*Buletin Peternakan* 47 (3): 190-197, August 2023

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

**Bulletin of Animal Science**

ISSN-0126-4400/E-ISSN-2407-876X Accredited: 230/E/KPT/2022
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v47i3.84653

# Evaluation of the Physical Quality of Supplement Wafer and Application of Supplement on Layer Performance

**Anna Megawati Br Pakpahan[1], Yuli Retnani[2*], Rita Mutia[2], and Wira Wisnu Wardani[2]**

[1]Graduate School of Animal Nutrition and Feed Science, Department of Animal Nutrition and Feed Technology, Faculty of Animal Science, IPB University, Bogor, 16680, Indonesia
[2]Department of Animal Nutrition and Feed Technology, Faculty of Animal Science, IPB University, Bogor, 16680, Indonesia
[3]Nutricell R&D, Cibis Nine 12th Floor Unit G1, Jakarta, 12560, Indonesia

**Article history**
Submitted: 22 May 2023
Accepted: 10 August 2023

* Corresponding author:
E-mail: yuli_retnani@apps.ipb.ac.id

**ABSTRACT**

This study aimed to evaluate the physical quality of the wafer supplement with different binders and evaluate the performance of laying hens fed the supplement wafer in drinking water. The rearing stage used 64 Isa Brown chickens raised for 12 weeks. Stage 1 of the experiment used a 3x4 Completely randomized design (T1: Pollard, T2: Cassava Flour, T3: Tapioca Flour Waste). Phase two of the study used a completely randomized design with two treatments x 4 replicates x 8 chickens (P0: without supplement wafers, P1: supplement wafers). The variables observed were the wafer's physical quality and Isa Brown's performance. Different adhesives in the manufacture of wafers produced no significant difference in water content ($p>0.05$) but significant differences ($p<0.05$) in water activity, bulk density, wafer durability index, and total solubility. Supplementary wafer administration did not affect ($p>0.05$) feed consumption, drinking water consumption, Feed Conversion Ratio (FCR), egg weight, and daily egg production but did affect ($p<0.05$) chicken mortality. The conclusion is that wafers with the best physical quality use cassava flour binder, and giving wafer supplements in drinking water can reduce mortality.

Key words: Binders, Isa Brown, Performance, Physical quality, Supplement wafer

## Introduction

One of the most important food sources of animal protein for Indonesian people is eggs. Consumption of eggs in Indonesia reaches 78.80%, the figure is much higher than the consumption of meat and milk, where the respective values are 38.5 and 31.6% (Ariani *et al.*, 2018). Indonesia's egg consumption will continue to increase in the future. The average consumption of purebred chicken eggs for 2018-2021 according to BPS (2022), in 2019 was 2.314 kg per capita per week, in 2020 (2.338 kg per capita per week), and in 2021 (2.448 kg per capita per week). In addition to genetic factors, environmental factors such as livestock population (poultry), livestock age (months), feed intake (g/head/day), cage temperature (ºC), humidity (%), vaccinations, and nutrition also affect egg production (Ratriyanto *et al.*, 2019). Indonesia is a tropical country with high temperatures and humidity, especially during the dry season. The ambient temperature in Central Java ranges from 27-37ºC (Ismoyowati *et al.*, 2020). According to the research results of Suswoyo *et al.* (2021) the average temperature and humidity during the day are 31.91ºC and 79.43%, while in the afternoon, it is 31.35ºC and 82.21%. These values converted to heat stress index values of 168.86 and 170.64. Heat stress can occur in chickens due to a mismatch in temperature requirements.

Heat stress is pressure due to temperature and humidity above normal limits. The comfortable temperature range for poultry is 18ºC to 25ºC ( El-Badry *et al.*, 2009). The impact of heat stress is predicted to be more distant in the future, because the average temperature of the earth's surface and oceans is increasing due to global warming. Kilic and Simsek (2013) stated that heat stress significantly reduces productivity due to reduced feed intake, higher mortality, reduced egg production, lower eggshell quality, and smaller egg size.

One strategy to increase the efficiency of laying hens is to add supplements to drinking water. The Supplements contain the amino acids DL-Methionine and L-Lysine, vitamins, and minerals. These nutritional components are needed by livestock in the process of metabolism. Add Supplements on a small scale in drinking water will make the mixing more homogeneous than mixing supplements into the feed. It will increase the efficiency of the feed used.

Supplements in drinking water for poultry are usually given in the form of mash, which is mixed in drinking water with the dosage according to the recommendations listed on the package. Which is mixed with the dosage according to the recommendations stated on the package. This requires prior weighing which requires tools and is time-consuming. Making wafers will make it easier for farmers to provide supplements, with a dose of 1 wafer for 10 liters of drinking water. With the wafer supplement innovation, giving supplements to poultry drinking water will be more practical. Besides being practical, wafer-shaped supplements are more durable. Harahap *et al.* (2021) stated that the purpose of making wafers is to increase the durability of feed raw materials.

Making wafers requires another material, namely a binder. Binders in wafer manufacture so that the resulting wafer structure is not easily crushed and solid (Sandi *et al*., 2016). Impact resistance, water content, stack density, texture, and bulk density of wafers are affected by the binder used (Syahri *et al*., 2018). Wafers remain compact due to starch gelatinization due to the heating process in wafer manufacturing (Purba *et al*., 2018). Wafers remain compact due to the gelatinization of starch caused by the heating process in making wafers (Purba *et al.,* 2018). Then the physical quality of the wafer is greatly influenced by the binder used. This study aimed to evaluate the physical characteristics of the wafer supplement with different binders and evaluate the performance of laying hens fed the supplement wafer in drinking water.

## Materials and Methods

This research consisted of two stages, making wafer supplements and rearing Isa Brown chickens. In the first stage research, the materials used were vitamin and mineral supplements from PT. Nutricell Pacific South Tangerang, the contains presented in Table 1. Then the binder consists of pollard, cassava flour, tapioca flour waste, and molasses. The material used in the second stage is the GT-1 layer phase produced by PT. Sinta Prima Feedmill, and wafer supplements. Sixty-four Isa Brown chickens aged 20 weeks. The tools used in stage 1 of the study were digital scales, wafer-making machines, moisture content testers, aw meters, wafer durability index, and a series of total solubility analysis tools. In stage 2 the equipment used was 8 units of 120 x 45 cm cages equipped with feed and drinking containers, digital scales, egg trays, measuring cups, and fans. The composition of the supplement wafers is presented in Table 2.

### Making of supplement wafers

Supplementary wafers are a mixture of vitamins and minerals with different binders (pollard, cassava flour, and tapioca flour waste) and molasses made through a pressure and heating process, in the form of blocks with a size of 3 x 3 x 1 cm with a weight of 15.38 g. The wafer constituent materials according to the treatment were weighed (Table 2), mixed until homogeneous, then printed using a hydraulic wafer press machine with a temperature of 80ºC and a pressure of 200-300 kg/cm$^3$ for 10 min (Syahri *et al.,* 2018), then cooled to room temperature.

Table 1. The content of vitamin-mineral supplements per kg

| Content | |
|---|---|
| Vitamin A | 6,000,000.00 IU |
| Vitamin E | 20,000.00 IU |
| Vitamin C | 50,000.00 mg |
| Lysine | 20,000.00 mg |
| Methionine | 30,000.00 mg |
| Calcium | 9,000.00 mg |
| Magnesium | 7,000.00 mg |
| Curcuma | 25,000.00 mg |

Source: Vitamin-mineral packaging.

Table 2. Composition of supplement wafers

| Materials | T1 (%) | T2 (%) | T3 (%) |
|---|---|---|---|
| Mineral vitamins | 65 | 65 | 65 |
| Pollard | 30 | | |
| Cassava flour | | 30 | |
| Tapioca flour waste | | | 30 |
| Molasses | 5 | 5 | 5 |
| Total | 100 | 100 | 100 |

T1: Pollard, T2: Cassava flour, T3: Tapioca flour waste.

### Analysis of physical characteristics of supplement wafers

**Water content.** Wafer moisture content was measured using the Grain Moisture Tester PM-650. The trick, the sample of 60 g poured into the tool container, press the power button to turn on the tool, press select, the test code is selected according to the type of sample, press MEA, then wait a few seconds the display will change and an order appears to enter it. Then put it in until the detector is closed, then the water content value in percent will appear.

**Water activity (WA).** Water activity was measured using a Retronic Aw meter type HP23-AW-A-SET-40. Retronic HP23-AW-A-SET-40 is a rapid test tool used to measure the water activity of feed ingredients. The sample of 30 g pouring into the measuring cup. The water activity value will appear.

**Wafer durability index (WDI).** Wafer Durability Index (WDI) is measured using a wafer durability tester equipped with a box and rotary tool. One wafer (15.38 g) is included in the toolbox. Press the power button to start the machine. Set the rotation duration for 5 min and 55 rpm speed. Then the ratio of the weight of the whole wafer to the mass of the wafer after playing is calculated by the formula:

$$\text{WDI (\%)} = \frac{\text{wafer mass after twisting}}{\text{whole wafer mass}} \times 100$$

**Bulk density.** A measuring cup that has been filled with 100 ml of aquadest is filled with 50 g of sample. Changes in water volume are recorded and calculated using the formula:

$$\text{Bulk Density (g/cm}^3\text{)} = \frac{\text{Sample mass (gram)}}{\text{Change in aquadest volume (ml)}}$$

**Total solubility test (Araba and Dale, 1990).** Dry the cup and filter paper using the oven for 1 h. Weigh 5 g of filter paper and sample using a digital analytical balance, then put it in an Erlenmeyer containing 200 mL of distilled water. Stir for 15 min using a magnetic stirrer until homogeneous. Then filter using Whatman Number 42 filter paper and a vacuum pump. After that, dry the sample using an oven for 24 h at 105ºC. Weigh the sample as the final mass. The total solubility expressed in percent, can be calculated by the formula % total solubility:

$$\text{Total Solubility (\%)} = \frac{\text{Initial mass of ingredients -mass after baking}}{\text{Initial mass of ingredients}} \times 100\%$$

From making wafers with 3 treatments in stage 1 the best results are given to laying hens by dissolving them in drinking water. A total of 64 laying hens aged 20 wk were kept in battery cages for 12 wk. Feed and drinking water are given ad-libitum, given twice a day at 07.00 a.m and at 17.00 p.m.

**Performance measurement of laying hens**

Feed consumption (g/head/day), obtained by reducing the amount of feed given with the remaining feed. Consumption of drinking water (ml/head/day), result of reducing the water given with the rest of the drinking water for a day. Feed conversion ratio (FCR), the ratio between the amount of feed consumed and the mass of eggs during the study. Feed Conversion Ratio (FCR) calculated from the amount of feed consumed to produce 1 g of eggs so that the FCR of dead chickens are not counted because they do not produce eggs. Hen day production (HDP), the percentage of the ratio between the number of eggs produced in one group of laying hens during a day.

Egg weight (g) was weighed every day, then the average for each treatment and repetition was calculated. Mortality, the percentage of chickens that died during the study. Heat stress index, this variable is observed every day by recording the temperature and humidity of the cage. According to Abdullah *et al.* (2018), heat stress index is calculated using the formula:

$$\text{Heat Stress Index} = \{9/5 \times \text{Temperature (°C)} + 32\} + \text{Relative Humidity (\%)}$$

Experimental design and data analysis, the experimental design stage 1 for the physical characteristics of the supplement wafers used was a completely randomized design with 3 treatments and 4 replications. Data were analyzed by analysis of variance (ANOVA). Data was processed using the Statistical Package for the Social Sciences (SPSS 25) software. If the treatment has a significant effect on the variables, it will be followed by the Tukey test to find out the differences between treatments. The experimental design stage 2 of laying hen performance was a completely randomized design with 2 treatments x 4 replications x 8 chickens. The treatment consisted of P0 (without adding wafer supplements) and P1 (adding supplementary wafers in drinking water). Data were analyzed using the Independent-sample T Test and and were processed using SPSS 25 software.

## Results and Discussion

**Physical characteristics of supplementary wafers**

The physical characteristics of wafer supplements with different binders observed in phase 1 research were water content, water activity, wafer durability index (WDI), bulk density, and total solubility. The average results of the wafer physical characteristic analysis are in Table 3.

Statistical test results showed that the use of different binders in the manufacture of supplemental wafers did not affect ($p>0.05$) water content but affected ($p<0.05$) water activity (WA). The results of the Tukey test showed that the water activity of wafers supplemented with cassava binders was significantly higher than that of pollard and tapioca flour waste binders. Moisture content determines feed quality because it is one of the determinants of shelf life. According to Marbun *et al.* (2019), a feed ingredient that contains a lot of water will cause the feed ingredient to be easily damaged by decomposing microbes will make it doesn't last long. The average water content of this research supplement wafer ranged from 8.65-8.82%. The water content value of wafer supplements in this study is safe for storage. According to Triyanto *et al.* (2013), water content of 12-14% can suppress microbial activity in wafers. Wafers will grow mold if the water content is above 14%. In line with the opinion of Miftahudin *et al.* (2015) that feed with a moisture content of 12-14% is not easily moldy or decomposed because the activity of microorganisms can be suppressed.

Wafer water activity is measured so that the minimum limit of microorganisms that can grow on the material is known. The value of water activity according to Table 3 ranges from 0.47-0.57. The results of Wati *et al.* (2020) the water activity value of wafers with different ingredients and adhesive, that value of the wafer is directly proportional to the increase in the concentration of the adhesive. The water activity in this study was categorized as safe for storage, supported by the opinion of Winarno (2007) stated that at aw below 0.7 or with a relative humidity of 70%, microorganisms cannot grow. The low value of water activity is affected by the absorption of water vapor from the air to the wafers during storage, handling during wafer storage can also cause changes in the free water content in the wafers. Each microorganism has a minimum limit for growth, the lower the water activity of the feed material the more durable. Kayadoe *et al.* (2020) reported that water activity determines the level of damage because a water activity value of 0.6-0.7 indicates the growth of mold and bacteria at a water activity of 0.9.

Analysis of variance showed that different binders for the manufacture of supplement wafers affected ($p<0.05$) the wafer durability index, bulk density, and total solubility of vitamin and mineral supplement wafers. The adhesive materials used in the manufacture of wafers can affect the physical characteristics of the wafers, such as bulk density, stack density, and wafer impact resistance (Syahri *et al.,* 2018). Wafer durability index value according to Table 3 ranges from 54.25-90.75%. The lowest WDI on wafers with cassava binder. The difference in WDI value is thought to be because cassava has a higher binding power than pollard and tapioca flour waste. Syahri *et al.* (2018) stated the benefits of measuring the wafer durability index to determine the resistance of the wafer to collisions during the packaging and transportation processes. The difference in WDI on the wafer is thought to be due to the amylose content in the adhesive. Starch consists of amylose and amylopectin. According to Sistanto *et al.* (2017), the hardness is caused by amylose while the stickiness is caused by amylopectin. In line with the opinion of Hidayat *et al.* (2007) high amylose content in starch is less sticky while the high amylopectin content in starch is adhesive. The amylose content of cassava flour is 25.33%, amylopectin is 46.79% (Selian *et al.,* 2019), the pollard amylose is 25% and amylopectin is 75% (Arnyke *et al*., 2014), and tapioca flour waste amylose is 16% amylopectin is 74% (Kurniadi, 2010). According to Retnani *et al.* (2020), the gelatinization of starch is influenced by the ratio of amylose and amylopectin in feed ingredients.

According to Table 3, the bulk density of supplement wafers ranges from 1.05-1.41 g/cm$^3$. Where the bulk density of wafers with cassava binder is greater than that of wafers with pollard and tapioca flour waste binders. According to Christmas *et al.* (2022), it is necessary to know the bulk density for storage which is obtained by calculating the ratio between the mass and volume of the material in a measuring cup to which distilled water is added. Wafer-bulk density is the ratio of wafer mass to volume. The bulk density value of this wafer is almost the same as the results reported by Christmas *et al.* (2022) which ranges from 1.12-1.22 g/cm$^3$. The high and low bulk density of the wafer is influenced by the wafer density where the wafer density is affected by the particle size of the wafer constituent material, so this will affect the volume when the sample is put into distilled water. The difference in the value of the bulk density of the wafer is caused by the composition of the ingredients and the different chemical compositions. The particle size of the material which is relatively the same material will bond with each other resulting in a higher bulk density (Salam, 2017).

The total solubility value of wafer supplements according to Table 3 ranges from 83.17-94.97%, where the solubility value of wafers using cassava flour binder is higher when compared to wafers using pollard and tapioca flour waste binders. According to Sari and Hidayat (2014) solubility is the ability of a chemical substance to dissolve in a solvent, expressed in the maximum amount of substance dissolved in a solvent in equilibrium. The total solubility is different because of the different types of carbohydrates that make up each material.The higher the non-starch polysaccharides in feed, the lower their solubility in water, because non-starch polysaccharides are difficult to hydrolyze in water. The crude fiber contained in the feed also affects the solubility value. The crude fiber content of cassava flour (4.18%), pollard (10%), and tapioca flour waste 14% (Lovell, 1989) and (Vidyana *et al.,* 2014). The best wafer solubility value with cassava flour binder (T2) was 94.97%.

**Selected supplement wafers**

The selected wafer supplement with the best characteristics was the T2 (cassava flour binder) treatment. The results showed water content and safe water activity for storage, the best WDI, the highest bulk density, and the highest solubility value. These wafers were then used in phase 2 of the study.

**Performance of Isa Brown's chicken**

The performance of Isa Brown chickens aged 20-31 weeks is presented in Table 4. The provision of vitamin and mineral supplement wafers did not affect (p>0.05) feed consumption, drinking water consumption, FCR, hen day production, and egg weight. However, giving wafer supplements can reduce mortality.

Feed consumption by adding wafer supplements to drinking water did not differ from the control. This shows that giving wafer supplements in drinking water cannot reduce feed consumption for Isa brown chickens. This is presumably because the percentage of binder in the wafer does not contribute high calories so it does not reduce feed consumption. The value of feed consumption according to Table 4 is 100.61 g/head/day and 97.64 g/head/day. This value is low when compared to the results of Pambuka *et al.* (2014) feed consumption by administering probiotics in drinking water was 119.76-119.96 g/head/day, 115.14 g/head/day (Afikasari *et al.*, 2020). According to Setiawati *et al.* (2016), the comfort of chickens depends on the temperature of the cage, if the temperature of the cage is too high it will make the chickens uncomfortable and can reduce their

Table 3. Physical quality of wafers with different binders

| | Treatment | | |
|---|---|---|---|
| | T1 | T2 | T3 |
| Water content (%) | 8.67±0.95 | 8.82±0.17 | 8.65±0.19 |
| Water activity (WA) | 0.47±0.02$^a$ | 0.57±0.06$^b$ | 0.47±0.02$^a$ |
| Wafer durability index (%) | 90.75±8.61$^a$ | 54.25±11.78$^b$ | 90.75±10.75$^a$ |
| Bulk density (g/cm$^3$) | 1.11±0.53$^a$ | 1.41±0.22$^b$ | 1.05±0.04$^a$ |
| Total solubility (%) | 83.17±3.26$^a$ | 94.97±0.26$^b$ | 85.80±7.18$^a$ |

$^{a,b}$ Different superscripts are on the same line show significantly different (p<0.05).
T1: pollard binder, T2: cassava flour binder, T3: tapioca flour waste binder.

Table 4. Performance of Isa Brown chicken aged 20-31 weeks with supplementary wafers

| | Treatment | |
|---|---|---|
| | P0 | P1 |
| Feed consumption (g/head/day) | 100.61±3.96 | 97.64±5.07 |
| Drinking water consumption (ml/head/day) | 387.06±25.99 | 384.84±15.71 |
| Feed conversion ratio | 2.83±0.54 | 2.74±0.60 |
| Hen day production (%) | 55.87±10.95 | 60.45±12.01 |
| Egg weight (g) | 63.43±4.19 | 63.06±3.13 |
| Mortality (%) | 0.11±0.07$^{a}$ | 0.00±0.00$^{b}$ |

$^{a,b}$ Different superscripts on the same line indicate significantly different (p<0.05).
P0: without supplement wafers, P1: supplement wafers.

productivity. The low feed consumption in this study is thought to be due to the high temperature of the cage which causes the chickens to experience heat stress and causes increased consumption of drinking water. According to Ismoyowati *et al.* (2020), feed consumption decreased at high house temperatures because livestock drank more water to reduce heat stress. When conditions of heat stress, chickens tend to reduce ration consumption (Xie *et al.*, 2017). Decreased feed consumption aims to reduce heat in the chicken body. Consumption of drinking water in this study ranged from 384.06-387.06 ml/head/day, different from the report by Pambuka *et al.* (2014) consumption of drinking water was lower, namely 269.64-274.34 ml/head/day. According ISA (2020) the drinking water consumption standard for Isa Brown chickens depends on the temperature of the cage, at 25ºC is 230 ml, at 30ºC is 320 ml/head/day. ISA (2020) provides a standard for feed consumption for Asian Isa Brown chickens, namely 100-115 g/head/day. If the temperature of the cage is above normal, it causes heat stress for livestock, which results in a decrease in feed consumption but an increase in drinking water consumption.

Feed conversion ratio is an illustration of feed utilization, namely by calculating the ratio between the feed consumed to produce eggs in a certain time unit (Said and Sulmiyati, 2019). FCR with the addition of wafer supplements in the drinking water of Isa Brown's chickens was better (2.74) than without the addition of wafer supplements (2.83). The content of vitamins and minerals in supplement wafers dissolved in drinking water plays a role in reducing stress on chickens thereby increasing egg production. The ratio conversion of this study was greater than that of Sulaiman *et al.* (2019) at 1.89, where this value is by the standard ISA (2020) FCR at 31 weeks of age 1.91. According to Jahejo *et al.* (2016) during heat stress, some of the energy that should be used for production will be diverted to stabilize body temperature and will have an impact on the high conversion of rations. According to Hidayat *et al.* (2017), an efficient ration can be obtained if the nutrient content in the ration is balanced such as the content of protein, minerals, vitamins, energy, Ca, and P.

The value of hen day production (HDP) in Table 4 is 55.87% (P0) and 60.45% (P1). HDP with the addition of supplement wafers in drinking water was higher than without the addition of supplemental wafers. That showed that giving wafer supplements can increase feed utilization in producing eggs. The content of vitamins (A, C, and E), minerals (C, Mg), and amino acids (lysine, methionine, and Curcuma) can maintain livestock health in conditions of a high heat stress index. When heat stress occurs due to temperatures exceeding normal, the addition of antioxidants is necessary, one of which is vitamin E (Nailis *et al.*, 2022). According to Kusumasari *et al.* (2013), stress can cause decreased egg production, but with the addition of antioxidants, it can prevent and reduce stress, and antioxidant vitamins A and E play a role in reproduction. Ismail (2012) supports the opinion that vitamin A can increase the level of Follicle Stimulating Hormone (FSH), Luteinizing hormone (LH), and estradiol. In stressful conditions, the need for vitamins will increase (Widodo, 2019). This HDP value is low compared to the report by Sulaiman *et al.* (2019) that Isa Brown aged 24-28 weeks 90.02-93.93%. Environmental temperatures above 25ºC can increase livestock energy requirements causing non-optimal livestock production (Widiawati *et al*., 2016).

According to Table 4, the egg weight values without wafers and with the addition of wafers in drinking water were 63.43 and 63.06 g/item, respectively. Factors that affect egg weight are the nutritional content of the feed, the age of the chicken, the strain, the body weight of the chicken, the time the eggs are produced, and the ambient temperature. According to Argo *et al.* (2013) the higher the feed protein given, the higher the weight of chicken eggs. Egg weight in this study did not differ in each treatment because it was given feed with the same nutrient content. Kusumasari *et al.* (2013) stated that the nutrient content of rations that affect egg weight includes protein and fat. The egg weight value of the results of this study was higher when compared to the report by Edi *et al.* (2018) namely 58.30-61.65 g/item. According to the ISA (2020), the standard weight of chicken eggs aged 20-31 wk ranges from 49.3-61.8 g/item, eggs weighing 63-73 g were eggs with the Large class.

Mortality value is the ratio of dead chickens to the number of chickens kept expressed in percent. According to Kamaludin *et al.* (2019), the success of the livestock business is influenced by the mortality rate. The addition of wafer supplements in this study can reduce the mortality rate of Isa Brown's chicken. This shows that giving wafer supplements in drinking water can increase the immunity of chickens. The content of water-soluble and fat-soluble vitamins in the wafer has a positive effect on chicken. According to Nailis *et al.* (2022)

when experiencing heat stress the immune organs will experience disturbances in warding off various pathogens, as the antioxidant vitamin E supports immunity in chickens and helps chicken health. Vitamin E can boost immunity and protect the body from free radicals (Lubis *et al.,* 2015).

**Heat stress index (HSI) during maintenance**

The heat stress index is a calculation of the temperature and humidity of the cage. Heat stress index in chickens is a combination of air temperature and humidity to calculate the degree of heat stress in chickens. Heat stress index <150 (comfortable), 150-160 (decreased activity, increased water consumption, and decreased production), >160 (heat stress occurred). The heat stress index is presented in Table 5.

Table 5. Heat Stress Index for 12 weeks of maintenance

| | Heat Stress Index |
|---|---|
| Minimum | 157.86 |
| Maximum | 170.67 |
| Average | 163.15±3.37 |

The optimal temperature and humidity for chickens are 18-28ºC and less than 70% (Joachim *et al.,* 2011). According to Nailis *et al.* (2022), chickens will experience heat stress if the temperature and humidity exceed normal conditions, it is necessary to add antioxidants to overcome the effects of heat stress. According to Dirgahayu *et al.* (2016), 25-25ºC and 55-65% are the ideal temperature and humidity for laying hens, adult chickens are more likely to experience cases of heat stress. Heat stress is a very important factor to pay attention to because it can cause an increase in the mortality rate of chickens (Bayhan *et al.,* 2013). According to Palupi (2015) at 160 there will be a decrease in feed intake, an increase in water intake and a decrease in performance, at 165 there will be death and permanent damage to the lungs and circulatory system, and at 170 there will be very high mortality. During maintenance, the average of heat stress index value was 163.15, which at this value resulted in a decrease in feed consumption, an increase in drinking water consumption, reduce hen day production (HDP), and a high feed conversion ratio.

In further research, it is better to make a comparison between giving supplements in the form of mash and wafers. Furthermore, it is necessary to observe the organs of immunity and the blood profile of laying hens given the supplement wafers.

## Conclusions

The best physical quality of supplement wafers is a Wafer with cassava flour binder with a higher solubility value than pollard and tapioca flour waste. Giving wafer supplements to Isa Brown did not affect feed consumption, drinking water consumption, egg production, egg weight, and FCR. However, giving wafers can reduce mortality.

## References

Abdullah, G. B., E. Suprijatna, and Isroli. 2018. Effect of feeding period on hematologic of crossbred native chicken age 3-12 week. Jurnal Sain Peternakan Indonesia 14: 306-311. https://doi.org/10.31186/jspi.id.13.2.140-150.

Afikasari, D., R. Rifa'i, and D. A. Candra. 2020. Effects of probiotic supplementation through feedon the feed consumption of layers strain isa brown. Jurnal Ternak. 11: 35-38. doi:10.30736/jy.v11i1.70.

Araba, M. and N. M. Dale. 1990. Evaluation of protein solubility as an indicator of underprocessing of soybean meal. Poult. Sci. 69: 1749–1752. https://doi:10.3382/ps.0691749.

Argo, L. B., Tristiarti, and I. Mangisah. 2013. Kualitas fisik telur ayam Arab petelur fase i dengan berbagai level *Azolla microphylla.* Animal Agricultural Journal 2: 445-457.

Ariani, M., A. Suryana, S. H. Suhartini, and H. P. Saliem. 2018. Performance of animal food consumption based on region and income at household level. Analisis Kebijakan Pertanian 16: 147-163. https://doi:10.21082/akp.v16n2.2018.147-163.

Arnyke, E. V., D. Rosyidi, and L. E. Radiati. 2014. Peningkatan potensi pangan fungsional naget daging kelinci dengan substitusi wheat bran, pollard dan rumput laut. Jurnal Ilmu-Ilmu Peternakan. 24: 56–71.

Bayhan, A. K., S. Karaman, and Ö. Koşkan. 2013. Effects of heat stress on egg yield and mortality rates of caged poultry houses. Kafkas Univ. Vet. Fak. Derg. 19: 881–887. doi:10.9775/kvfd.2013.9041.

BPS. 2022. Rata-rata konsumsi perkapita seminggu menurut kelompok telur dan susu per kabupaten/kota (satuan komoditas). Badan Pusat Statistik (bps.go.id).

Christmas, E., R. Murni, and S. Fakhri. 2022. The effects of storage periods on the physical characteristics of wafer complete ration based on cabbage waste with molasses adhesive. Jurnal Ilmu dan Industri Peternakan 8: 96–107.

Dirgahayu, F. I., D Septinovab, and N. Khaira. 2016. Perbandingan kualitas eksternal telur ayam ras. Jurnal Ilmiah Peternakan Terpadu 4: 1–5.

Edi, D. N., M. Natsir, and I. Djunaidi. 2018. The effect of extract tecton leaf (*tectona grandis linn*. F) in diet on performance of laying hen. Jurnal Nutrisi Ternak Tropis 1: 33–44. doi:10.21776/ub.jnt.2018.001.01.5.

El-Badry, A. S. O., M. M. Hassanane, E. S. Ahmed, and K. H. El-Kholy. 2009. Effect of early-age acclimation on some physiological, immunological responses and chromosomal aberrations in muscovy ducks during exposure to heat stress. Globa Journal of Biotechnolgy and Biochemistry 4: 152–159.

Harahap, R. M., A. E. Harahap, and D. Febrina. 2021. Kualitas fisik wafer dengan penambahan berbagai level tepung tapioka serta tepung daun pepaya *(Carica papaya L)* yang diolah dengan teknik berbeda. Jurnal Triton 12: 92–103. https://doi:10.47687/jt.v12i2.214.

Hidayat. B., B. A. Adil, and Sugiyono. 2007. Characterization of sweet potato flour *(Ipomoea batatas L.)* var. shoyprutaka and assesmentof its potential as alternative carbohydrate source for food product. Jurnal Teknologi dan Industri Pangan 18: 32-39.

Hidayat, Z. P., T. Kurtini, and F. Fathul. 2017. Pengaruh penambahan masamix kws dengan dosis berbeda dalam ransum terhadap performa ayam petelur. Jurnal Riset dan Inovasi Peternakan. 1: 26–32.

ISA. 2020. ISA Brown - ISA. Available from: https://www.isa-poultry.com/es/products-es/isa-brown-es/. Accessed 21 March 2023.

Ismail, N. H. 2012. Effects of vitamin A supplementation on reducing toxicity of aflatoxin B1 on the ovary of young female rats. Life Science Journal 9: 603–612.

Ismoyowati, I., I. Suswoyo, R. Rosidi, S. Mugiyono, and N. Hidayat. 2020. The effect of environmental factors, population and age of duck on egg production. Animal Production 22: 118–125. https://doi:10.20884/1.jap.2020.22.2.51.

Jahejo, A. R., N. Rajput, N. M. Rajput, I. H. Leghari, R. R. Kaleri, R. A. Mangi, M. K. Sheikh, and M. Z. Pirzado. 2016. Effects of heat stress on the performance of Hubbard broiler chicken. Cells Anim. Therapeutics. Ther. 2: 1–5.

Joachim, A. J., A. B. Perez, and A. T. Mollineda. 2011. Effects of high temperature on production in layer chickens supplemented with vitamins C and E Efectos de la alta temperatura sobre la producción en gallinas. Rev. MVZ Córdoba. 16: 2283–2291.

Kamaludin, P. W. Dzikrillah, M. F. Azhoheru, Suhendrian, W. Hardiyansyah, D. D. Putri, and G. G. Maradon. 2019. Management of male and female broilers with addition of liquid organic supplements. Jurnal Peternakan Terapan 1: 21-25.

Kayadoe, M., S. Sinaga, A. Rochana, and U. H. Tanuwiria. 2020. Study of the physical quality of pelet ration as an effort to modify rations for common spotted cuscus. Jurnal Sain Peternakan Indonesia 15: 7–17. doi:10.31186/jspi.id.15.1.7-17.

Kilic, I. and E. Simsek. 2013. The effects of heat stress on egg production and quality of laying hens. J. Anim. Vet. Adv. 12: 42–47. doi:10.3923/javaa.2013.42.47.

Kurniadi, T. 2010. Kopolimerisasi grafting monomer asam akrilat pada onggok singkong dan karakterisasinya. Tesis. IPB, Bogor.

Kusumasari, D. P., I. Mangisah, and D. I. Estiningdriati. 2013. Effect of addition vitamin A and vitamin E in diet on egg weight and embryo mortality in kedu black hens. Animal Agriculture Journal 2: 191–200.

Lovell, T. 1989. The concept of feeding fish. An VI Book. Van Nostrand Reinhold, New York.

Lubis, F. N., R. Alfianty, and E. Sahara. 2015. Pengaruh suplementasi selenium organik (SE) dan vitamin E terhadap performa itik pegagan. Jurnal Peternakan Sriwijaya 4: 28–34. doi:10.33230/jps.4.1.2015.2297.

Marbun, F. G. I., R. Wiradimadja, and I. Hernaman. 2019. The effect of storage time on the physical characteristics of rice bran. Jurnal Ilmu Peternakan Terpadu 6: 163. doi:10.23960/jipt.v6i3.p163-166.

Miftahudin, M., L. Liman, and F. Fathul. 2015. The effect of the savings on the quality of physical and the water level in a wafer of agricultural waste based on carrots. Jurnal Ilmu Peternakan Terpadu 3: 121–126.

Nailis S., S. Sumiati, and T. Suryati. 2022. Supplementation of vitamin E in the diet containing different nutrition levels to increase growth and overcome heat stress of local chicken IPB-D3. Jurnal Ilmu Nutrisi dan Teknologi Pakan 20: 58–65.

Palupi, R. 2015. Heat Stress Management Overcomein Broiler Chickens Reared On Dry Land. Prosiding Seminar Nasional Lahan Suboptimal 2015, Palembang 08-09 Oktober 2015.

Pambuka, S. R., O. Sjofjan, and L. E. Radiati. 2014. Effect of liquid probiotics mixed culture supplements through drinking water on laying hens performance and yolk cholesterol. Journal of World's Poultry Research 4: 05-09.

Purba, A. M., Yatno, and R. Murni. 2018. Kadar bahan kering dan kualitas fisik ransum komplit berbasis limbah sawi pada lama waktu penyimpanan yang berbeda. Prosiding Seminar Nasional Fakultas Pertanian Universitas Jambi Tahun 2018. 6: 227–239.

Ratriyanto, A., B. F. Hidayat, N. Widyas, and S. Prastowo. 2019. Kurva produksi telur di awal masa peneluran pada puyuh yang diberi ransum dengan kandungan protein berbeda. Jurnal Ilmu Ternak Universitas Padjadjaran 19: 28-35. https://doi:10.24198/jit.v19i1.22171.

Retnani, Y., N. N. Barkah, A. Saenab, and . Taryati. 2020. Processing technology of feed wafer to increase feed production and efficiency. Wartazoa 30: 37-50. https://doi:10.14334/wartazoa.v30i1.2473.

Said, N. S. and S. Sulmiyati. 2019. Pengaruh injeksi selenium dan vitamin e pada ayam petelur fase molting (force molting) terhadap performa produksi. Jurnal Ilmu dan Teknologi Peternak Tropis 6: 48-51. https://doi:10.33772/jitro.v6i1.5616.

Salam, R. M. 2017. Sifat fisik wafer dari bahan baku lokal sebagai bahan pakan ternak ruminansia. Jurnal Ilmiah Peternakan 5: 1–23.

Sandi, S., A. I. M. Ali, and A. A. Akbar. 2016. Uji in-vitro wafer ransum komplit dengan bahan perekat yang berbeda. Jurnal Peternakan Sriwijaya 4: 7–16. https://doi:10.33230/JPS.4.2.2015.2802.

Sari, A. M. and H. Hidayat. 2014. Pengaruh konsentrasi diklorometan terhadap daya larut selulosa asetat dari limbah cair industri tahu. Seminar Nasional Sains dan Teknologi. Fakultas Tenkik Universitas Muhammadiyah, Jakarta, 12 November 2014.

Selian, N., Ridwansyah, and G. Sentosa. 2019. Characteristic quality of physical, chemical, and functional cassava flour and mocaf (modified cassava flour) using conventional drying and mechanical drying methods. Jurnal Rekayasa Pangan dan Pertanian 7: 99–105.

Setiawati, T., R. Afnan, and N. Ulupi. 2016. Productive performance and egg quality of layer in litter and cage system with different temperatures. Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan 04: 197–203.

Sistanto, S., E. Sulistyowati, and Y. Yuwana. 2017. Utilization of durian (*durio zibethinus* murr) seeds by- product as a stabilizer of dairy cow milk ice cream. Jurnal Sain Peternakan Indonesia 12: 9–23. https://doi:10.31186/jspi.id.12.1.9-23.

Sulaiman, D., N. Irwani, and K. Maghfiroh. 2019. Production activities of isa brown strain chicken at the age 24-28 weeks. Jurnal Peternakan Terapan 1: 26–31. https://doi:10.25181/peterpan.v1i1.1477.

Suswoyo, I., I. Ismoyowati, W. Widodo, and Z. Vinceviča-Gaile. 2021. The use of probiotics and antioxidants to improve welfare and production of layer duck at commercial farms for global warming mitigation. E3S Web Conf. 226: 1–7. https://doi:10.1051/e3sconf/202122600025.

Syahri, M. 2018. Pembuatan mineral wafer dengan penambahan binder berbeda dan uji hasil terbaik pada performa sapi Sumba Ongole. Buletin Makanan Ternak 16: 1–25.

Triyanto, E., B. W. H. E. Prasetiyono, and S. M. 2013. The effect of package and storage periods on physical and chemical quality of complete feed wafer based on agroindustry waste. Animal Agriculture Journal 2: 400–409.

Vidyana, I. N. Ary, S. Tantalo, and Y. S. Liman. 2014. Survey of the physical properties and nutrient content of cassava to different drying methods in two districts of lampung province. Jurnal Ilmu Peternakan Terpadu 2: 58-62.

Wati, N., R. A. Muthalib, and R. Dianita. 2020. Kualitas fisik biskuit konsentrat mengandung indigofera dengan jenis dan konsentrasi bahan perekat berbeda. Pastura 9: 82-89.

Widiawati, Y., R. Sutrisna, and Siswanto. 2016. Physiological response of mojosari's male duck with giving protein crude in a different ratio. Jurnal Ilmiah Peternakan Terpadu 4: 182-187.

Widodo, W. 2019. Ilmu nutrisi ternak unggas. Cetakan Edisi Tiga. UMM Press, Malang.

Winarno, F. G. 2007. Teknobiologi pangan. M-Brio Press, Bogor.

Xie, S., E. J. Turrell, and T. J. McWhorter. 2017. Behavioral responses to heat in captive native Australian birds. Emu Austral Ornithology. 117: 51–67. https://doi:10.1080/01584197.2016.1271989.