**Food Research 7 (Suppl. 5) : 38 - 45 (2023)**
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

# Nutritional and antioxidant content in complementary feeding from soybeans and dragon fruit peel

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***Article history:***
Received: 29 June 2023
Received in revised form: 2 December 2023
Accepted: 13 December 2023
Available Online: 25 December 2023

***Keywords:***
Complementary feeding,
Dragon fruit peel,
Malnutrition,
Soybean powder,
Stunting

***DOI:***
https://doi.org/10.26656/fr.2017.7(S5).11

**Abstract**

Infants aged 6-24 months can be given complementary feeding to fulfil their nutritional needs. Giving complementary feeding on time can prevent infants from malnutrition. Malnutrition in the long term can increase the risk of stunting. The Indonesian government implements a malnutrition prevention program in the form of complementary feeding in infants. Complementary feeding can be made from a mixture of several food ingredients in order to obtain a product with high nutritional value. The purpose of this study was to determine the effect of the ingredient formulation on the nutritional and antioxidant content of complementary feeding from soybeans and dragon fruit peels. Complementary feeding was made from soybean powder, milk powder, dragon fruit peel extract and sugar. The research treatment was the ratio of soy powder and milk powder (1:1, 5:9, 9:5). The results showed that the ratio of soy powder and milk powder had an effect on the ash, protein, carbohydrates, vitamin C, total phenol and antioxidants, but had no effect on fat and moisture of complementary feeding. The complementary feeding contains 2.62-2.91% moisture, 15.51-15.60% fat, 4.28-5.05% ash, 16.28-20.60% protein, 58.62-61.00% carbohydrates, 27.91-35.30 mg/100 g vitamin C, 0.28-0.35% total phenol and 65.89-68.02% antioxidants. Soybeans are a good source of protein to increase protein content in complementary feeding. In addition to protein, infants who malnutrition also need antioxidant to prevent inflammation. Antioxidants in complementary feeding formulas are obtained from several nutrients that have antioxidant activity such as vitamin C and phenols. Milk provides vitamin C, while phenols come from soybeans. The use of dragon fruit peel also contributes antioxidants derived from anthocyanin pigments and phenols. Additionally, the use of dragon fruit peel is able to cover the beany aroma of soybeans, provide red color and a thick texture.

## 1. Introduction

Complementary feeding is any food or drink other than breast milk that is nutritious and given to infants to achieve nutritional adequacy. The complementary feeding period from 6 to 24 months become an important part of the first 1000 days of life. Inappropriate feeding practice affect in many aspects of life like organ development, growth, and metabolism, which have long-term effects on development and health. The aim of complementary feeding is to prevent malnutrition, including wasting, overweight, stunting and obesity (Michaelsen *et al*., 2017). Malnutrition prevalence is still high and spread in several provinces in Indonesia. A recent study from Indonesia showed that in 1993 to 2007, children from 2 to 5 years old are being at risk of obese, being overweight or overweight that has body mass index (Z-scores) +1 from 10.3% to 16.5% (Rachmi *et al*., 2016). Malnutrition cases are still high, making the Indonesia's government to implement malnutrition prevention programs. One of the programs is the complementary feeding of breast milk, mainly for children under five from poor families who have malnutrition. Biscuits is one form of complementary feeding program which are distributed by the central government to all districts in Indonesia (Sumantri *et al*., 2021).

There are four requirements of complementary feeding: 1. must introduced when the need for energy and nutrients exceeds what can be provided through exclusive breastfeeding, 2. provide sufficient energy, protein and micronutrients to fulfil child's nutritional need, 3. hygienically stored and prepared, and fed with

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eISSN: 2550-2166 
Published by Rynnye Lyan Resources

clean hands using clean utensils and not bottles and teats, and 4. given consistent with a child's signals of appetite and satiety, and that meal frequency and feeding are suitable for age (World Health Organization and UNICEF, 2003). Complementary feeding can be a mixture of several food ingredients in a certain ratio so that it is a product with a high value. Instant complementary food powder can be made from cereals, tubers, nuts, seeds (soybeans, peanuts), milk, fish, meat, poultry, fruit and or other suitable food ingredients (Mufida *et al*., 2015). Food sources of protein include chicken meat (Karwanti *et al*., 2023), chicken eggs (Agustono *et al*., 2022; Lokapirnasari *et al*., 2022), meat and egg of quail (Lokapirnasari *et al*., 2018; Lovela *et al*., 2023; Lokapirnasari *et al*., 2023).

Soybeans are a good source of protein, cheap and easy to be processed into complementary feeding. Soybean powder contains 35.9% protein, 20.6% fat, 29.9% carbohydrates and 2.6 mg/100g zinc. The combination with dragon fruit extract aims to reduce the unpleasant aroma of soybeans, gives natural dyes and as a fortification of vitamin C. Complementary feeding from sorghum, yam bean and soybean with ratio 60:20:20 had the highest crude fat, energy, mineral contents and lowest antinutrient contents. This formulation had also shown a good level of functionality with favour to water absorption, bulk density, gelling temperature and swelling (Abolaji *et al*., 2019). Soybean as complementary feeding main ingredients gives improvement in the nutrient quality of the formulated complementary foods which can be improved on with the ultimate goal of contributing to the reduction of malnutrition in children (Anigo *et al*., 2010; Manihuruk *et al*., 2017). The purpose of this study was to determine the effect of the ingredient formulation on the nutritional and antioxidant content of complementary feeding from soybeans and dragon fruit peels.

## 2. Materials and methods

### *2.1 Materials*

Local soybeans (*Glycine max*) were purchased from Jember local market with the characteristics of whole seeds, uniform size, yellowish colour and not broken. The dragon fruits were harvested from the Rembangan plantation at Jember. Dragon fruit has maturity and similar age, same in size, colour, and no defects. The fruits were delivered immediately to the laboratory. Other ingredients used for complementary feeding were milk powder "Primamil" from Frisian Flag and sugar "Gulaku" from Sugar Group Companies.

### *2.2 The production of complementary feeding*

Procedures of making complementary feeding started by weighing 600 g of soybeans and put into a container after washing and then drain. The soybeans were then dried in an oven at 70$^{o}$C for 3 hours. Then roast over low heat for 2 minutes. Grind the soybeans into flour and sieve using an 80 mesh sieve. Dry the flour at 50$^{o}$C in an oven (Venticell 55 – Ecoline) to reduce the unpleasant smell. Soybean flour was stored in a dry and airtight place (Suryana *et al*., 2022).

The production of simplicia peel powder for dragon fruits began with washing the peel of the red dragon fruit and cleaning it from the green scales, then the fruit peel was cut into small pieces and dried in a dehydrator (Harvest Saver Model R-5A) at 50$^{o}$C for 7 hours. After drying, it was milled with a grinder and sieved using an 80 mesh sieve to obtain red dragon fruit peel powder. Extraction of dragon fruit peel extract was carried out by adding water with a ratio of 1:9 dragon fruit peel powder. Approximately 200 g of dragon fruit peel powder was macerated with 1.8 litres of water using ultrasonic (Elmasonik type 15 L) extraction for 1 hour. The maceration results were filtered using flannel. The dregs are discarded, the solution is dried by freeze drying (Zirbus type 5-II-D) for 2x24 hours (Manihuruk *et al*., 2017).

### *2.3 Formulation of complementary feeding*

Soybean powder, dragon fruit peel extract, milk powder and sugar were mixed according to the formulation to get complementary feeding. The ratio of soybean powder and milk powder were 1:1 (P1), 5:9 (P2), 9:5 (P3). The complete formulation is shown in Table 1.

### *2.4 Proximate analysis*

All proximate analysis procedure based on the Association of Official Analytical Chemists (AOAC, 1995). Moisture determination by oven drying method at 105$^{o}$C. Crude protein content analysis by Kjeldahl method. Crude fat analysis by soxhlet method. Ash determination by dry method at 600$^{o}$C. Carbohydrates were determined by difference. Three measurements for

Table 1. The formulation of complementary feeding.

| Treatment | Soybean powder (%) | Milk powder (%) | Dragon fruit peel extract (%) | Sugar (%) | Total (%) |
|---|---|---|---|---|---|
| P1 | 35 | 35 | 10 | 20 | 100 |
| P2 | 25 | 45 | 10 | 20 | 100 |
| P3 | 45 | 25 | 10 | 20 | 100 |

https://doi.org/10.26656/fr.2017.7(S5).11 

all analysis were made, and the mean values were reported.

*2.5 Vitamin C*

The determination of vitamin C (ascorbic acid) was performed using iodine titration. A purple color is produced when iodine is added to a starch solution. However, the presence of vitamin C in the solution neutralizes the iodine, which prevents the formation of the purple color. Therefore, the amount of vitamin C in a solution can be measured by adding a small amount of acidified starch first, and then slowly adding iodine drops until the solution turns purple. The end point is reached when the blue starch-iodine color appears (AOAC, 1995).

*2.6 Total phenolic content*

Total phenolic content was determined by Indonesian National Standard Number 3143:2011 by weighing 10 g of sample, then dissolve it with distilled water up to 100 mL. An aliquot of the solution was added with 5 mL of 10% Folin–Ciocalteu and stand for 5 mins. The solution was added with 4 mL of 7.5% $Na_2CO_3$ and mixed until homogenous. The mixture was left for 2 hrs and protect from light. The absorbance was measured with visible spectrophotometer (Shimadzu UV -2600) at 740 nm. The polyphenol content was calculated based on the gallic acid calibration curve (National Standardization Agency of Indonesia, 2011).

*2.7 Antioxidant activity*

Antioxidant activity was determined by measuring the level of free radical scavenging in the samples using DPPH assay. A total of 2 mL of 10 mM DPPH solution was added to the sample extract, and made up to 2 mL with ethanol. Sample was mixed well, and incubated in the dark condition for 30 min. Absorbance of the prepared sample was measure at 520 nm using a Visible spectrophotometer (Shimadzu UV-2600) (Meenakumari *et al*., 2023).

*2.8 Sensory analysis*

The sensory analysis was conducted by 8 trained panelists who were mothers with babies. The samples were randomly coded with 3-digit numbers. The panelists were asked to rate the strength of sweetness, viscosity, clumpiness, red color intensity, and dragon fruit aroma on a scale of 1-9 (very weak-very strong). After that, the panelists evaluated their preference for each sample using a 1-9 scale system, ranging from 'dislike extremely' to 'like extremely'. Afterwards, the panelists were asked to rank their preferences among the samples to determine the best treatment (Meilgaard *et al*., 2007).

*2.9 Statistical analysis*

This analysis was done in duplicate. All experiments used a completely random design. The data were statistically analyzed using One-way ANOVA and multiple comparisons test (Duncan's post-hoc test). The significant difference in the data was assessed at $p < 0.05$. The best treatment was determined using Friedman rank test. Statistical analyses were performed using the statistical package SPSS (Version 26).

## 3. Results and discussion

*3.1 Moisture content*

The results of proximate composition of complementary feeding were presented in Table 2. The formulation (Table 1) was significantly different for the ash ($p<0.05$), protein ($p<0.05$), and carbohydrates ($p<0.05$), but no significantly different for fat ($p>0.05$) and moisture ($p>0.05$).

Based on proximate data analysis in Table 2, the moisture content of complementary feeding range from 2.34-2.91%. This moisture is below the standard (4%) (National Standardization Agency of Indonesia, 2005). The moisture content in this study is lower than complementary feeding that is made from mocaf and tempeh (3.84-4.99%) (Kristanti *et al*., 2020); bean sprout flour and roasted corn flour (8.35-9.21%) (Listyoningrum and Harijono, 2015). The moisture

Table 2. Proximate composition (% db) on complementary feeding.

| Parameter | P1 (1:1)* | P2 (5:9)* | P3 (9:5)* |
|---|---|---|---|
| Moisture (%) | 2.62±0.11 | 2.34±0.09 | 2.91±0.35 |
| Ash (%) | 4.60±0.09$^{a}$ | 4.28±0.09$^{a}$ | 5.05±0.20$^{b}$ |
| Fat (%) | 15.52±0.61 | 15.60±0.39 | 15.54±0.41 |
| Protein (%) | 18.97±0.17$^{b}$ | 16.28±0.27$^{a}$ | 20.60±0.92$^{c}$ |
| Carbohydrate (%) | 61.00±0.44$^{b}$ | 64.20±0.21$^{c}$ | 58.62±0.23$^{a}$ |

Values are presented as mean±SD. Values with different superscript within the same row are statistically significantly different ($p<0.05$). *Ratio of soybean powder to milk powder.

https://doi.org/10.26656/fr.2017.7(S5).11

content of the product depends on the ingredients used and the drying process. The drying process relieves free moisture on the food product. Then it removes bound moisture in the matrix of the food until the lowest moisture is reached. It involves heat and mass transfer operations together (Babu *et al*., 2018).

*3.2 Fat content*

Based on Table 2, the fat content in complementary feeding ranges from 15.52-15.60%. This fat is higher than complementary feeding that is made from mocaf and tempeh (11.19-14.29%) and from bean sprout flour and roasted corn flour (5.76-9%). Complementary feeding study that is made from sorghum, yam bean and soybean contain lower fat (4.18-5.23%). The higher soybean in the formulation of complementary feeding in this study gives higher fat too (Abolaji *et al*., 2019). It shows that using soybean as ingredients in complementary food gives high fat in the products.

The fat in complementary feeding serves several important purposes, including: 1. energy source that provides the necessary energy for a child's growth and development, particularly in the form of polyunsaturated fatty acids (unsaturated fatty acids) which are beneficial for health, 2. contains essential fatty acids such as omega -3 and omega-6 fatty acids, which are needed for normal body functions, including brain development, nervous system function, and immune function, 3. absorption of fat-soluble vitamins such as vitamin A, D, E, and K, so fat helps with the absorption and optimal utilization of these vitamins by the body, 4. providing a feeling of fullness by offering a longer-lasting feeling of fullness, which can help reduce excessive appetite in children, 5. as a protective barrier for organs in the body, providing organ protection, and it also functions as thermal insulation, helping to maintain a stable body temperature. However, it should be noted that the consumption of fat in complementary feeding should be in accordance with the recommended needs, which is 35 grams per day based on the Nutritional Requirement Index for infants aged 6-11 months (Health Ministry, 2019).

*3.3 Protein content*

The protein content in complementary feeding ranges from 16.28-20.60%. Higher soybean gives higher protein content in the products. The P3 treatment (45% soybean powder and 25% milk powder) showed the highest protein content among all treatments. The protein content in this study is higher than protein in complementary feeding that is made from mocaf and tempeh (8.65-9.54%) but lower than complementary feeding from bean sprout flour and roasted corn flour (21.64-24.48%) (Listyoningrum and Harijono, 2015; Kristanti, *et al.,* 2020). Soybean has a protein content of approximately 43% and about 3% lecithin which are helpful for the brain development especially of infants (Abolaji *et al*., 2019).

To ensure optimal growth and development, infants aged six months and older need adequate supply of essential nutrients and additional energy to prevent slow growth or nutritional deficiencies. Early introduction of high protein intake through complementary feeding has been associated with improved linear (length and height) and ponderal (weight) growth in infants, without excessive adiposity. In other words, providing infants with sufficient protein during the early stages of complementary feeding can support healthy growth in terms of length, height, and weight without excessive fat accumulation. A similar pattern was observed in childhood, where a higher intake of protein during the period of 2 to 12 months was associated with body mass index (BMI) or body fat, similar to the effect of high-energy intake (Velarde *et al*., 2016). Infants aged 6-11 months require 15 g of protein per day (Health Ministry, 2019).

*3.4 Carbohydrates content*

Carbohydrates are the largest nutritional component of complementary feeding that ranges from 58.62-64.20% (Table 2). The P3 treatment (45% soybean powder and 25% milk powder) exhibited the highest carbohydrate content among all treatments. This carbohydrates content is slightly higher from complementary feeding that is made from bean sprout flour and roasted corn flour (56.89-58.31%) but lower than mocaf and tempeh (70.14-76.29%) (Listyoningrum and Harijono, 2015) but lower than that made from modified cassava flour and tempeh (70.14-76.29%) (Kristanti *et al.,* 2020). Another study shows that carbohydrates content of complementary feeding ranges from 69.12-79.96% (Abolaji *et al*., 2019).

*3.5 Antioxidant content*

In infant’s early life, they get antioxidants from human milk. Human milk supplies bioactive agents like bioactive peptides, anti-inflammatory (e.g., lactoferrin), and antimicrobial (e.g., immunoglobulins). In addition, there are data demonstrating that breastfeeding promotes the development of the infant immune system and this might confer long-term health outcomes (Tsopmo, 2018). When the infants are older than six years old, the complementary feeding must have antioxidants to support the infant's immune system. Antioxidant content in complementary feeding in this study were presented in Table 3.

https://doi.org/10.26656/fr.2017.7(S5).11 

*3.5.1 Vitamin C*

Table 3 shows that vitamin C in the complementary feeding ranges from 27.09-35.30 mg/100 g. The highest vitamin C content, which is 35.30 mg/100 g, was found in treatment P1 which had an equal ratio of soybean powder and milk. The milk packaging label used stated a vitamin C content of 98 mg/100 g. Vitamin C is one of the micronutrients essential for many kinds of metabolic processes. Vitamin C is a strong antioxidant that reduces free radicals. It is an essential vitamin for bone health, against infections, growth, and. It also modulates neurotransmitter systems, absorption iron, and is involved in the biosynthesis of carnitine and collagen (Uğur *et al*., 2020). Infants need vitamin C to support the infant's immune system. Before infants get complementary feeding, infants get vitamin C from human milk. But, after six months, human milk cannot fulfill all of the needs of infants' nutrition. Vitamin C is one of the antioxidants components, the other is total phenol.

*3.5.2 Total phenol*

Another compound that has antioxidant activity besides vitamin C is phenol. Based on result shown in Table 3, the total phenol in the complementary feeding ranges from 0.28-0.35%. The lowest total phenol content was found in P3, which contained the highest amount of soybean powder compared to other treatments. The total phenol content in soybean powder was 0.25% (Rosiana *et al*., 2021). It is suspected that the phenol content in milk is higher than in soybean powder, so P1 and P2 have higher phenol content than P3. Phenol is secondary plant metabolites, and specifically those with anti-inflammatory and antioxidant properties, play an important role in infants health (Tsopmo, 2018).

*3.5.3 Antioxidant activity*

Vitamin C and total phenol contribute to antioxidant activity that in this complementary feeding ranges from 65.89-68.01%. The lowest antioxidant activity was found in P3, which was 65.89%. Soybean powder had an IC50 value of 18.60. It is suspected that milk has higher antioxidant activity than soybean powder because it contains a higher amount of vitamin C. The main oxidant damage products (malondialdehyde/MDA, and protein carbonyl/PC) contents were significantly increased in malnourished (Khare *et al*., 2014). The malnourished infants need more antioxidants to prevent infection in their bodies.

*3.6 Sensory evaluation of the complementary feeding*

Generally, soybean flour had unpleasant flavors such as beany/grassy flavors of soybean that decrease panelist preference when it was made into a product. The combination of soybean flour with dragon fruit extract in this complementary feeding aims to reduce the unpleasant aroma of soybeans and gives natural dyes (Figure 1). Soybean flour reduces sweetness but there are no unpleasant flavors such as beany/grassy flavor of soybean. The catalyzed enzymatic oxidation of linoleic acid and linolenic acid by the lipoxygenases cause beany flavor in soybean. Other major odor compounds that effect on beany flavor is hexanol, 1-octen-3-ol, 1-octen-3 -one, trans, trans-2,4-decadienal, and trans, trans-2,4-nonadienal. The heating time and heating temperature tend to reduce the lipoxygenase activity of processing soymilk. The flavor compounds contents in soybean are gradually reduced with the increasing heating time (Yu *et al*., 2017). The higher the use of soybean powder, the lower the intensity of sweetness, viscosity, clotting, sweetness intensity, and dragon fruit aroma. Figure 1 shows that P3 had the lowest sweetness intensity of 2.13, below P1 (5.75) and P2 (5.62). Soybean powder will have a bland taste, thus reducing the sweetness from sugar and milk.

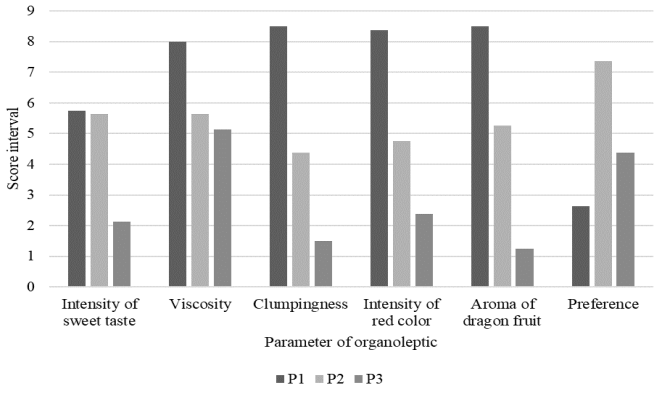


Figure 1. Organoleptic test result on complementary feeding.

Based on the result shown in Figure 1, the texture of P3 is less viscous (5.13) compared to P1 (8.00) and P2

Table 3. Antioxidant content in complementary feeding.

| Parameter | P1 (1:1)* | P2 (5:9)* | P3 (9:5)* |
|---|---|---|---|
| Vitamin C (mg/100 g) | 35.30±2.46$^{b}$ | 27.09±0.51$^{a}$ | 30.08±0.36$^{a}$ |
| Total phenol (%) | 0.35±0.02$^{b}$ | 0.35±0.014$^{b}$ | 0.28±0.03$^{a}$ |
| Antioxidant (%) | 68.01±0.66$^{b}$ | 67.43±0.32$^{b}$ | 65.89±0.04$^{a}$ |

Values are presented as mean±SD. Values with different superscript within the same row are statistically significantly different ($p<0.05$). *Ratio of soybean powder to milk powder.

https://doi.org/10.26656/fr.2017.7(S5).11

(5.63). The use of dragon fruit skin affects the texture of the complementary feeding. If there is more soybean powder, the pectin in dragon fruit skin cannot make more viscous because the water will be absorbed by the soybean powder. The pectin content in dragon fruit is up to 23%. In the food industry, pectin is used as a gelling agent, a thickener, a stabilizer, an emulsifier, and also as a fat substitute (Tongkham *et al*., 2017).

Clumpingness occurs when water cannot dissolve all solids. The lowest clump occurred in P3 (1.50) compared to P1 (8.50) and P2 (4.37). P3 contains the most soybean powder. The lower amount of dragon fruit powder in P1 and P2 results in more water being absorbed by the dragon fruit peel that hygroscopic and easy to thick. Formula P1 and P2 require more water to dissolve all solids.

The red color comes from dragon fruit skin. The lowest intensity of red color is in P3 (2.37) compared to P1 (8.37) and P2 (5.25). The higher the use of soybean powder in the formula, the more faded the red color will be. The white to yellowish color of soybean powder will cover the red color of dragon fruit skin. Red color in the formula comes from anthocyanin. Anthocyanin content in dragon fruit peel extract is higher than others, that are 387,833 mg/100 g (Rosiana *et al*., 2021).

The beany aroma of soy in the formula does not appear because it is masked by the aroma of dragon fruit. The dragon fruit aroma in P3 (1.25) is the lowest compared to P1 (8.50) and P2 (5.25). Dragon fruit peel contains major aroma volatiles, such as 2-hexenal and hexanal, which are green-note C6 aldehydes. These volatiles give the fruit a sweet, almond, fruity, green, leafy, apple, plum, vegetable, fresh, fatty, aldehydic, grassy, and sweaty odor (Liang *et al*., 2022).

Overall, the panelists preferred treatment P2, which had the best organoleptic quality among P1 and P3. This result is in line with the ranking test results, which showed the panelist's preference order for treatments as P2, P3, and then P1. The panelists did not like too strong or too weak sweetness, viscosity, clumpingness, color and aroma.

## 4. Conclusion

Soybeans are a good source of protein to increase protein content in complementary feeding. In addition to protein, infants who malnutrition also need antioxidant to prevent inflammation. Antioxidants in complementary feeding formulas are obtained from several nutrients that have antioxidant activity such as vitamin C and phenols. Milk provides vitamin C, while phenols come from soybeans. The use of dragon fruit peel also contributes antioxidants derived from anthocyanin pigments and phenols. Additionally, the use of dragon fruit peel is able to cover the beany aroma of soybeans, provide red color and a thick texture.

## Conflict of interest

The authors declare no conflict of interest.

## Acknowledgments

Special thanks to PNBP of Jember State Polytechnic in 2022 for funding this research. The authors duly acknowledge Dr. Widya Paramita Lokapirnasari, drh., MP., Faculty of Veterinary Medicine, Airlangga University, for for her assistance, advice, and revisions in the preparation of this article.

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