same superscript ($^{d}$). In contrast, ash content remained significantly different, with F3 (3.75 ± 0.04$^{de}$) maintaining the highest value. Protein content in F2 and F3 (both $^{c}$) was significantly higher than in F1, indicating better protein retention in formulas with higher animal-protein proportions. Lipid content increased significantly during storage, with F3 (7.74 ± 0.15$^{d}$) remaining significantly higher than the other formulas. Conversely, carbohydrate content decreased significantly after storage, with F2 and F3 showing no significant difference from each other ($^{a}$), but significantly lower values than F1.

Overall, the ANOVA and post hoc analyses confirmed that formulation type had a stronger effect than storage on protein content, while storage predominantly affected moisture, lipid, and carbohydrate fractions. Overall, F3 consistently demonstrated the most favorable nutritional composition among all formulations, showing significantly higher nutritional values ($p < 0.05$) both before and after storage for Ash, protein, and lipid.

## DISCUSSION

### Physical properties

Modern food color research emphasizes that *L, a*, b* measurements provide objective data on product appearance that correlate with consumer perception and product quality. Hunter Lab instruments (or similar spectrophotometers) are standard in food powder analysis, enabling precise brightness and chromaticity values that can be statistically compared across formulas and processing conditions (Hunter Lab, 2025).

The data in Table 1 show that F3 had significantly higher L* values than F1 and F2 both before and after storage**,** indicating that F3 appeared visually brighter or lighter. In contrast, F1 had the lowest brightness values, suggesting a comparatively darker appearance. Higher L* values generally reflect greater light reflectance by the powder's surface, which can be influenced by particle size, surface texture, and the pigmentation of raw materials (Hunter Lab, 2025; Yian & Phing, 2020). In composite powders like those studied here, increased brightness in formulas with greater anchovy content may result from the lighter physical color of dried fish proteins compared with the deeper red/brown pigments associated with liver tissue.

The effects of storage on brightness were also notable. L* values increased modestly after storage, particularly in F2, suggesting changes in surface light reflectance possibly due to particle rearrangement or slight oxidation that can alter powder optical properties over time. Although color changes during storage are complex and influenced by multiple reactions, instrumental studies in other food systems have shown that auxiliary color changes often accompany storage due to Maillard browning, pigment degradation, or oxidation, which influence L* dynamics over time (Bassey et al., 2013).

All formulas exhibited positive a***** values, indicating a *reddish hue* rather than green, consistent with the presence of muscle and heme pigments in chicken liver and the natural flesh color of anchovy proteins. However, the a***** values were relatively low overall, showing only modest red intensity. This reflects typical observations in powdered protein products where intense chromatic pigments are diluted during drying and grinding (e.g., commercial plant and protein powders show variation but generally limited redness compared to whole muscle foods) (Baye & Mekonone, 2025).

The significant differences in a* among formulas before and after storage imply that both formulation composition and storage time affect redness**.** In F3, the a* values remained relatively stable, suggesting that its balance of ingredients and possibly lower pigment reactivity contributed to chromatic stability. Changes in redness during storage, shown by lower a* in some formulas, may be influenced by oxidative reactions of heme proteins and lipid oxidation products, which can subtly reduce red chromaticity over time. Such color alterations due to oxidation are well documented in powdered and dried food products during extended storage (Yadav et al., 2018).

All measured b* values were positive, indicating a tendency toward yellow coloration, which is typical for dried protein and fish powders where protein–lipid complexes and Maillard reaction products contribute to moderate yellowness. Yellowness is often associated with natural pigments and processing effects, including drying and heat exposure, which can generate yellow–brown hues in powders and flours (Yian & Phing, 2020).

The observed decreases in b* after storage for some formulas suggest that storage processes, possibly involving oxidation or slight pigment degradation, can alter yellow chromaticity. This aligns with findings from other studies where prolonged storage influenced color parameters in powdered foods through chemical changes, including pigment oxidation and nonenzymatic browning reactions (Yadav et al., 2018).

In the case of the chicken liver and anchovy composite powder, Formulation differences (i.e., how much of each ingredient is included) affected how light was scattered and reflected from the powder surface, explaining why F3 (with presumably more anchovy or lighter components) had higher L* and lower a* and b*. Storage influenced both L* and chromatic parameters, likely due to subtle chemical changes such as lipid oxidation and protein–sugar interactions, which can alter pigment states and thus the visual appearance of powders over time (Giannakourou et al., 2025).

**Sensory evaluation**

**Paired comparison test**

The paired comparison test is a discriminative sensory method used to determine whether panelists can perceive a difference between two samples based on a specific sensory attribute, such as color, aroma, or texture. In this method, panelists are presented with two coded samples simultaneously and are required to select the sample that shows a stronger intensity of the evaluated characteristic. This test is particularly suitable for evaluating changes caused by processing or storage, as it is simple, sensitive, and can be performed using untrained panelists (ABNT NBR ISO 20613, 2019).

Based on the results shown in Table 2, Formula F1 exhibited a significant difference in color between samples before and after storage, as 28 out of 30 panelists perceived a difference. This indicates that storage significantly affected the color of F1, with the product tending to become darker after 4 weeks. Such changes are commonly associated with oxidative reactions, pigment degradation, or non-enzymatic browning, which may occur during the storage of protein-rich powders (Mutamimah et al., 2023).

In contrast, Formulas F2 and F3 did not show significant color differences, as the number of panelists reporting differences (18 and 12, respectively) was below the critical value. This suggests that the color of F2 and F3 remained relatively stable during storage, likely due to differences in formulation composition that contributed to greater color stability.

For the aroma attribute, Formulas F1 and F2 showed significant differences between samples before and after storage, with 26 and 22 panelists, respectively, detecting a change. This indicates that storage influenced the aroma profile of these formulas, with panelists perceiving the aroma after storage as stronger. The increase in aroma intensity may be attributed to the formation of volatile compounds resulting from lipid oxidation or protein degradation, processes that commonly occur during storage of animal-based powders (Mutamimah et al., 2023).

Conversely, Formula F3 demonstrated the greatest aroma stability, as only 19 panelists reported a difference, which is below the significance threshold. This finding suggests that the formulation of F3 was more resistant to aroma changes during storage, possibly due to a lower susceptibility to oxidative reactions or a more balanced ingredient composition.

The paired comparison test results also showed that storage did not significantly affect the texture of any of the three formulas. Only 11–13 panelists reported texture differences between samples before and after storage, indicating that the powders were perceived as texturally similar. After 4 weeks of storage, all composite powders remained smooth, free-flowing, non-clumping, and easily separable, reflecting good physical stability during storage. This result suggests that the packaging and storage conditions were effective in maintaining powder texture, which is a critical quality parameter for powdered food products (Mutamimah et al., 2023).

Overall, the paired comparison test demonstrated that storage affected specific sensory attributes of chicken liver and anchovy composite powders, particularly color and aroma, depending on the formulation. Formula F1 was the most sensitive to color changes, while F3 exhibited the greatest stability in aroma and texture. These findings confirm that the paired comparison test is a valuable sensory tool for detecting formulation and storage-related changes in composite powder products and complements instrumental analyses in assessing product quality and stability.

**Scalar test**

In the color evaluation, Formula F1 and F2 consistently showed lower scores, indicating a stronger tendency toward brown coloration, whereas Formula F3 showed the highest scores both before and after storage, reflecting a lighter, brownish-white appearance. This finding is closely related to the composition of the composite powder, as F3 contained a higher proportion of anchovy powder (75%) compared to chicken liver powder (25%). Anchovy powder generally exhibits a lighter visual appearance after drying and grinding, whereas chicken liver contains higher levels of heme pigments that contribute to darker brown coloration. Therefore, increasing the proportion of anchovy powder resulted in a perceptibly lighter color, consistent with previous findings that ingredient composition strongly affects color intensity in composite food powders (Sitepu et al., 2022; Windya Kusumaningtyas et al., 2024).

The aroma scale ranged from pungent (0) to savory (10). Before storage, all formulas exhibited aroma scores trending toward the savory end of the scale, and no significant effect of formulation on aroma intensity was observed, indicating that panelists perceived similar aroma profiles among formulas at the initial stage. After storage, however, aroma scores generally decreased, indicating a slight shift toward more pungent characteristics.

Statistical analysis showed that storage influenced aroma perception, while formulation effects became apparent after storage, with Formula F2 maintaining a relatively stable aroma intensity. Changes in aroma during storage are commonly associated with the formation of volatile compounds resulting from lipid oxidation and protein degradation, particularly in animal-based powders. Such changes can increase pungent or off-odor notes over time, reducing perceived savory intensity (Qu et al., 2021).

Texture was evaluated on a scale ranging from very coarse (0) to very fine (10). The results demonstrated that both formulation and storage significantly influenced texture intensity. Formula F1 consistently showed the lowest texture scores, indicating a coarser perception, whereas Formula F3 showed the highest scores, indicating a smoother and finer texture both before and after storage.

The smoother texture observed in F3 can be attributed to the higher proportion of anchovy powder, which likely produced finer particles and a more uniform powder structure compared to chicken liver powder. In powdered food systems, particle size distribution and ingredient composition strongly influence tactile perception, with finer particles contributing to smoother mouthfeel and handling properties. Storage slightly reduced texture scores in all formulas, but the overall perception remained within the smooth range, suggesting good physical stability of the composite powders during storage (Granato et al., 2017)

**Chemical properties**

**Moisture content**

Moisture content is a key quality parameter in powdered complementary foods (*MP-ASI*), as it directly affects microbial stability, shelf life, nutrient concentration, and reconstitution properties. Low moisture content in powdered foods helps suppress microbial growth and reduces water activity (*aw*), which is essential for food safety, particularly in complementary foods intended for infants aged 6–24 months, where contamination risk must be minimized (Moriconi et al., 2023).

In this study, the composite powder formulations exhibited low initial moisture contents (4.94 ± 0.00, 4.72 ± 0.10, and 4.50 ± 0.01 g/100 g), which are well below the typical wisdom threshold (<10%) for stable powdered foods and align with moisture levels seen in other high-quality complementary formulations (<5%) (Ali, 2023). Such low moisture content is crucial because elevated moisture can accelerate microbial growth and spoilage, ultimately compromising product safety and lowering nutrient availability, both of which are linked to poor growth outcomes when these foods are used in infant feeding programs.

After 4–6 weeks of storage, the moisture content increased slightly to 5.27±0.07, 5.38±0.03, and 5.32±0.06g/100g, likely due to moisture adsorption from the environment, a common phenomenon in hygroscopic powders stored at room temperature. Although the increase was statistically significant, values remained low and within acceptable ranges for powdered complementary foods, suggesting good physical stability even after storage. This is important for products targeted at stunting prevention, as maintaining a low moisture content during distribution and storage enhances safety and nutrient integrity, critical factors for infants at risk of growth faltering (Pawar & Thompkinson, 2016).

From a nutritional standpoint, moisture content directly influences the concentration of macronutrients per serving. Low moisture ensures that protein and micronutrients remain concentrated on a dry weight basis, thereby enhancing the nutrient density of complementary foods, a known determinant of better linear growth and reduced stunting risk when introduced appropriately in the critical 6–24 months period. Research demonstrates that optimized complementary feeding interventions that improve nutrient density correlate with improved growth outcomes and lower stunting prevalence in resource-limited settings (Lassi et al., 2013).

Standards for complementary foods also emphasize appropriate moisture levels. While specific moisture limits for *MP-ASI* may vary by regional standards, Codex and infant formula guidelines suggest low moisture (<5%) to ensure microbiological safety and physical stability in powder products (Ali, 2023). Indonesian National Standards (SNI) for instant complementary foods include methods for moisture determination and implicitly require moisture control as part of hygienic and safe production processes (Badan Standarisasi Nasional, 2005).

Overall, the moisture content results in this study confirm that the composite powders exhibit low and stable moisture profiles both before and after storage, supporting their suitability as safe, nutrient-dense *MP-ASI* products. These characteristics are critical in ensuring that powdered complementary foods retain nutrient quality and safety during shelf life, thereby supporting efforts to improve nutrient intake and reduce stunting risks in infants.

**Ash content**

Ash content represents the total inorganic residue remaining after complete combustion of organic matter and serves as an indirect indicator of the total mineral content in food products. Minerals such as calcium, phosphorus, iron, zinc, potassium, and magnesium play essential roles in growth, bone development, enzymatic activity, and immune function, making ash content particularly relevant in foods intended for nutritional interventions, including stunting prevention.

In the present study, ash content before storage ranged from 3.20±0.00g to 3.80±0.02g, while after 4–6 weeks of storage, it increased slightly to 3.45±0.06g to 3.75±0.04g. Statistical analysis indicated that formulation significantly influenced ash content, with higher values observed in formulations containing a greater proportion of anchovy powder. This finding is consistent with previous studies reporting that small marine fish, especially when processed whole, contribute higher mineral concentrations, particularly calcium and phosphorus, due to the inclusion of bones and scales (Gbogbo et al., 2018; Windya Kusumaningtyas et al., 2024).

The increase in ash content after storage does not necessarily indicate mineral gain but is more likely associated with relative concentration effects, resulting from minor changes in moisture or organic fractions during storage. Similar trends have been reported in powdered animal-source foods, where storage may slightly alter proximate composition percentages without compromising nutritional quality (Pinto et al., 2021; Khathir et al., 2021). The increase in ash content with higher anchovy powder concentration may be associated with the mineral-rich composition of anchovies, particularly calcium and phosphorus derived from the edible fish bones. Adequate mineral intake is important for bone growth and skeletal development, which are closely related to the prevention of growth retardation and stunting in children.

From a nutritional perspective, the ash content values observed in this study fall within acceptable ranges for protein-rich powdered foods and support the product's role as a mineral source. According to the World Health Organization (WHO), adequate intake of minerals such as calcium, iron, and zinc during the first 1,000 days of life is critical for preventing growth faltering and impaired cognitive development (World Health Organization, 2023). Furthermore, Indonesian National Standards (SNI) for powdered complementary foods emphasize the importance of sufficient mineral content while maintaining product safety and stability (Badan Standarisasi Nasional, 2005).

Importantly, none of the ash values exceeded levels that might indicate contamination or excessive inorganic residue, suggesting that the processing method and packaging were appropriate. Overall, the consistently higher ash content in formulations with greater anchovy proportions highlights their potential contribution to mineral adequacy, reinforcing the suitability of chicken liver–anchovy composite powder as a locally sourced food ingredient for stunting prevention programs. Sejati et al. (2025) stated that 75g of chicken liver and 25g of anchovy composite powder contain iron and zinc, which meet the needs of toddlers, and thus can be used to overcome stunting.

**Protein content**

Protein is a fundamental macronutrient critical for growth, tissue synthesis, immune function, and overall development during infancy and early childhood. During the complementary feeding (*MP-ASI*) period (6–23 months), protein needs increase because breast milk alone becomes insufficient to meet the rising nutrient and energy requirements necessary for optimal growth and prevention of growth faltering, such as stunting. According to the WHO, complementary foods should provide adequate protein, energy, and micronutrients to fill nutrient gaps as breast milk intake declines after 6 months of age. Failure to meet these needs can lead to poor growth outcomes, including stunting (World Health Organization, 2023).

In this study, the chicken liver and anchovy composite powders demonstrated high protein content across all formulations: 60.36±0.04 to 62.25±0.32g/100g before storage, which remained stable after 4–6 weeks of storage (60.66±0.55 to 62.68±0.09g/100g). Although the protein content of the chicken liver and anchovy composite powder is slightly lower than that of Utami et al. (2025), 65.58g per 100g, the results of this research are still considered high. These values indicate that the composite powders are protein-dense food matrices, making them promising candidates for nutrient-rich complementary foods. Higher protein content is desirable because protein concentrates bulk nutrient intake in small serving sizes, which is particularly important in complementary feeding, where stomach capacity in infants is limited (World Health Organization, 2023).

High protein content from animal-source foods is especially beneficial because animal proteins provide complete profiles of essential amino acids that are more readily utilized by the body for growth and linear development compared to some plant proteins. This biological quality supports catch-up growth and healthy linear growth, reducing risks of stunting if protein adequacy is maintained. Research shows that inadequate protein intake in toddlers is significantly associated with higher odds of stunting, emphasizing the importance of protein-rich complementary feeding practices (Amalia et al., 2022).

Moreover, maintaining protein stability after storage is important for *shelf-stable* complementary food products. Nutrient degradation during storage can reduce the efficacy of *MP-ASI* formulations to meet daily nutrient needs. The relatively stable protein content observed suggests that the composite powders can maintain nutrient density during typical storage periods, which supports their practical use in community nutrition programs and household feeding practices. So, it may be suitable for household-level storage and distribution, particularly in regions with limited access to fresh animal-source foods or refrigeration facilities.

WHO guidelines for complementary feeding emphasize not only the timely introduction of *MP-ASI* from 6 months of age but also that these foods be nutrient-dense and adequate in protein to support energy, protein, and micronutrient needs for growth and development. Providing nutrient-dense complementary foods with sufficient protein is essential to help fill nutrient gaps and may contribute to improved growth outcomes and lower prevalence of stunting in infants and young children.

In conclusion, the high and stable protein content demonstrated in this study aligns with global recommendations for nutrient-dense complementary foods and supports their potential role in preventing stunting by ensuring that infants and young children receive adequate amounts of quality protein during the critical first 1,000 days of life.

**Lipid content**

Lipid (fat) content is an essential component of complementary foods (*MP-ASI*) because fats provide concentrated energy, essential fatty acids, and facilitate the absorption of fat-soluble vitamins (A, D, E, K), all of which are crucial for infant growth and neurodevelopment. During the transition from exclusive breastfeeding to complementary feeding (typically starting at 6 months), the energy and nutrient demands of infants increase substantially. Fats contribute significantly to meeting these increased energy requirements, especially when gastric capacity is limited, as infants need nutrient-dense foods to support linear growth and prevent stunting. World Health Organization complementary feeding guidelines emphasize that complementary foods should be energy- and nutrient-dense to help fill the nutritional gap left by declining breast milk intake. Although specific numeric fat recommendations vary, WHO and national standards underscore the importance of adequate fat alongside protein and micronutrients in complementary foods (World Health Organization, 2023).

In this study, the chicken liver and anchovy composite powders showed increasing lipid content across formulations, from 5.95±0.01g to 7.11±0.05g/100g before storage and further increases after storage up to 7.74±0.15g/100g. The upward trend reflects the higher proportion of anchovy, a naturally lipid-rich marine animal source, in the composite formulations. These fat levels are within ranges that can meaningfully contribute to infant energy needs without compromising product quality (Badan Standarisasi Nasional, 2005). Adequate dietary fat in *MP-ASI* is particularly important given that infants and young children require a higher proportion of energy from fats relative to adults to support rapid growth, brain development, and immune function.

Recent research on small-quantity lipid-based nutrient supplements (SQ-LNS) supports the critical role of lipids in complementary feeding. SQ-LNS products, which are fortified with lipids and micronutrients, have been shown to increase overall energy and macronutrient intakes in infants consuming complementary foods, thus contributing to improved growth outcomes and a lower incidence of stunting when integrated into feeding programs. For example, lipid-based supplements provided during complementary feeding improved linear growth and reduced stunting rates compared with controls in multiple settings, reinforcing the importance of dietary fats in early nutrition interventions (Adu-Afarwuah et al., 2016).

From a physiological perspective, incorporating adequate lipids in complementary diets supports more than just caloric intake. Essential fatty acids in fats such as omega-3 and omega-6 play roles in brain and retinal development and modulate inflammatory pathways. Studies have linked improved fat intake in young children to better developmental outcomes and reduced growth faltering when provided as part of nutrient-dense feeding regimens during the critical first 1,000 days (Bala et al., 2024). This underscores why global and national guidelines recommend that *MP-ASI* contain sufficient healthy fats alongside proteins and micronutrients to meet the complex needs of infants transitioning to family foods.

In summary, the observed lipid contents in the chicken liver and anchovy composite powders are not only consistent with recommended nutrient-dense profiles for complementary foods but may also contribute positively to energy adequacy and growth outcomes when used in infant feeding programs aimed at preventing stunting. Ensuring adequate fat in *MP-ASI* formulations is essential for achieving both nutrient density and developmental support during this crucial period of infant growth.

**Carbohydrate content**

Carbohydrates are a major source of energy in complementary foods (*MP-ASI*) and play an important role in supporting the metabolic demands of infants during rapid growth. Adequate energy intake from carbohydrates, in combination with proteins and fats, is essential for maintaining positive energy balance, supporting physical activity, and promoting linear growth, key factors in the prevention of stunting. In the complementary feeding period (typically 6–23 months), infants require nutrient-dense foods that provide sufficient energy per unit volume because their gastric capacity is limited and they cannot consume large quantities of food at a single feeding.

In this study, the carbohydrate content of the chicken liver and anchovy composite powders ranged from 25.55±0.04g to 22.35±0.24g per 100g before storage and decreased slightly to 24.45±0.82g to 20.51±0.27 g per 100g after 4–6 weeks of storage. The observed trend of decreasing carbohydrate content from Formulations F1 to F3 reflects the inverse relationship between carbohydrate and protein/lipid fractions in the proximate composition. As the proportion of anchovy and liver (rich in protein and fat) increases, the relative carbohydrate content tends to decrease. This phenomenon is common in high-protein/premium complementary formulations where macronutrient priorities are shifted toward protein and lipids to enhance growth support (Li et al., 2023).

The slight reduction in carbohydrate content after storage may be associated with minor biochemical changes, moisture redistribution, or analytical variation, but the changes observed remain within acceptable ranges for complementary foods intended to provide energy without compromising safety. Furthermore, carbohydrate levels in the range observed in this study are comparable to those in other nutrient-dense complementary food powders and are consistent with the emphasis on balanced macronutrient profiles needed for infant growth.

From a nutritional standards perspective, complementary feeding guidelines by the World Health Organization emphasize that energy from complementary foods should complement the energy provided by breast milk to meet the total energy requirements of infants. WHO recommends that complementary foods be energy-dense (≥0.8kcal/g), with contributions from carbohydrates, proteins, and fats that together help fill the energy gap that emerges after 6 months of age (World Health Organization, 2023). Similarly, Indonesian National Standards (SNI) for powdered complementary foods encourage formulations that ensure adequate energy and macronutrient provision aligned with the dietary needs of infants. Although SNI does not prescribe specific carbohydrate percentages, it emphasizes the need for balanced nutrient profiles that support growth and development (Badan Standarisasi Nasional, 2005).

Carbohydrates in *MP-ASI* also contribute to palatability and texture, improving acceptability and intake among infants — a critical factor since poor acceptance can limit energy consumption and increase risk of growth faltering. Diets that fail to provide adequate energy, including insufficient carbohydrate contribution, have been linked to poor growth outcomes, including stunting, particularly where complementary feeding practices are suboptimal (Harrison et al., 2023).

In summary, the carbohydrate contents observed in the chicken liver and anchovy composite powders provide a meaningful contribution to energy density in these formulations while maintaining an appropriate balance with protein and lipid content. This balance aligns with global recommendations for complementary feeding and supports the role of these composite powders as nutrient-dense *MP-ASI* products that may help prevent stunting by ensuring infants receive adequate energy during critical periods of growth.

## CONCLUSION

The chicken liver and anchovy composite powder demonstrated good nutritional quality, physical stability, and acceptable sensory characteristics, indicating its potential use as a nutrient-dense complementary food (*MP-ASI*). All formulations showed low moisture content and high protein levels, supporting product stability and suitability for infant feeding. Increasing anchovy proportions enhanced protein, lipid, and mineral contents, while carbohydrate levels decreased, resulting in a more energy- and nutrient-dense profile. Storage caused slight changes in moisture, lipid, and carbohydrate contents but did not significantly compromise overall quality. Among the formulations, Formula F3 showed the most favorable nutritional profile and is considered the most promising formulation for supporting complementary feeding strategies aimed at stunting prevention.

## AUTHOR’S DECLARATION

### Authors’ contributions and responsibilities

**NIPS**: Writing original draft, visualization, funding acquisition, conceptualization; **ESW**: Assisted in data collection and manuscripts revision; **BB**: Assisted in data collection; **DF**: assisted in data collection and provide resources.

**Availability of data and materials**
All data are available from the authors.

**Competing interests**
All authors have no competing interests.

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