



Carcass and Meat Qualities of New Zealand White Rabbits with Honey Supplements

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Abstract | This study examined the effects of honey supplements on carcass and meat quality in New Zealand White rabbits. This study used 32 rabbits divided into 4 treatments, P0 as a control, P1 given honey supplements 0.2 ml kg⁻¹ body weight, P2 given honey supplements 0.4 ml kg⁻¹ body weight, and P3 given honey supplements 0.6 ml kg⁻¹ body weight. Rabbits were reared for eight weeks. The parameters studied were carcass percentage, meat bone ratio, physical quality and chemical quality of meat. The results showed that the treatment of honey supplements was significantly different ($P < 0.05$) to the percentage of carcass, but not significantly different ($P > 0.05$) to the meat bone ratio. Honey significantly affected cooking and drip loss ($P < 0.05$) but had no effect on tenderness, pH, or water-holding capacity ($P > 0.05$). Honey significantly influenced fat, protein, and carbohydrate content ($P < 0.05$), but not water or ash content ($P > 0.05$). Honey supplements increased carcass percentage, reduced cooking and drip losses, raised protein content, and lowered fat and carbohydrate content.

Keywords | Carcass percentage, Meat bone ratio, Meat cooking loss, Meat drip loss, Protein content, Carbohydrate content

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INTRODUCTION

Currently, changes in mindset and healthy lifestyle trends in society are opening up opportunities for livestock businesses, one of which is rabbit farming which provides animal protein (Cullere and Zotte, 2018). Rabbits excel with high feed efficiency and can produce up to 10 litters annually, averaging six kits per litter (Petrescu and Petrescu, 2018). Apart from that, rabbit meat also has the advantage of having a high protein content and low fat

(Frunza *et al.*, 2023). Kumar *et al.* (2023) stated that rabbits are capable to produce meat with a protein content of up to 25.08%. Therefore, rabbits have also been named as one of the versatile livestock species that responds to bioeconomic principles that encourage efficient use of resources which makes rabbit meat have added value, such as functional food (Petrescu and Petrescu, 2018).

New Zealand White (NZW) rabbits are a type of meat rabbit with high production performance as a potential

ETHICAL APPROVAL

This study was approved by the Animal Ethics Committee of the University of Malayahati, Indonesia (Approval number: 4169/EC/KEP-UNMAL/III/2024)

ANIMALS, SUPPLEMENT TREATMENT AND MANAGEMENT

A randomized block design was used with 32 New Zealand White rabbits (2-3 months old) divided into four weight-based groups. P0 as a control (rabbits not given honey), P1 rabbits given honey supplements 0.2 ml/kg body weight, P2 rabbits given honey supplements 0.4 ml/kg body weight, P3 rabbits given honey supplements 0.6 ml/kg body weight. Rabbits were reared for eight weeks in galvanized cages (30×40×50 cm)³. Honey from Apis mellifera bees with Acacia crassiparpa nectar was given orally each morning.

RABBIT SLAUGHTERING, CARCASS AND MEAT ANALYSIS

Rabbits are slaughtered by cutting the carotid artery, jugular vein, trachea, esophagus, and vagus nerve (Nakyinsige *et al.*, 2014). Slaughtered rabbits were bled, skinned, and had their genitals, bladder, gastrointestinal tract, and distal legs removed. The head, set of organs, liver, and kidneys were removed from each carcass to obtain the reference carcass (RC), which included the meat, bones, and fat deposits (Zotte *et al.*, 2016). Carcass percentage was calculated as (carcass weight ÷ slaughter weight) × 100%. The meat bone ratio is obtained by dividing the weight of lean meat by the weight of carcass bones.

ANALYSIS PHYSICAL PROPERTIES OF MEAT

The physical properties of meat observed in this study include tenderness, cooking loss, drip loss, pH, and water holding capacity (WHC). A pH meter was used in determining the pH value of the meat (Iso and Kennedy, 2021). In the determination of meat cooking losses, meat samples were put into a plastic bag, cooked at 80°C for 45 mins, cooled at room temperature then weighed. Differences in weights before and after cooking was expressed as a percentage to form the cooking loss values (Iso and Kennedy, 2021).

Water-holding capacity (WHC) was determined by compressing meat on filter paper between plates. Measurements were carried out on muscles stored at 2°C, 24 hours after slaughter. WHC was assessed by placing 3 g of meat on filter paper (7 cm of diameter). The paper containing the sample was placed between two glass plates and immediately given a load of 2.25 kg, for 5 minutes. Furthermore, the wet filter paper is weighed immediately after the compressed meat is removed. The WHC percentage is calculated

source of animal protein which is widely reared in Indonesia (Brahmantiyo *et al.*, 2017; Amira *et al.*, 2023; Frunza *et al.*, 2023). NZW rabbits are commonly used in therapeutic research and for producing hyperimmune serum (Putri *et al.*, 2018; Putri *et al.*, 2022). Rearing NZW rabbits in Indonesia faces challenges in achieving optimal production.

Indonesia, as a tropical country, with an average daily temperature of 30-35°C, is an inadequate habitat for rabbit rearing activities. Rabbits are more susceptible to heat stroke than other animals (Marhaeniyanto *et al.*, 2015). Rabbits have a limited ability to sweat and cool themselves. Prolonged heat exposure causes hyperthermia and stress in rabbits (Liang *et al.*, 2022). Heat stress reduces body weight gain (20-25%), feed efficiency (8-15%), and reproductive performance (6-10%) while increasing mortality (9-12%) and lowering meat and carcass quality (Abdelsalam and Fathi, 2023). Rabbit meat quality can be influenced by various variables such as genetics, rearing system, feed and environment (Siregar *et al.*, 2014; Kumar *et al.*, 2023). Rabbit meat protein acts as an antioxidant and inhibits angiotensin-converting enzyme (ACE) (Chen *et al.*, 2021; Permadi *et al.*, 2019). However, several studies conducted in Indonesia regarding the protein content of rabbit meat have not provided maximum results, less than 25%, namely 19.99% (Fadlilah *et al.*, 2020) and 20.22%-21.02% (Sutaryo *et al.*, 2021). Supplements are needed to minimize stress and maintain optimal performance.

Honey is one of the ingredients used not only because of its high nutritional content, but also because of its health benefits. Previous research results prove that a large number of beneficial elements are found in honey such as protein, essential amino acids, unsaturated fatty acids, especially linolenic and linoleic acids, minerals, vitamins, flavonoids and phytosterols. Phenolic compounds in honey show great variability, as well as strong antioxidant capabilities (Olas, 2020). The high antioxidant content in honey also has the potential to eliminate free radicals resulting from stress in rabbits (Pita-Calvo *et al.*, 2017; Olas, 2020; Ramli *et al.*, 2021). Giving honey has a significant effect on the slaughter weight of male quail at the age of 10 weeks (Tugiyanti *et al.*, 2021). Research Abdel-Hamid and El-Tarabany (2019), using bee pollen as an oral supplement at a dose of 250 or 350 mg/kg body weight, can increase the ratio of feed, immunity, and blood index in rabbits. Based on the content of honey, honey can be utilized as a supplement for rabbits. Giving honey supplements is valuable as an antioxidant for rabbits and can improve the quality of carcass and NZW rabbits meat. This study aims to analyze the effect of honey supplements on the quality of rabbit carcasses and rabbit meat. Carcass quality includes the percentage of carcass dan MBR, and meat quality meat includes the physical properties and chemical properties of rabbit meat.

ed as the ratio of the weight percentage of water released (weight of wet filter paper-weight of dry filter paper) to the initial weight of meat. (Frunza *et al.*, 2023).

Measurement of meat drop loss is carried out by weighing a meat sample with a thickness of 2.0 cm without fat and connective tissue, recorded as the initial weight of the sample. After that, the meat is tied with string and hung until it is tightly wrapped. Meat should not touch the plastic bag. Hang the meat at room temperature for 24 hours. Before weighing, the meat is dried and then weighed (Arsana *et al.*, 2019). Drip loss (%) was calculated as [(initial weight – final weight) ÷ initial weight] × 100.

CHEMICAL PROPERTIES OF MEAT

The chemical properties of meat include water content, ash, protein, crude fiber, fat and carbohydrates. Measuring the chemical properties of meat used the proximate analysis method based on the Association of Official Agricultural Chemists (AOAC, 2005). Meanwhile, the analysis of carbohydrate content uses the calculation: 100-(protein + fat + ash content) (Setyorini and Puspitasari, 2021).

STATISTICAL ANALYSIS

The study results were analyzed using one-way analysis of variance (ANOVA). ANOVA was used to analyze the data in the general linear including carcass percentage, MBR, physical and chemical properties of meat. ANOVA applied to SPSS conforms to Group Random Design. The difference between treatments was analyzed using Duncan's multiple distance test and was considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

Honey is a natural and nutritious food produced by honey bees from nectar and plant pollen. Honey contains 16 oligosaccharides including 11 disaccharides and 5 trisaccharides. The oligosaccharide components in honey have potential prebiotic activity by increasing the population of bifidobacteria and lactobacilli. Honey has antibacterial, antioxidant, anti-inflammatory activity so it can be used to fight infections, help heal wounds, treat infections, fight metabolic syndrome and increase immunity (Pita-Calvo *et al.*, 2017). Based on the content and benefits of honey, giving honey supplements to rabbits is expected to increase nutritional intake which has implications for improving the quality of rabbit carcasses and meat.

CARCASS QUALITY

PERCENTAGE OF CARCASSES: Percentage of NZW rabbits carcasses with honey supplement treatment presented in Table 1. Based on Table 1 showed that giving honey supplements had a significant effect ($P < 0.05$) on the

percentage of NZW rabbit carcasses. Rabbits given 0.4 ml/kg body weight (P2) and 0.6 ml/kg body weight (P3) honey supplements had a higher carcass percentage than the rabbits given honey supplements 0.2 ml/kg body weight (P1) and control. Honey contains essential components, including minerals, vitamins, and enzymes, beneficial for metabolism (Edo *et al.*, 2023). This is in line with Syahpura *et al.* (2020) which used Fruktooligosakarida (FOS) in NZW cross-bred rabbits which was able to produce a carcass percentage of up to 56.7%.

Table 1: Percentage of NZW rabbit carcasses with honey supplement treatment.

Treatment	Slaughter weight (g)	Carcass weight (g)	Carcass Percentage (%)
P0	1,865 ± 227.13 ^a	1,015 ± 150.11 ^a	53.55 ± 0.09 ^a
P1	1,872 ± 133.37 ^a	1,005 ± 72.75 ^a	53.92 ± 0.06 ^b
P2	1,895 ± 66.39 ^a	1,023 ± 31.75 ^a	54.61 ± 0.24 ^c
P3	2,122 ± 297.34 ^a	1,155 ± 161.65 ^a	54.42 ± 0.01 ^{b,c}

Note: The same superscript in the same column shows that it is not significantly different ($P < 0.05$); while different superscripts show that it is significantly different ($P < 0.05$).

Table 2: Meat bone ration from NZW rabbits treated with honey supplements.

Treatment	Meat weight (g)	Bone weight (g)	MBR	Percentage of meat (%)	Bone percentage (%)
P0	846 ± 127.02	169 ± 23.09	4.94 ± 0.07	83.33 ± 0.09	16.67 ± 0.09
P1	836 ± 50.81	169 ± 6.92	5.00 ± 0.10	83.17 ± 0.42	16.83 ± 0.42
P2	855 ± 30.60	168 ± 1.15	5.05 ± 0.15	83.56 ± 0.63	16.44 ± 0.63
P3	965 ± 139.14	191 ± 22.52	5.08 ± 0.13	83.47 ± 0.62	16.53 ± 0.62

Note: The results of Anova analysis show that the MBR parameters are not significantly different ($P < 0.05$) between treatments.

MEAT BONE RATION (MBR): Meat bone ration is a comparison to find out how much meat is produced compared to bone (Wibowo *et al.*, 2014). Meat bone ration from NZW rabbits treated with honey supplements can be seen in Table 2. The percentage of bone meat in NZW rabbits between treatments was not significantly different ($P > 0.05$). Honey contains the mineral calcium and gluconic acid which can affect bone growth. Honey also contains polyphenols, vitamins (A, C, E and beta-carotene) which are antioxidants and anti-inflammatory substances that are able to protect bones, through their polyphenol content which works on several signaling pathways, leading to bone anabolic and antiresorptive effects (Ramli *et al.*, 2021). Based on these results shows that giving honey at

0.6 ml/kg body weight is still able to maintain the same bone percentage value as the group that did not give honey supplements. Prentice *et al.* (2005) stated that calcium carbonate supplementation can increase bone growth resulting in greater bone mineral addition.

MEAT QUALITY

PHYSICAL QUALITY OF MEAT: The physical quality of meat observed in this study includes: pH, meat tenderness, cooking loss, water holding capacity and drip loss. The physical quality of NZW rabbit meat treated with honey supplements can be seen in Table 3. pH and is an important indicator in determining meat quality. It should be used in the evaluation of meat standards especially in selecting meat aging process (Weglarz, 2010). Based on Table 3, it shows that the pH of the meat in all treatment groups was still at standard with an average 5.9–6.2. The pH of meat in NZW rabbits between treatments was not significantly different ($P>0.05$). The pH of meat is measured at pH 7.1 and after slaughter, the pH becomes acidic (pH 5.5–6.2) within 18–24 hours due to the conversion of glycogen to lactic acid (Firmansyah *et al.*, 2015; Zotte *et al.*, 2016; Pusparini *et al.*, 2020).

Meat tenderness was evaluated using physical methods. The results showed that P0 and P3 had the same level of tenderness, while P1 and P2 had different levels of tenderness. This result indicate that honey supplement had no effect on the level of rabbit meat tenderness. Meat tenderness is related by the biochemical properties of muscle fibers and connective tissue matrix and increases with age due to degradation of cytoskeletal proteins. Meat tenderness influenced by handling and slaughter conditions, genetic characteristics, and animal growth (Zotte *et al.*, 2016). Rabbit meat tenderness in this study smaller than Firmansyah *et al.* (2015) 2.35 ± 0.38 and the research by Hermawan *et al.* (2021) 3.78 ± 0.05 .

Cooking loss is the difference in weight of meat before and after cooking and is expressed as a percentage. The average cooking loss for rabbit meat in this study showed that P0 and P1 were higher and significantly different ($P<0.05$) from P2 and P3. Cooking loss in this study was lower than the 43.57% reported by Firmansyah *et al.* (2015) for local rabbits 2015, while Brahmantiyo *et al.* (2014) stated that the cooking loss of male Rex rabbits was 36.01%. Research by Hermawan *et al.* (2021) expressed that NZW crossbred rabbits produce cooking losses ranging from 35.00–40.00%. Giving honey at levels 0.4 and 0.6 ml/kg body weight produced better meat tenderness. The meat quality related to the amount of nutrients lost during cooking. According to Liur *et al.* (2022), the amount of cooking loss is influenced by the amount of damage to cell membranes, the amount of water that comes out of the meat, the shelf life of the meat, protein degradation and the ability of the meat to bind water.

Table 3: The physical quality of NZW rabbit meat treated with honey supplements.

Treatment	pH	Tenderness (kg cm ⁻²)	Cooking loss (%)	WHC (%)	Drip loss (%)
P0	6.11 ± 0.01 ^a	1.46 ± 0.01 ^b	17.61 ± 0.38 ^b	19.99 ± 0.56 ^{a,b}	15.64 ± 0.11 ^c
P1	5.93 ± 0.02 ^a	1.34 ± 0.01 ^a	22.54 ± 0.84 ^b	21.15 ± 0.05 ^a	14.38 ± 0.25 ^b
P2	6.05 ± 0.02 ^a	1.52 ± 0.05 ^c	15.99 ± 0.37 ^a	18.79 ± 0.24 ^{b,c}	12.83 ± 1.43 ^a
P3	6.22 ± 0.03 ^a	1.45 ± 0.02 ^b	15.55 ± 0.44 ^a	18.39 ± 1.66 ^c	11.93 ± 0.02 ^a

Note: The same superscript in the same column shows no significant difference ($P<0.05$); while different superscripts show significant difference ($P<0.05$).

Drip loss is an indicator used to show the loss of several nutritional components of meat accompanied by the release of meat juice over time. Based on the results of statistical analysis of meat drip loss in all treatments showed that P1, P2 and P3 are significantly different ($P<0.05$) from P0, this shows that giving honey supplements has an effect on meat drip loss. The dose of honey supplement also affects the drip loss value, giving honey 0.4 and 0.6 ml/kg body weight resulted in lower drip loss values compared to 0.2 ml/kg body weight. Low drip loss indicates better protein water retention, preserving nutritional content. Arsana *et al.* (2019) states that the number of droplets lost is influenced by the amount of liquid that comes out of the meat and the presence of factors related to the water holding capacity of meat proteins.

Water-holding capacity of meat is defined as the ability of the postmortem muscle (meat) to retain water even though external pressures (Kudryashov and Kudryashova, 2023). Based on Table 3, the water holding capacity of rabbit meat in all treatments was not significantly different ($P>0.05$). This shows that honey supplementation does not affect WHC. The average WHC increases as the pH value decreases. In this research, increasing the concentrate level causes the protein content of the meat to also increase. Increasing the protein content causes the ability of the meat to bind water to also increase because protein has the property of binding water.

CHEMICAL QUALITIES OF RABBIT MEAT: The chemical quality indicators of NZW rabbit meat that were observed in this study included water, ash, fat, protein and carbohydrate. The chemical quality of NZW rabbit meat treated with honey supplements can be seen in Table 4. Based on Table 4, showed the water content of all treatment ranged from 71.53–73.14%, and the water percentage of P2 and P3 are significantly different ($P<0.05$) from P0 and P1. The water percentage in this study lower than the Fadlilah *et al.* (2020) research results 75.84%. Carrasco-García *et al.*

(2020) states that the water content of fresh meat is more influenced by the level of dehydration of livestock before slaughter.

Table 4: The chemical quality tests on NZW rabbit meat treated with honey supplements.

Treatment	Water (%)	Ash (%)	Fat (%)	Proteins (%)	Carbohydrate (%)
P0	73.14 ± 0.93 ^a	0.78 ± 0.15 ^a	1.63 ± 0.87 ^a	19.43 ± 0.52 ^a	5.03 ± 0.52 ^a
P1	72.95 ± 0.97 ^a	0.69 ± 0.18 ^a	2.50 ± 0.78 ^a	22.28 ± 1.14 ^b	1.59 ± 1.14 ^b
P2	71.53 ± 0.03 ^b	0.60 ± 0.01 ^a	2.25 ± 1.37 ^a	24.05 ± 1.54 ^b	1.57 ± 0.13 ^b
P3	71.95 ± 0.13 ^b	0.78 ± 0.00 ^a	0.80 ± 0.28 ^b	24.32 ± 1.23 ^b	2.14 ± 1.09 ^b

Note: The same superscript in the same column shows no significant difference ($P < 0.05$); while different superscripts show significant difference ($P < 0.05$).

Table 4 showed ash content of the meat rabbits that was not significantly different ($P > 0.05$) in all treatment in range 0.60–0.78%. The ash content in this study was lower than the Fadlilah *et al.* (2020) 1.43% and Brahantiyo *et al.* (2014) namely 1.06–1.19%. Ash content refers to the minerals and inorganic substances left after heating to extremely high temperatures to remove moisture, volatiles, and all organic materials. The higher the ash content value indicate the higher of mineral content. Ash content can vary depending on the type of meat, as well as other factors like the animal's age, breed, sex, feed, and body weight (Geletu *et al.*, 2021).

Protein, a key component of meat, forms the building blocks of muscle tissue. Protein is a complex molecule made up of simple organic molecules known as amino acids (Geletu *et al.*, 2021). Table 4 showed the protein levels of rabbits given honey were significantly different ($P < 0.05$) compared to control. Protein levels increased with higher doses of honey supplementation. The result indicate that honey can influence the level protein of meat. The protein content in this study was higher compared to Fadlilah *et al.* (2020) was 19.99% and Sutaryo *et al.* (2021) namely 20.22–21.02%. Protein content is the most important indicator in food. Honey contains a number of amino acids and enzymes which can play a role in synthesizing protein in rabbit muscles (Cianciosi *et al.*, 2018).

Meat contains almost no carbohydrates. This is because the main carbohydrate found in muscle, the complex sugar glycogen, is broken down when muscle is converted into meat (Geletu *et al.*, 2021). The results of this study (Table 4) show that the carbohydrate content in meat with honey supplement treatment at P1, P2, and P3 showed signifi-

cantly different ($P < 0.05$) with the control treatment (P0). Carbohydrate levels in the animal's body are stored in the form of glycogen (muscle sugar). Glycogen is metabolized into lactic acid, influencing meat pH. The carbohydrate content of the meat from the study was slightly higher than the carbohydrate content of the study by Fadlilah *et al.* (2020) was 0.43%.

CONCLUSIONS AND RECOMMENDATIONS

Honey can be used as a supplement for rabbits during the fattening period. Honey supplementation increased carcass percentage but had no effect on MBR. Honey supplements reduced cooking and drip losses. Honey supplements increased meat protein content while reducing fat and carbohydrates.

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AUTHOR'S CONTRIBUTIONS

Vitta Herina and Dwi Desmiyeni Putri designed the research; Vitta Herina and Dwi Desmiyeni Putri conducted the experiment in the laboratory; Vitta Herina, Dwi Desmiyeni Putri, and Suraya Kaffi Syahpura analyzed the data; Vitta Herina, Dwi Desmiyeni Putri, and Suraya Kaffi Syahpura drafted the manuscript; Vitta Herina and Dwi Desmiyeni Putri revised the manuscript.

CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interests.

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