



Effects of Moringa Leaf and Fruit Powder Supplementation on Hematological Parameters and Growth Performance in Kacang Goats

Sagaf Sagaf^{1*}, Abdullah Naser¹, Nirwana Nirwana¹, Sri Wulan Cakrawati¹, Zainal Zainal¹,
Mustafa Mustafa¹, Naharuddin Naharuddin²

¹ Department of Animal, Faculty of Animal and Fishery, Tadulako University, Palu 94118, Indonesia

² Department of Forestry, Faculty of Forestry, Tadulako University, Palu 94118, Indonesia

Corresponding Author Email: sagaf@untad.ac.id

Copyright: ©2024 The authors. This article is published by IETA and is licensed under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

<https://doi.org/10.18280/ijdne.190326>

ABSTRACT

Received: 15 April 2024
Revised: 17 May 2024
Accepted: 21 May 2024
Available online: 25 June 2024

Keywords:

female Kacang goats, alternative feed resources, animal nutrition, sustainable agriculture

Livestock producers are currently facing challenges such as scarcity and high prices of concentrate feed, which significantly impact livestock productivity. Therefore, this research aimed to assess the impact of supplementing moringa leaf and fruit powder on hematological parameters, cholesterol levels, weight gain, and carcass weight in female Kacang goats. To conduct the analysis, a Randomized Block Design (RBD) with three treatments was adopted, each repeated four times as groups. The treatments included P0: Concentrate without moringa leaf and fruit powder, P1: Concentrate with the addition of 20% moringa fruit powder, and P2: Concentrate with the addition of 20% moringa leaf powder. The experimental livestock comprised 12 female Kacang goats aged 10-12 months, weighing between 8 kg to 12.5 kg. The observed variables included weight gain, dry matter intake, feed efficiency, leukocyte count, erythrocyte count, hemoglobin levels, hematocrit levels, High-Density Lipoprotein (HDL), Low-Density Lipoprotein (LDL), Triglyceride (TG) levels, carcass weight, and carcass percentage. The analysis of variance (ANOVA) indicated significant effects of supplementing concentrate with moringa leaf and fruit powder on weight gain, HDL, LDL, and TG levels, carcass weight, and carcass percentage in female Kacang goats. These results showed that adding moringa leaf and fruit powder into concentrate could effectively reduce cholesterol levels in goats meat. Additionally, the 20% addition of the powder to concentrate enhanced protein contribution, thereby accelerating livestock weight gain.

1. INTRODUCTION

The escalating prices of ingredients have led to the high cost of livestock feed, resulting in poor nutrition [1, 2] and subsequently decreased livestock productivity in developing countries such as Indonesia [3]. Feed scarcity poses a significant challenge to livestock production, worsening the issue of low protein intake sufficiency [2, 4]. Therefore, it is necessary to explore alternative livestock feed derived from agricultural or plantation lands to address the limited availability of feed [5, 6].

The use of legume and non-leguminous tree forage to support nutritional intake for goats is something that needs to be continuously pursued considering the low nutritional content of natural grass forage used, especially in tropical countries. In Indonesia, particularly in Central Sulawesi, goats are recognized to be a promising small ruminant species for development and low-maintenance husbandry [7]. Goats serve as a valuable source of animal protein [8, 9], but there is a public perception that their meat contains higher cholesterol contents compared to beef or poultry meat.

Cholesterol contents in goats' meat are 75 mg lower than those in beef, which are at 90 mg [10, 11]. This result

contradicts the assumption that goat's meat is a significant contributor to cholesterol without scientific evidence. Cholesterol exists in food and the body, primarily as free cholesterol or fatty acids [12, 13]. It serves essential functions, comprising hormone production and cell wall formation [14, 15]. Upon excretion, it is released in bile as unchanged cholesterol, cholic acid, or chenodeoxycholic acid (bile acids) and stored in a bile solution by bile salts and phospholipids [16].

Cholesterol released from peripheral tissues is extracted and lecithinized by lecithin cholesterol acyltransferase (LCAT) and esterified in plasma by fatty acids, which are then transported to the liver as High-Density Lipoprotein (HDL) [17]. Moreover, it can be transported to lipoproteins through triglyceride exchange [18, 19]. Decreased plasma cholesterol esters occur when hepatic parenchymal cells are damaged due to LCAT deficiency in the liver. The rare occurrence of the deficiency results in the accumulation of free cholesterol in plasma and tissues [20].

Moringa (*Moringa oleifera*) is a popular plant in Indonesian society, particularly in Palu City. Phytochemical tests have shown that moringa leaf contains chemical compounds such as alkaloids, flavonoids, phenols, triterpenoids/steroids, and

tannins, which serve as anticancer and antibacterial agents [21]. Moringa leaf and fruit are widely used as raw materials in the cosmetics industry, pharmaceuticals, and probiotic beverages for health, or added to food as fortifiers (nutrients) to enrich their nutritional value. Moreover, moringa fruit offers various benefits including preventing colon cancer, aiding in edema treatment, reducing the risk of diabetes and asthma exacerbation, preventing prostate cancer and hypertension, lowering cholesterol levels, combating cardiovascular diseases, and possessing anti-inflammatory properties [22, 23].

Moringa is a nutrient-rich plant species, with its leaf containing protein (28.25%), Beta-carotene (Provitamin A) 11.93 mg, calcium (Ca) (2241.19) mg, iron (Fe) (36.91) mg, and magnesium (Mg) (28.03) mg [24, 25]. On the other hand, the main content in moringa fruit is minerals, particularly Fe, with a concentration of 0.36 mg per 100 grams [26], Is a source of animal feed that is rich in other bio-active compounds including flavonoids and phenolic compounds [23].

The nutritional benefits of moringa leaf and fruit offer an opportunity for utilization in livestock farming. They can be used as mixed feed to reduce cholesterol contents in goats' meat and enhance the performance, hematological parameters, and carcass quality. In general, the aim of this research is to explore alternative food sources for peanut goats that come from nature towards sustainable agriculture. Meanwhile, the specific is aimed to assess the effect of adding moringa leaf and fruit powder on hematological parameters, cholesterol contents, weight gain, and carcass weight of female Kacang goats.

2. MATERIAL AND METHODS

2.1 Research time and place

The research was conducted from March to November 2023 following a preliminary test on the nutritional content of feed ingredients, conducted from March to October 2022, at the Agrotechnology Laboratory of the Faculty of Agriculture, Tadulako University. The goat pens, owned by residents, were situated in Boyaoge Village, Tatanga Sub-district, Palu City, Central Sulawesi Province.

2.2 Research materials

The experimental livestock comprised 48 female Kacang goats aged 10 to 12 months, weighing between 8 to 12.5 kg. The determination of livestock age relied on the condition of the goats' temporary and spaced-out incisor teeth [27, 28]. The Kacang Goats are used with permission from the Central Sulawesi Provincial Livestock Service in collaboration with Tadulako University.

During the research, the treatment feed included concentrate and *Panicum sarmentosum* (Roxb) forage. The concentrate covered a mixture of several ingredients including ground soybeans (13%), rice bran (55%), and ground corn (32%). Additionally, moringa leaf and fruit powder were each supplemented at a 20% ratio into the concentrate. Feeding occurred at 07:30 in the morning at 1% dry matter of body weight, while *Panicum sarmentosum* (Roxb) grass was offered ad libitum after the consumption of the concentrate and treatment.

The main pens used comprised two elevated units featuring asbestos roofs, bamboo flooring, and tasowood frame walls.

Each pen measured 6 × 1.25 m and was subdivided into individual sections measuring 1 × 1.25 m, housing one experimental goats per section. Each section was furnished with a feed trough constructed of boards and a drinking water basin. Three days before using the pens, they were cleaned and sprayed with Antisep disinfectant diluted at a rate of 15 cc per 10 liters to eliminate germs.

Table 1. Nutritional content of feed ingredients used in the research

Feed Ingredients	Dry Matter (%)	Crude Protein (%)	Crude Fiber (%)	Crude Fat (%)
<i>Panicum sarmentosum</i>	26.29	11.51	30.20	1.90
Ground Corn	86.82	9.54	9.92	8.30
Ground Soybeans	91.97	31.35	9.73	11.65
Rice Bran	89.6	9.67	30.65	2.08
Moringa Fruit Powder	90.18	18.27	18.95	14.04
Moringa Leaf Powder	92.70	22.54	12.59	7.32

Source: Analysis Results of the Agrotechnology Laboratory, Faculty of Agriculture, Tadulako University, 2022.

Table 2. Concentrate content used

Ingredient Name	Composition	Dry Matter	Crude Protein	Crude Fiber	Crude Fat	TDN
Ground Corn	32	27.78	3.05	3.17	2.66	25.88
Ground Soybeans	13	11.96	4.08	1.26	1.51	7.93
Rice Bran	55	49.46	5.87	10.11	2.54	33.67
Total	100	89.19	12.99	14.55	6.7115	67.47

2.3 Research design

This research adopted a Randomized Block Design (RBD) using with 3 treatments and repeated 4 times as groups, with one experimental unit consisting of 4 female Kacang goats so that a total of 48 goats were used. The treatments provided includes referring to Tables 1 and 2.

P0: Concentrate without the addition of moringa leaf and fruit powder.

P1: Concentrate with the addition of 20% moringa fruit powder.

P2: Concentrate with the addition of 20% moringa leaf powder.

2.4 Observed variables

According to Mthi et al. [29], the observed variables included:

Hematological parameters: The levels of erythrocyte, leukocyte, thrombocyte, hemoglobin, and hematocrit in goats were measured through blood sampling [30]. Blood samples were drawn from the jugular vein situated on the neck of the goats. The sampling procedure included applying pressure to the lower part of the blood vessel to impede blood flow, followed by sample collection using a 3 ml syringe inserted into the designated collection tube.

Cholesterol: The sampling process was carried out concurrently with the cholesterol sampling. Blood samples were collected to determine Triglyceride (TG), High-Density Lipoprotein (HDL), and Low-Density Lipoprotein (LDL) levels.

Weight gain: Weight gain was calculated by subtracting the

initial body weight from the final body weight and dividing it by the observation period, with weighing conducted weekly before feeding.

2.5 Carcass weight

Carcass weight was directly measured immediately after slaughter and determined by calculating the difference between the pre-cut weight and the weight after cutting [31, 32]. The weight after cutting included the head, lower limb joints (tibia and fibula) at the tarsal bumps for both hind legs, and at the elbow joints (radius and ulna) at the carpal bumps for both front legs, as well as internal organs (digestive tract, reproductive tract, urinary tract, heart, lungs, spleen, liver, excluding kidneys). The carcass percentage was calculated by dividing the carcass weight by the pre-cut weight, and then multiplying by 100% [33].

2.6 Data analysis

The data obtained were analyzed using the analysis of variance (ANOVA), and overall analysis using Minitab 16 software [34, 35]. When the treatment had a significant effect, the least significant difference (LSD) test was performed [36]. The mathematical method used was as follows:

$$Y_{ij} = \mu + ai + \beta j + \epsilon_{ij}$$

where,

i: Treatment 4

j: Group 4

Y_{ij}: Observation value *i* and treatment *j*

μ : Population mean value

A: Effect from group *i*

B_j: Treatment from treatment *j*

ϵ_{ij} : Experimental error

3. RESULTS AND DISCUSSION

Weight Gain

Based on the ANOVA results, the addition of concentrate with moringa leaf and fruit powder significantly affected ($P < 0.01$) the weight gain of female Kacang goats. Post-hoc tests using the honest significance difference (HSD) method indicated significant differences between treatment groups P0 and P1, as well as between P1 and P2 (Table 3).

Table 3. Mean weight gain of Kacang goats during the research

Group	Treatment		
	P0	P1	P2
1	65.18	91.96	122.32
2	67.68	94.64	123.75
3	66.79	94.46	124.11
4	68.57	95.36	124.46
Mean	67.05A	94.11B	123.66C

Note: Numbers followed by the same letter toward the rows indicate significant and highly significant differences.

The data in Table 1 indicating the trend of weight gain increase in treatments P1 and P2 suggested that feeding with concentrate supplemented with 20% moringa leaf and fruit powder provided a high protein contribution, thereby

accelerating livestock weight gain. This result was in line with the research by Kim et al. [37], indicating that excess protein in feed could be efficiently used by livestock for weight gain.

The observed increase in weight gain in treatment group A3 correlated with the level of feed consumption and digestibility. Higher feed consumption and better digestibility resulted in improved weight gain, consistent with the observations by Wilkinson and Lee [38], and Cantalapiedra-Hijar et al. [39]. Moreover, feed intake and digestibility were recognized as crucial factors affecting livestock productivity [40, 41]. Higher energy intake also led to faster growth and increased growth rates.

Based on the F-test results from the ANOVA, the addition of moringa fruit and leaf powder into concentrate significantly influenced ($P < 0.01$) the levels of HDL, LDL, and TG in female Kacang goats (Table 4).

Table 4. Mean cholesterol values of experimental livestock in various treatments

Parameter	Treatment		
	P0	P1	P2
HDL	24.8	34.95	41.37
LDL	5.15	3.45	1.62
TG	24.5	30.75	36.25

Note: P0: Control, P1: Moringa fruit powder, P2: Moringa leaf powder
Numbers followed by different letters toward the rows indicate significant differences.

High-Density Lipoprotein (HDL)

High-Density Lipoprotein (HDL), considered beneficial and harmless, carried lower cholesterol contents compared to Low-Density Lipoprotein (LDL). HDL was referred to as good cholesterol because it could extract surplus bad cholesterol from the arteries before being transported to the liver. It prevented cholesterol buildup in the arteries, safeguarding blood vessels from atherosclerosis, which was plaque formation on the vessel walls. Cholesterol synthesized by the liver was transported through LDL to various body cells, including those in the heart, brain, and others. Excessive cholesterol was then transported back to the liver by HDL, where it was metabolized and eliminated through bile acid. LDL, containing more fat, tended to float in the bloodstream, and the main protein that formed HDL was Apo-A (apolipoprotein).

The metabolism of HDL cholesterol started with the liberation of small particles carrying apolipoprotein (apo) A, C, and E, termed nascent HDL. Originating from the small intestine and liver, nascent HDL had a flattened structure and contained apolipoprotein A1. It interacted with macrophages to absorb stored cholesterol before being transitioned into mature spherical HDL. To facilitate the uptake of free cholesterol from macrophages, nascent HDL must be transported to the cell membrane surface with the assistance of a transporter called adenosine triphosphate-binding cassette transporter-1 or ABC-1 [42]. Following cholesterol absorption from macrophages, it was esterified into cholesterol esters by the enzyme LCAT. Consequently, some cholesterol esters carried by HDL would follow two pathways. The first was centered toward the liver, intercepted by the SR-B1 receptor, and the second from Very Low-Density Lipoprotein (VLDL) and LDL with the aid of CETP. HDL functioned as a provider through both direct and indirect VLDL and LDL to return cholesterol to the liver [43, 44].

The ANOVA results showed that the addition of moringa fruit and leaf powder into concentrate significantly affected

($P < 0.01$) the HDL levels in the blood of female Kacang goats. Additionally, the HSD post-hoc test indicated significant differences between P0 and both P1 and P2, as well as P1 and P2. High HDL levels are important because they function as antioxidants and anticoagulants which can prevent various diseases in the livestock's body [45].

Low-Density Lipoprotein (LDL)

Cholesterol was a vital nutrient similar to other nutrients such as carbohydrates, proteins, vitamins, and minerals. It was naturally present in various foods, comprising beef, pork, goats, chicken, fish, poultry, and eggs, being an inherent component of animal cells. However, excessive consumption of fats could increase blood pressure, particularly LDL, leading to the accumulation of cholesterol in the body. This accumulation might result in the formation of plaque, potentially causing blockages in blood vessels, known as atherosclerosis. Atherosclerosis diminished the elasticity of blood vessels, disrupted blood flow, and could trigger an increase in blood volume and pressure, thereby contributing to hypertension [46].

The ANOVA results showed that the addition of moringa fruit and leaf powder in concentrate significantly affected ($P < 0.01$) LDL levels in the bloodstream of female Kacang goats, this is very beneficial because LDL is often called bad fat so its content must be lower than HDL. Moreover, the HSD post-hoc test indicated a significant difference between P0 and both P1 and P2, while there was no significant difference between P1 and P2.

Triglyceride (TG)

Triglyceride (TG) constituted a type of fat that circulated in the blood and various organs [47]. Being an organic compound insoluble in water, fat was soluble in nonpolar organic solutions and was used by the body for metabolic processes. It had several types, including cholesterol, HDL, LDL, VLDL, and TG [48].

TG was composed of glycerol alcohol and three fatty acid molecules, including saturated, monounsaturated, and polyunsaturated fats [49]. It primarily served as an energy source in metabolic processes, with a small portion used to form cell membranes throughout the body. In the bloodstream, TG formed complexes with specific proteins called apoproteins, thereby forming lipoproteins, which became its transportation mode [18]. TG was derived from dietary sources and synthesized in the liver, where it was stored as fat under the skin and in other organs. Elevated TG levels result from excess calorie intake relative to energy expenditure, thereby becoming a significant energy source for bodily functions [50, 51].

Based on the ANOVA results (Table 4), the addition of moringa fruit and leaf powder into concentrate significantly affected ($P < 0.01$) the HDL levels in the blood of female Kacang goats. The HSD post-hoc test showed significant differences between P0 and P1, as well as P0 and P2, but not between P1 and P2.

Carcass

Carcass, the main expected outcome of livestock butchering, held substantial economic value. It comprised meat, bones, fat, and connective tissue, with consumer preference leaning toward a higher proportion of meat, lower bone contents, and optimal fat levels. The fresh carcass, which represented the hot carcass weight, was obtained after removing internal organs

such as the liver, spleen, heart, lungs, trachea, digestive tract, gallbladder, and pancreas excluding the kidneys, with mean carcass weight according to Table 5. The weight was calculated by subtracting the weight of blood, head, legs, skin, internal body organs (except kidneys), and reproductive organs from the fasting body weight [52].

Table 5. Mean carcass weight and carcass percentage of female Kacang goats during the research

Group	Treatment					
	P0		P1		P2	
	Weight	%	Weight	%	Weight	%
1	5.19	43.86	7.28	48.00	8.49	48.13
2	5.52	44.23	7.39	47.62	8.76	48.32
3	5.62	43.48	7.42	47.54	9.0	48.82
4	5.75	43.76	7.49	46.94	9.36	48.84

Note: Numbers followed by the same letter toward the rows indicate significant and highly significant differences.

Carcass Weight

The ANOVA results showed a significant effect of adding moringa leaf and fruit powder on carcass weight ($P < 0.05$). Post-hoc testing further indicated that there were significant differences between treatment groups P0, P1, and P2. This trend suggested that with each increase in cut weight, there was a corresponding increase in carcass weight, indicating development in body parts or carcass structures [53]. Energy, primarily supplied by feed ingredients, played a crucial role in supporting livestock growth, with ruminants particularly reliant on feeds high in crude fiber [54].

Carcass Percentage of Female Kacang Goats

The ANOVA results showed a significant impact of adding moringa leaf and fruit powder on carcass percentage ($P < 0.05$). Post-hoc tests confirmed significant differences between treatments P0, P1, and P2. The results showed a higher carcass percentage for female Kacang goats compared to previous reviews by Olawuwo et al. [55] and Jiwuba et al. [56], which reported percentages of 38.47% and 37.50%, respectively. Suggested that carcass percentages for goats or sheep in tropical climates typically ranged between 40-50% [57].

Several factors influenced the carcass percentage of female Kacang goats, including cut weight, carcass weight, body confirmation, cutting method, and fatness level. Additionally, fat livestock tended to have a higher carcass percentage [58], while a larger live weight correlated with an increased percentage [59, 60]. Carcass percentage was also influenced by factors such as carcass weight, livestock weight, condition, breed, proportion of non-carcass parts, and diet [61, 62]. Factors determining the value of slaughtered livestock included carcass weight percentage, proportion of high-value carcass parts and cuts, meat-to-bone ratio, fat distribution, and meat quality. Consumers typically prefer carcass or cut with a high proportion of lean meat, low bone content, and optimal fat content.

4. CONCLUSIONS

In conclusion, feeding with the addition of 20% moringa fruit and leaf powder in concentrate offered a high protein contribution, thereby accelerating livestock weight gain. Additionally, the inclusion of fruit powder in concentrate significantly affected HDL levels in the blood of female

Kacang goats ($p < 0.01$).

Each increase in cut weight correlated with a subsequent rise in carcass weight, indicating a direct relationship between increased cut weight and the development of body parts or carcass. The carcass percentage of female Kacang goats was influenced by factors such as cut weight, carcass weight, body confirmation, cutting method, and fatness level. Moreover, the addition of moringa fruit and leaf powder significantly affected various aspects including weight gain, dry matter intake, feed efficiency, leukocyte, erythrocyte, hemoglobin, hematocrit, HDL, LDL, TG levels, carcass weight, and carcass percentage in female Kacang goats.

These findings confirm that the provision of moringa fruit and moringa leaf powder in concentrate form has made an important contribution to increasing protein thereby accelerating weight gain in Kacang goats. Therefore, it is important to develop moringa as a source of animal feed in order to move towards sustainable agriculture.

ACKNOWLEDGMENT

This research was carried out with funding from DIPA BLU Tadulako University for the 2023 Fiscal Year Leading Research scheme, through Contract Number 1221ag/UN28.2/KU/2023, thanks are expressed to the Rector of Tadulako University, Chair of the Research and Community Service Institute of Tadulako University, and various parties who helped carry out this research.

REFERENCES

- [1] Babatunde, O.O., Park, C.S., Adeola, O. (2021). Nutritional potentials of atypical feed ingredients for broiler chickens and pigs. *Animals*, 11(5): 1196. <https://doi.org/10.3390/ani11051196>
- [2] Balehegn, M., Duncan, A., Tolera, A., Ayantunde, A.A., Issa, S., Karimou, M., Zampaligré, N., André, K., Gnanda, I., Varijakshapanicker, P., Kebreab, E., Dubeux, J., Boote, K., Minta, M., Feyissa, F., Adesogan, A.T. (2020). Improving adoption of technologies and interventions for increasing supply of quality livestock feed in low-and middle-income countries. *Global food security*, 26(9): 100372. <https://doi.org/10.1016/j.gfs.2020.100372>
- [3] Khusun, H., Februhartanty, J., Anggraini, R., Mognard, E., Alem, Y., Noor, M.I., Karim, N., Laporte, C., Poulain, J.P., Monsivais, P., Drewnowski, A. (2022). Animal and plant protein food sources in Indonesia differ across socio-demographic groups: Socio-cultural research in protein transition in Indonesia and Malaysia. *Frontiers in Nutrition*, 9: 762459. <https://doi.org/10.3389/fnut.2022.762459>
- [4] Sekaran, U., Lai, L., Ussiri, D.A., Kumar, S., Clay, S. (2021). Role of integrated crop-livestock systems in improving agriculture production and addressing food security—A review. *Journal of Agriculture and Food Research*, 5: 100190. <https://doi.org/10.1016/j.jafr.2021.100190>
- [5] Naser, A., Padang, P., Sagaf, S., Abdullah, S., Naharuddin, N., Wulan, S., Nirwana, N., Zainal, Z., Mustafa, M. (2023). The impact of processing methods and levels of *Jatropha gossypifolia* L. leaves on

- productivity of goats, considering distance. *International Journal of Design & Nature and Ecodynamics*, 18(3): 653-659. <https://doi.org/10.18280/ijdne.180317>
- [6] Sabariyah, S., Rusdi, Damry, Hasanuddin, A. (2021). The nutritional value enhancement of oil palm empty fruit bunches as animal feed using the fungus *Coprinus comatus*, with different numbers of inoculums and incubation times. *International Journal of Design & Nature and Ecodynamics*, 16(3): 269-274. <https://doi.org/10.18280/ijdne.160304>
- [7] Abdullah, S., Padang, P., Sagaf, S., Naharuddin, N., Cakrawati, S.W., Harmoko, H. (2023). The impact of *Lannea coromandelica* leaf flour supplementation on the production performance and hematological values of local goats. *International Journal of Design & Nature and Ecodynamics*, 18(4): 989-994. <https://doi.org/10.18280/ijdne.180427>
- [8] Pardo, G., Prado, A.D., Fernandez-Alvarez, J., Yanez-Ruiz, D.R., Belanche, A. (2022). Influence of precision livestock farming on the environmental performance of intensive dairy goat farms. *Journal of Cleaner Production*, 351(2-3): 131518. <https://doi.org/10.1016/j.jclepro.2022.131518>
- [9] Morales-Jerrett, E., Mancilla-Leytón, J.M., Delgado-Pertíñez, M., Mena, Y. (2020). The contribution of traditional meat goat farming systems to human wellbeing and its importance for the sustainability of this livestock subsector. *Sustainability*, 12(3): 1181. <https://doi.org/10.3390/su12031181>
- [10] Jayanegara, A., Wiryawan, K.G., Ginting, S.P., Syamsudin, A.A. (2021). Effects of gambir (*Uncaria gambir*) leaf extract as a feed additive on meat quality and cholesterol content in goats. *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 788: 012054. <https://doi.org/10.1088/1755-1315/788/1/012054>
- [11] Jia, W., Shi, Q.Y., Shi, L. (2021). Effect of irradiation treatment on the lipid composition and nutritional quality of goat meat. *Food Chemistry*, 351: 129295. <https://doi.org/10.1016/j.foodchem.2021.129295>
- [12] Schade, D.S., Shey, L., Eaton, R.P. (2020). Cholesterol review: A metabolically important molecule. *Endocrine Practice*, 26(12): 1514-1523. <https://doi.org/10.4158/EP-2020-0347>
- [13] Majdalawieh, A.F., Dalibalta, S., Yousef, S.M. (2020). Effects of sesamin on fatty acid and cholesterol metabolism, macrophage cholesterol homeostasis and serum lipid profile: A comprehensive review. *European Journal of Pharmacology*, 885: 173417. <https://doi.org/10.1016/j.ejphar.2020.173417>
- [14] Aguilar-Ballester, M., Herrero-Cervera, A., Vinué, Á., Martínez-Hervás, S., González-Navarro, H. (2020). Impact of cholesterol metabolism in immune cell function and atherosclerosis. *Nutrients*, 12(7): 2021. <https://doi.org/10.3390/nu12072021>
- [15] Ouweneel, A.B., Thomas, M.J., Sorci-Thomas, M.G. (2020). The ins and outs of lipid rafts: Functions in intracellular cholesterol homeostasis, microparticles, and cell membranes: Thematic review series: Biology of lipid rafts. *Journal of lipid research*, 61(5): 676-686. <https://doi.org/10.1194/jlr.TR119000383>
- [16] Wang, H.H., Portincasa, P., Liu, M., Wang, D.Q.H. (2023). Effects of biliary phospholipids on cholesterol crystallization and growth in gallstone formation.

- Advances in Therapy, 40: 743-768. <https://doi.org/10.1007/s12325-022-02407-8>
- [17] Norum, K.R., Remaley, A.T., Miettinen, H.E., Ström, E.H., Balbo, B.E.P., Sampaio, C.A.T.L., Wiig, I., Kuivenhoven, J.A., Calabresi, L., Tesmer, J.J., Zhou, M.Y., Ng, D.S., Skeie, B., Karathanasis, S.K., Manthei, K.A., Retterstøl, K. (2020). Lecithin: cholesterol acyltransferase: symposium on 50 years of biomedical research from its discovery to latest findings. *Journal of Lipid Research*, 61(8): 1142-1149. <https://doi.org/10.1194/jlr.S120000720>
- [18] Salih, K.J. (2021). The major pathways of lipids (triglyceride and cholesterol) and lipoprotein metabolism. *Zanco Journal Pure and Applied Sciences*, 33(4): 61-72. <https://doi.org/10.21271/ZJPAS.33.4.6>
- [19] Pownall, H.J., Rosales, C., Gillard, B.K., Gotto Jr, A.M. (2021). High-density lipoproteins, reverse cholesterol transport and atherogenesis. *Nature Reviews Cardiology*, 18(10): 712-723. <https://doi.org/10.1038/s41569-021-00538-z>
- [20] Yang, K., Wang, J., Xiang, H.J., Ding, P.L., Wu, T., Ji, G. (2022). LCAT-targeted therapies: Progress, failures and future. *Biomedicine & Pharmacotherapy*, 147: 112677. <https://doi.org/10.1016/j.biopha.2022.112677>
- [21] Guda, S., Bharani, K., Matukumalli, U.R., Mekala, L., Donga, D.V.H., Banothu, A. (2023). Phytochemical analysis and total antioxidant potential of *Moringa oleifera* leaf extract. *Frontiers in Nutrition*, 12(9): 1736-1739. <https://doi.org/10.3389/fnut.2022.1078896>
- [22] Cuellar-Núñez, M.L., Mejia, E.G.D., Loarca-Piña, G. (2021). *Moringa oleifera* leaves alleviated inflammation through downregulation of IL-2, IL-6, and TNF- α in a colitis-associated colorectal cancer model. *Food Research International*, 144: 110318. <https://doi.org/10.1016/j.foodres.2021.110318>
- [23] Aboulthana, W.M., Shousha, W.G., Essawy, E.A.R., Saleh, M.H., Salama, A.H. (2021). Assessment of the anti-cancer efficiency of silver *Moringa oleifera* leaves nano-extract against colon cancer induced chemically in rats. *Asian Pacific Journal of Cancer Prevention: APJCP*, 22(10): 3267-3286. <https://doi.org/10.31557/APJCP.2021.22.10.3267>
- [24] Damayanthi, L.R., Hufairoh, D., Nurjanah, S., Dewi, D.K., Magasida, D., Kumalasary, D.K. (2024). Nugget ayam daun kelor (*moringa oleifera* l.) sebagai variasi makanan sehat bergizi pada masyarakat desa sarewu. *Dedikasi: Jurnal Pengabdian Lentera*, 1(2): 61-68.
- [25] Rikandi, M., Lamona, A., Sari, W.K. (2022). pemanfaatan daun kelor sebagai upaya pencegahan kejadian stunting pada anak usia pra sekolah di tk 'aisyiyah 6 padang. *Gemassika: Jurnal Pengabdian Kepada Masyarakat*, 6(1): 47-58. <https://doi.org/10.30787/gemassika.v6i1.781>
- [26] El-Anoos, E.M., Fahmy, H.A., Mahmoud, E.A., Sharaf, A.M. (2022). Effect of soaking process on chemical characteristics and anti nutritional factors of some *moringa* seed varieties. *Journal of Food and Dairy Sciences*, 13(1): 9-15. <https://doi.org/10.21608/jfds.2022.117048.1035>
- [27] Kohut, G. (2022). Tooth wear age estimation of ruminants from archaeological sites. *Pathways*, 3(1): 82-105. <https://doi.org/10.29173/pathways33>
- [28] Rout, P.K., Behera, B.K. (2021). *Goat and sheep farming. Sustainability in Ruminant Livestock*, Springer, Singapore, 33-76. https://doi.org/10.1007/978-981-33-4343-6_3
- [29] Mthi, S., Nyangiwe, N., Gwaze, F.R., Yawa, M., Tyasi, T.L., Tokozwayo, S., Thubela, T., Jansen, M., Goni, S., Khetani, T., Qokweni, L., Washaya, S., Guza, B., Magwaza, M., Mbangi, B.B. (2021). Exploratory Study on relationship among body weight, body condition score and some blood biochemical parameters of non-descriptive goats in mzimvubu local municipality: A case of santombe village. *Open Journal of Animal Sciences*, 11(4): 646-657. <https://doi.org/10.4236/ojas.2021.114044>
- [30] Stayt, J. (2022). Hematology of sheep and goats. *Schalm's Veterinary Hematology*, 1012-1018. <https://doi.org/10.1002/9781119500537.ch112>
- [31] Nikolaou, K., Koutsouli, P., Bizelis, I. (2020). Evaluation of Greek cattle carcass characteristics (carcass weight and age of slaughter) based on SEUROP classification system. *Foods*, 9(12): 1764. <https://doi.org/10.3390/foods9121764>
- [32] Álvarez-Rodríguez, J., Teixeira, A. (2019). Slaughter weight rather than sex affects carcass cuts and tissue composition of Bisaro pigs. *Meat Science*, 154: 54-60. <https://doi.org/10.1016/j.meatsci.2019.04.012>
- [33] Coyne, J.M., Evans, R.D., Berry, D.P. (2019). Dressing percentage and the differential between live weight and carcass weight in cattle are influenced by both genetic and non-genetic factors. *Journal of Animal Science*, 97(4): 1501-1512. <https://doi.org/10.1093/jas/skz056>
- [34] Saeidnia, F., Taherian, M., Nazeri, S.M. (2023). Graphical analysis of multi-environmental trials for wheat grain yield based on GGE-biplot analysis under diverse sowing dates. *BMC Plant Biology*, 23(1): 198. <https://doi.org/10.1186/s12870-023-04197-9>
- [35] Reski, S., Rusli, R.K., Montesqrit, M.M., Mahata, M.E., Montesqrit, M. (2023). The effect of using fermentation products *Turbinaria murayana* seaweed in rations on the quality of quail eggs (*Coturnix coturnix japonica*). *Advances in Animal and Veterinary Sciences*, 11(3): 453-458. <https://doi.org/10.17582/journal.aavs/2023/11.3.453.458>
- [36] Kahn-Lang, A., Lang, K. (2020). The promise and pitfalls of differences-in-differences: Reflections on 16 and pregnant and other applications. *Journal of Business & Economic Statistics*, 38(3): 613-620. <https://doi.org/10.3386/w24857>
- [37] Kim, S.W., Less, J.F., Wang, L., Yan, T.H., Kiron, V., Kaushik, S.J., Lei, X.G. (2019). Meeting global feed protein demand: Challenge, opportunity, and strategy. *Annual Review of Animal Biosciences*, 7: 221-243. <https://doi.org/10.1146/annurev-animal-030117-014838>
- [38] Wilkinson, J.M., Lee, M.R.F. (2018). Use of human-edible animal feeds by ruminant livestock. *Animal*, 12(8): 1735-1743. <https://doi.org/10.1017/S175173111700218X>
- [39] Cantalapiedra-Hijar, G., Abo-Ismael, M., Carstens, G. E., Guan, L.L., Hegarty, R., Kenny, D.A., McGee, M., Plastow, G., Relling, A., Ortigues-Marty, I. (2018). Biological determinants of between-animal variation in feed efficiency of growing beef cattle. *Animal*, 12(s2): s321-s335. <https://doi.org/10.1017/S1751731118001489>
- [40] Terry, S.A., Basarab, J.A., Guan, L.L., McAllister, T.A. (2020). Strategies to improve the efficiency of beef cattle production. *Canadian Journal of Animal Science*, 101(1):

- 1-19. <https://doi.org/10.1139/cjas-2020-0022>
- [41] Kenny, D.A., Fitzsimons, C., Waters, S.M., McGee, M. (2018). Invited review: Improving feed efficiency of beef cattle—the current state of the art and future challenges. *Animal*, 12(9): 1815-1826. <https://doi.org/10.1017/S1751731118000976>
- [42] Karadeniz, M., Ozgen, A.G., Vardarli, A.T., Cetintas, V.B., Eroglu, Z., Erdogan, M. (2022). ATP-binding cassette cholesterol transporter-1 (ABC1) G1051A, and G2706A gene polymorphism in patients with primary hyperlipidemi. *Research Article*. <https://doi.org/10.21203/rs.3.rs-1503060/v1>
- [43] Yamamuro, D., Yamazaki, H., Osuga, J.I., Okada, K., Wakabayashi, T., Takei, A., Takei, S., Takahashi, M., Nagashima, S., Holleboom, A.G., Kuroda, M., Bujo, H., Ishibashi, S. (2020). Esterification of 4 β -hydroxycholesterol and other oxysterols in human plasma occurs independently of LCAT. *Journal of Lipid Research*, 61(9): 1287-1299. <https://doi.org/10.1194/jlr.RA119000512>
- [44] Tanaka, S.I., Fujioka, Y., Tsujino, T., Ishida, T., Hirata, K.I. (2018). Impact of serum cholesterol esterification rates on the development of diabetes mellitus in a general population. *Lipids in Health and Disease*, 17(1): 180. <https://doi.org/10.1186/s12944-018-0822-5>
- [45] Sokoła-Wysoczańska, E., Wysoczański, T., Wagner, J., Czyż, K., Bodkowski, R., Lochyński, S., Patkowska-Sokoła, B. (2018). Polyunsaturated fatty acids and their potential therapeutic role in cardiovascular system disorders—a review. *Nutrients*, 10(10): 1561. <https://doi.org/10.3390/nu10101561>
- [46] Liu, Y., Luo, X., Jia, H.B., Yu, B. (2022). The effect of blood pressure variability on coronary atherosclerosis plaques. *Frontiers in Cardiovascular Medicine*, 9: 803810. <https://doi.org/10.3389/fcvm.2022.803810>
- [47] Helvacı, M.R., Salaz, S., Yalcin, A., Muftuoglu, O.E., Abyad, A., Pocock, L. (2021). Cholesterol may be a negative whereas triglycerides positive acute phase reactants in the plasma. *Asclepius Medical Research and Reviews*, 4(1): 1-8.
- [48] Duran, E.K., Aday, A.W., Cook, N.R., Buring, J.E., Ridker, P.M., Pradhan, A.D. (2020). Triglyceride-rich lipoprotein cholesterol, small dense LDL cholesterol, and incident cardiovascular disease. *Journal of the American College of Cardiology*, 75(17): 2122-2135. <https://doi.org/10.1016/j.jacc.2020.02.059>
- [49] Salaheldeen, M., Mariod, A.A., Aroua, M.K., Rahman, S.A., Soudagar, M.E.M., Fattah, I.R. (2021). Current state and perspectives on transesterification of triglycerides for biodiesel production. *Catalysts*, 11(9): 1121. <https://doi.org/10.3390/catal11091121>
- [50] Lee, Y.Y., Tang, T.K., Chan, E.S., Phuah, E.T., Lai, O.M., Tan, C.P., Wang, Y., Karim, N.A.A., Dian, N.H.M., Tan, J.S. (2022). Medium chain triglyceride and medium-and long chain triglyceride: Metabolism, production, health impacts and its applications—a review. *Critical Reviews in Food Science and Nutrition*, 62(15): 4169-4185. <https://doi.org/10.1080/10408398.2021.1873729>
- [51] Schreiber, R., Xie, H., Schweiger, M. (2019). Of mice and men: The physiological role of adipose triglyceride lipase (ATGL). *Biochimica et Biophysica Acta (BBA)-Molecular and Cell Biology of Lipids*, 1864(6): 880-899. <https://doi.org/10.1016/j.bbalip.2018.10.008>
- [52] Luo, J., Shen, L.Y., Tan, Z.D., Cheng, X., Yang, D.L., Fan, Y., Yang, Q., Ma, J.D., Tang, Q.Z., Jiang, A.A., Jiang, D.M., Tang, G.Q., Jiang, Y.Z., Li, X.W., Yang, R.L., Zhang, S.H., Zhu, L. (2018). Comparison reproductive, growth performance, carcass and meat quality of Liangshan pig crossbred with Duroc and Berkshire genotypes and heterosis prediction. *Livestock Science*, 212: 61-68. <https://doi.org/10.1016/j.livsci.2017.09.010>
- [53] Mykhalko, O., Povod, M., Verbelchuk, T., Shcherbyna, O., Susol, R., Kirovich, N., Riznychuk, I. (2022). Effect of pre-slaughter weight on morphological composition of pig carcasses. *Open Agriculture*, 7(1): 335-347. <https://doi.org/10.1515/opag-2022-0096>
- [54] Tona, G.O. (2018). Current and future improvements in livestock nutrition and feed resources. *Animal Husbandry and Nutrition*, 147-169. <https://doi.org/10.5772/intechopen.73088>
- [55] Olawuwo, O.S., Olaogun, S.C., Azeez, O.I., Oyewale, J.O. (2020). Effects of graded crude protein diet on haematological indices and body weight of African Giant Rat (*Cricetomys gambianus*). *Sahel Journal of Veterinary Sciences*, 17(4): 8-15. <https://doi.org/10.54058/saheljvs.v17i4.177>
- [56] Jiwuba, P.D.C., Onunka, B.N., Nweke, J.C.J.C. (2018). Influence of supplemental cassava root sieviate-cassava leaf meal based diets on carcass and economics of production of West African dwarf goats. *Sustainability, Agri, Food and Environmental Research*, 6(4): 40-54. <https://doi.org/10.7770/safer-V0N0-art1483>
- [57] Corazzin, M., Bianco, S.D., Bovolenta, S., Piasentier, E. (2019). Carcass characteristics and meat quality of sheep and goat. *More Than Beef, Pork and Chicken—the Production, Processing, and Quality Traits of other Sources of Meat for Human Diet*, 119-165. https://doi.org/10.1007/978-3-030-05484-7_6
- [58] Wang, Y.J., Wang, Z.S., Hu, R., Peng, Q.H., Xue, B., Wang, L.Z. (2021). Comparison of carcass characteristics and meat quality between Simmental crossbred cattle, cattle-yaks and Xuanhan yellow cattle. *Journal of the Science of Food and Agriculture*, 101(9): 3927-3932. <https://doi.org/10.1002/jsfa.11032>
- [59] Ekiz, B., Yilmaz, A., Yalcintan, H., Yakan, A., Kocak, O., Ozcan, M. (2019). The effect of production system and finish weight on carcass and meat quality of Kivircik lambs. *Annals of Animal Science*, 19(2): 517-538. <https://doi.org/10.2478/aoas-2019-0010>
- [60] Mohd Azmi, A.F., Mat Amin, F., Ahmad, H., et al. (2021). Effects of bypass fat on buffalo carcass characteristics, meat nutrient contents and profitability. *Animals*, 11(11): 3042. <https://doi.org/10.3390/ani11113042>
- [61] Alkass, J.E., Yateem, C.A., Al-Sherwany, D.A.O., Mustafa, K.N. (2023). Allometry growth coefficients of carcass and non-carcass components in small ruminants: A review. *Mesopotamia Journal of Agriculture*, 51(2): 25-35. <https://doi.org/10.33899/MAGRJ.2023.137250.1227>
- [62] Akinleye, S.B., Afolabi, K.D., Luka, J.S. (2019). Performance and carcass characteristics of four breeds of rams in Nigeria under fattening condition. *Journal of Meat Science and Technology*, 7(4): 31-37.