

Meat Fatty Acid Composition and Malondialdehyde Concentration of Dried Star Gooseberry Leaf Extract for Duck Feed

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Abstract: Local ducks have good potential to be developed as a producer of meat and eggs as a source of animal protein. However, compared to other poultry, duck meat has relatively high fat and cholesterol contents, which are not preferred as they may have harmful effects on health. Additionally, excessive meat fat content can also cause a rotten smell to the meat. Containing carotene, flavonoids, tannins, and antioxidants, star gooseberry (*Sauropus androgynus*) leaves are potential to be used a feed additive in poultry ration. This study aimed to assess the effects of the inclusion of dried star gooseberry leaf extract (DSGLE) meal in rations on the composition of fatty acids, malondialdehyde (MDA), and cholesterol of local duck meat. One-hundred local ducks were randomly allocated into 5 treatments and 5 replicates in a completely randomized experimental design. Treatments consisted of rations containing 0, 0.5, 1.0, 1.5, and 2.0% DSGLE. Measurements were taken on meat fat content, MDA contents, cholesterol level, and fatty acid composition. Results showed that treatments significantly affected meat fat content, fatty acid composition, cholesterol level, and MDA content. It was concluded that feeding ducks with DSGLE meal reduced meat fat and cholesterol levels, improved meat fatty acid composition and protected the meat from oxidative damage. This study reinforced the benefits of using phytochemicals in diets in improving the production performance and product quality of poultry animals. Results of this study uncovered another way to produce healthier duck meat containing less fat and having less off-odor.

Keywords: *Sauropus androgynus*, cholesterol, antioxidation, meat quality.

鸭饲料用干星醋栗叶提取物的肉脂肪酸组成和丙二醛浓度

摘要：本地鸭子有很大的潜力被开发为肉和蛋的生产者，作为动物蛋白的来源。然而，与其他禽肉相比，鸭肉的脂肪和胆固醇含量较高，可能对健康有害，因此不宜食用。此外，过多的肉脂肪含量也会使肉产生腐烂的气味。星醋栗(雌雄蜥)叶含有胡萝卜素、类黄酮、单宁和抗氧化剂，有可能用作家禽日粮中的饲料添加剂。本研究旨在评估日粮中加入干星醋栗叶提取物(DSGLE)粉对当地鸭肉中脂肪酸、丙二醛(丙二醛)和胆固醇成分的影响。在完全随机的实验设计中，将 100 只本地鸭子随机分配到 5 个处理和 5 个重复中。治疗包括含有 0、0.5、1.0、1.5 和 2.0% DSGLE 的日粮。对肉脂肪含量、丙二醛含量、胆固醇水平和脂肪酸组成进行了测量。结果表明，处理显著影响肉脂肪含量、脂肪酸组成、胆固醇水平和丙二醛含量。得出的结论是，用 DSGLE 膳食喂养鸭子可降低肉脂肪和胆固醇水平，改善肉脂肪酸组成并保护肉免受氧化损伤。该研究强调了在日粮中使用植物化学物质对提高家禽动物的生产性能和产品质量的好处。这项研究的结果揭示了另一种生产更健康的鸭肉的方法，它含有更少的脂肪和更少的异味。

关键词：雌雄蜥, 胆固醇, 抗氧化, 肉品质.

1. Introduction

Until now, the duck meat production has not been able to match that of purebred chickens. The increase in duck meat production is not as large as that of broiler meat. As livestock products play an important role in improving people's welfare, producers are required to produce meat that is not only tasty and tender but also healthy with high nutrient and low fat and cholesterol contents. One of the causes of low consumer demand for duck meat is its relatively high fat and cholesterol content.

It is commonly believed that excessive levels of cholesterol in the blood may increase the risk of accumulation or deposition of cholesterol on the walls of arteries, which may lead to the development of atherosclerosis, coronary heart disease (CHD), and stroke [1]. It has been a big challenge for the poultry industry to produce poultry products containing high unsaturated fatty acids and low cholesterol. The use of feed additives containing many kinds of active substances is a promising answer to this challenge. Star gooseberry leaves are known to contain chemical compounds including phytosterols, tannins, saponins, flavonoids, alkaloids, saponins, sterols, amino acids, proteins, carbohydrates, vitamins, and minerals [2]-[3]. Star gooseberry was found as one of 24 Indonesian native vegetables with the highest content of kaempferol, an antioxidative flavonoid polyphenol [4].

The use of star gooseberry leaves in diets and its effects on the performance and quality of products of ruminants and poultry have been the subject of many studies. The research results in [5] showed that feeding fish with an extract of star gooseberry leaves significantly increased growth and feed consumption but decreased feed conversion. Does fed star gooseberry leaves produced colostrum milk with higher protein content than that of does control group (5.41 vs 4.05%) [6]. However, supplementation of these leaves in Bali cow diets failed to improve milk yield and quality [7]. More extensive studies have been conducted on the use of star gooseberry leaf meal in rations of poultry animals. Feeding star gooseberry leaf meal was found to increase fertility and hatchability rates [8] and egg quality without hampering egg production in quails [9]. Star gooseberry leaf meal inclusion in rations was found to increase body weight [10], reduce feed intake, improve feed conversion ratio, lower carcass fat content [11] in broiler chickens, improve meat tenderness in local chickens [12], increase egg production in layer chickens [13], and improve the quality of yolk color and aroma of duck eggs [14].

Instead of the positive effects of the star gooseberry leaves on improving the production performance of various kinds of animals attributable to the antimicrobial and antioxidative properties of secondary metabolite contents, adverse effects on growth were

observed. This was found in broiler chickens fed star gooseberry leaves, which were given in the form of an unprocessed ingredient [15]. High content of tannins was suspected to be the cause of this phenomenon as they are known as anti-nutritional compounds, which are detrimental to feed intake and digestive processes in ruminant and monogastric animals particularly when it is used inappropriately and at high concentrations [16]-[17]. The application of treatments including fermentation and extraction of gooseberry leaves to overcome the problem has been studied [15], [18]-[20]. Based on this notion, a study on the effects of DSGLE on the fatty acid composition of duck meat was worthwhile to conduct.

2. Materials and Methods

2.1. Animals

One-hundred local ducks aged 9 months with an average initial body weight of 1406.25 ± 211.32 g were used. The ducks were raised in 25 battery cages (4 ducks per cage) and randomly allocated into 5 treatments in a completely randomized design with 5 replicates.

2.2. Star Gooseberry Leaf Extract

DGLSE was prepared based on the procedures used in [21]. Fifty grams of star gooseberry leaves were weighed and soaked in 300 ml ethanol (96%). The mixture was stirred slowly while it was heated in a water bath at 60°C for 2 hours. The mixture was then filtered, and the filtrate was evaporated until its volume reduced to 100 ml. Ninety grams of corn meal was added to the filtrate and mixture was stirred slowly and dried in an oven at 50-60°C for 90 minutes.

2.3. Treatment Rations

Basal rations were formulated from corn meal, rice bran, soybean cake meal, fish meal, premix, CaCO₃, CPO, and DCP. Treatment rations consisted of basal ration and the inclusion of DSGLE by 0% (R0), 0.5% (R1), 1.0% (R2), 1.5% (R3), and 2.0% (R4). Feed composition and nutrient content of the treatment ratios are listed in Table 1.

Table 1 Feed composition and nutrient content of treatment rations

Feed/nutrient	Treatment				
	R0	R1	R2	R3	R4
Amount (%)					
Corn meal	61.00	61.00	61.00	61.00	61.00
Rice bran	8.00	8.00	8.00	8.00	8.00
Soybean cake meal	11.50	11.50	11.50	11.50	11.50
Fish meal	10.50	10.50	10.50	10.50	10.50
Premix	1.00	1.00	1.00	1.00	1.00
CaCO ₃	5.00	5.00	5.00	5.00	5.00
Crude palm oil	0.50	0.50	0.50	0.50	0.50
Dicalcium phosphate	2.50	2.50	2.50	2.50	2.50
DSGLE	0.00	0.50	1.00	1.50	2.00

Continuation of Table 1

Dry matter	89.12	89.08	89.04	89.00	88.97
Crude protein	16.31	16.35	16.40	16.44	16.49
Fiber	4.51	4.51	4.51	4.51	4.51
Crude fat	3.68	3.69	3.70	3.72	3.73
Ash	8.08	8.09	8.10	8.10	8.11

Notes: RO: 0% DSGLE, R1: 0.5% DSGLE, R2: 1.0% DSGLE, R3: 1.5% DSGLE, R4: 2.0% DSGLE

2.4. Meat Fat, Cholesterol, and MDA Contents

The meat fat content was determined by referring to the method developed by [22]. Dried and homogenized meat samples were washed with ether in a Soxhlet extractor for 16 hours. The lipid extract was then evaporated at 95-100°C and weighed. Fat content was the difference in the weight of the samples before and after extraction.

Meat cholesterol was analyzed following the instructions of [23]. Meat samples of 0.1 mg were dissolved in 12 ml of alcohol-ether solution (3:1) in a mortar and ground until a homogenous mixture was obtained. The mixture was transferred into tubes and centrifuged at 3000 rpm for 15 minutes. The supernatant was heated on a hot plate and the dried sample was dissolved in 5 ml chloroform and vortexed until it became homogenous. Anhydrous acetic acid of 2 ml was then added to the solution before it was further homogenized using a vortex. One milliliter of concentrated sulfuric acid was added to the solution before it was allowed to stand for 15 minutes in a dark room. Finally, the absorbance was measured using a UV spectrophotometer at a wavelength of 430 nm.

MDA levels were determined by referring to the method of [24]. MDA level was quantified based of the ability of it to react with thiobarbituric acid (TBA). Every one molecule of MDA reacted with two molecules of TBA. The reaction was indicated by the appearance of pink pigment with maximum absorption at 532-538 nm. Frozen meat (-200°C) was thawed and used as a sample. A cold meat sample of 1.25 g was placed in an Erlenmeyer flask and chopped by using a syringe needle. Cold phosphate-buffered saline (2.5 ml, 5°C) containing 11.5 g/l potassium chloride (pH 7.4) was added in. The mixture was centrifuged at 4000 rpm for 10 minutes. Clear supernatant of 1 ml was taken and mixed with a mixture solution of cold 0.25 N (2.23 ml concentrated chloride acid/100 ml) chloride acid containing 15% (w/v) trichloroacetic acid, 0.38% thiobarbituric acid, and 0.5% butylated hydroxytoluene. The mixture was heated in an incubator at 80°C for an hour before it was cooled with running water and centrifuged at 3500 rpm for 10 minutes. The absorbance of this centrifuged supernatant was measured at 532 nm wavelength.

Fatty acid compositions were determined using a method developed by [25]. Meat sample of 100 g was extracted and homogenized using chloroform and methanol solution (2:1). NaCl 1.5% solution was then

added in to form methyl esters, which were further injected into a gas chromatography by using a GC-2010 Plus-Shimadzu AOC 20i autoinjector, SP®-2560 capillary columns L × I.D 100 m × 0.25 mm, df 0.20 µm, Supelco, Bellefonte, PA. The initial temperature was 70°C and it was increased gradually to 175°C within 27 minutes. The temperature was further elevated by 4°C per minute until it reached 215°C. This temperature was then held for 31 minutes.

Fatty acids were identified by comparing the retention time of sample methyl esters to standard fatty acid methyl esters (FAMES) including C4-C24 (FAME mix Sigma®), vaccenic acid C18: 1 trans-11 (V038-1G, Sigma®), C18: 2 trans-10 cis-12 (UC 61 M 100 mg), CLA C18: 2 cis-9, trans-11 (UC 60 M 100 mg) (Sigma®), and tricosanoic acid (Sigma®). Fatty acids were measured by normalizing the area under the methyl ester curve using 2.42, Shimadzu GC-2010 software. The amount of fatty acid was defined as the percentage of total FAMES.

3. Results and Discussion

An indication of the occurrence of oxidation in meat can be detected through the measurement of fat content, fatty acid composition, and levels of MDA formed. Increased fat content in duck meat is mainly caused by increases in triglyceride, saturated fatty acid, unsaturated fatty acid, and intramuscular fat contents. Therefore, feed fatty acid composition plays an important role in modifying meat fat content [26].

It was revealed that the value of meat saturated fatty acids (SFA) was not as large as that of polyunsaturated fatty acids (PUFA) (Table 2). This was not unexpected as, compared to red meat, poultry meat contains less fat and more unsaturated fatty acids than saturated ones [27]-[29]. However, PUFAs in poultry meat are more susceptible to oxidation [30].

Ducks fed on DSGLE were found to have meat containing higher PUFAs. This finding indicated that the antioxidant activity of DSGLE leaves could protect PUFAs from oxidation. Star gooseberry leaves contain high active phenolic compounds, including quercetin and kaempferol, having antioxidative properties [4]. Diet supplementation with quercetin was found to reduce lipid oxidation in broiler meat [30]-[31]. In this study, this notion was supported by the fact that meat MDA level was significantly lower (0.11 g/100 g) in ducks fed the highest level of DSGLE (Table 3). MDA is a by-product of PUFA peroxidation and an indicator of oxidative stress [32]. In addition, extracts of star gooseberry leaves were proved to have 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activities [33] [34]. Lower meat MDA levels were also found in ducks treated with leaf meals of *Pluchea indica* Less (*beluntas*) and *Cosmos caudatus* (*kenikir*) which are known to contain antioxidative phenols [35].

Table 2 Meat fatty acid composition of duck fed DSGLE (%)

Fatty acid	R0	R1	R2	R3	R4
Lauric	0.18 ± 0.06 ^b	0.15 ± 0.06 ^b	0.15 ± 0.04 ^b	0.08 ± 0.02 ^a	0.073 ± 0.01 ^a
Myristic	0.49 ± 0.05 ^b	0.47 ± 0.05 ^b	0.46 ± 0.07 ^{ab}	0.42 ± 0.04 ^a	0.41 ± 0.03 ^a
Palmitic	17.10 ± 1.97 ^b	16.67 ± 0.92 ^b	15.01 ± 0.76 ^a	15.30 ± 0.78 ^a	16.32 ± 0.53 ^b
Stearic	3.72 ± 1.08	4.14 ± 1.36	3.52 ± 0.81	3.45 ± 0.67	3.43 ± 0.56
SFA	21.48 ± 2.59 ^a	21.42 ± 2.18 ^a	19.14 ± 0.95 ^b	19.24 ± 0.81 ^b	20.23 ± 0.90 ^{ab}
Palmitoleic	1.67 ± 0.15 ^d	1.17 ± 0.09 ^a	1.42 ± 0.12 ^b	1.56 ± 0.18 ^{bcd}	1.47 ± 0.07 ^{abc}
Elaidic	0.41 ± 0.07	0.40 ± 0.04	0.36 ± 0.06	0.41 ± 0.09	0.39 ± 0.04
Oleic	25.73 ± 2.24 ^{ab}	24.30 ± 2.15 ^a	25.11 ± 1.62 ^a	26.74 ± 1.70 ^b	25.25 ± 1.14 ^{ab}
Linoleic	9.46 ± 1.02 ^a	11.18 ± 1.40 ^b	11.73 ± 1.22 ^{bc}	11.08 ± 1.35 ^b	11.65 ± 1.00 ^c
PUFA	37.27 ± 2.84 ^a	37.06 ± 2.58 ^a	38.61 ± 1.71 ^{ab}	40.04 ± 1.68 ^b	40.50 ± 1.52 ^b

Notes: Different superscripts in the same rows indicate significant differences (P<0.05). RO: 0% DSGLE, R1: 0.5% DSGLE, R2: 1.0% DSGLE, R3: 1.5% DSGLE, R4: 2.0% DSGLE, SFA: saturated fatty acids, PUFA: polyunsaturated fatty acids.

Meat fat and cholesterol contents were significantly lower in ducks fed on DSGLE (Table 3). These results agreed with what were found in other studies. In broiler chicken, the use of DSGLE resulted in meat with lower fat (1.44 vs. 5.95 g/100 g) and cholesterol (0.10 vs. 0.15 g/100 g) contents [15]. Ducks given star gooseberry leaf meal by 7.5% were found to have lower egg cholesterol levels (12.82 mg/g egg yolk) than those in the control group (15.35 mg/g egg yolk) [36]. These fat and cholesterol reducing effects might be attributable to groups of phenolic compounds, tannins, flavonoids, saponoids, triterpenoids, and alkaloids,

which can reduce fat [37]. Feeding ducks with various plant leaves rich in fat-reducing secondary metabolites was found to significantly lower the fat and cholesterol meat content. Bay leaf supplementation with 9% lowered meat fat contents from 2.59 to 1.22 and 1.44 to 1.25% and meat cholesterol levels from 1.17 to 1.03 and 1.25 to 1.02 mg/g in Mallard and Muscovy ducks, respectively [38]. In another study, in male Tegal ducks aged 9 weeks, feeding diets supplemented with 12% bread fruit leaf meal decreased meat fat and cholesterol contents from 5.56 to 5.05% and from 174.82 to 154.88 mg/100 g, respectively [39].

Table 3 Meat fat, cholesterol, and MDA contents of duck fed DSGLE (g/100 g)

	R0	R1	R2	R3	R4
Fat	27.33 ± 1.21 ^b	26.27 ± 1.38 ^b	27.07 ± 1.20 ^b	26.75 ± 1.14 ^a	25.22 ± 1.40 ^a
MDA	0.36 ± 0.22 ^c	0.36 ± 0.07 ^c	0.25 ± 0.08 ^{bc}	0.21 ± 0.06 ^{ab}	0.11 ± 0.06 ^a
Cholesterol	83.5 ± 8.3 ^a	83.69 ± 7.34 ^a	83.46 ± 7.34 ^a	77.10 ± 7.81 ^{ab}	75.56 ± 6.34 ^b

Notes: Different superscripts in the same rows indicate significant differences (P < 0.05). RO: 0% DSGLE, R1: 0.5% DSGLE, R2: 1.0% DSGLE, R3: 1.5% DSGLE, R4: 2.0% DSGLE, MDA: malondialdehyde

4. Conclusion

The use of star gooseberry leaves extracted by using ethanol (DSGLE) in the ration lowered duck meat fat and cholesterol levels, improved meat fatty acid composition, and protected the meat from oxidative damage.

This study reinforced the benefits of using phytochemicals in diets in improving the production performance and product quality of poultry animals. Results of this study revealed a way to produce healthier duck meat containing less fat and having less off odor.

Nonetheless, this study was conducted on a laboratory scale using a limited number of animals. Studies in larger farming scale involving a higher number of animals need to be conducted for more conclusive results. Economic aspects of the use of star gooseberry leaf extract in duck production and poultry production in general should be assessed. An investigation on the best feeding manner of star gooseberry leaves in poultry also deserves to be conducted.

References

- [1] BATJO R, ASSA YA, and TIHO M. Gambaran kadar kolesterol low density lipoprotein darah pada mahasiswa angkatan 2011 Fakultas Kedokteran Universitas Sam Ratulangi Manado dengan indeks massa tubuh 18,5 – 22,9 kg/m². *Jurnal e-Biomedik*, 2013, 1(2): 843-848. <https://doi.org/10.35790/ebm.v1i2.5470>.
- [2] AGRAWAL S.K, KARTHIKEYAN V, PARTHIBAN P, and NANDHINI R. Multivitamin plant: Pharmacognostical standardization and phytochemical profile of its leaves. *Journal of Pharmacy Research*, 2014, 8(7): 920-925.
- [3] RAHAYU N. and ARDIGURNITA F. Potential of katuk leaves as lowering fat levels in poultry product through phytochemical screening. *Agrivet Jurnal Ilmu Pertanian dan Peternakan*, 2021, 9(2): 136-139. <https://doi.org/10.31949/agrivet.v9i2.1697>.
- [4] ANDARWULAN N, KURNIASIH D, APRIYADI R.A, et al. Polyphenols, carotenoids, and ascorbic acid in underutilized medicinal vegetables. *Journal of Functional Food*, 2012, 4:339-347. <https://doi.org/10.1016/j.jff.2012.01.003>.
- [5] PUTRA A, SANTOSO U, LEE MC, and NAN FH. Effects of dietary katuk leaf extract on growth performance, feeding behavior and water quality of grouper *Epinephelus coioides*. *Aceh International Journal of Science and Technology*, 2013, 2(1): 17-25.

- <https://doi.org/10.13170/aijst.2.1.488>.
- [6] MARWAH MP, SURANINDYAH YY, and MURTI TW. Milk production and milk composition of ettawa crossbred goat, fed katu leaves (*Sauropus androgynus* (L.) merr) as supplementation during early lactation). *Buletin Peternakan*, 2010, 34(2): 94-102. <https://doi.org/10.21059/buletinpeternak.v34i2.95>.
- [7] SURIASIH K, SUCIPTA N, SITI W, and SUKMAWATI M.S. Effect of katu leaf (*Sauropus androgynus*) extract supplementation on milk quality and yield of bali cow fed rice straw and natural grass basal diet. *Journal of Biology, Agriculture and Healthcare*, 2015, 5(24): 74-79.
- [8] SUBEKTI S, SUMARTI S.S, and MURDIATI T.B. Effect of katuk leaf (*Sauropus androgynus* L. Merr) supplementation in the diet on reproductive function of quail. *Indonesian Journal of Animal and Veterinary Sciences*. 2008. 13(3): 167-173. <https://doi.org/10.14334/jitv.v13i3.580>.
- [9] HERMANA W, TOHARMAT T, SUMIATI, and MANALU W. Performances and quality of quail offered feed containing sterol from katuk (*Sauropus androgynus*) and mulberry (*Morus alba*) leaf meal. *International Journal of Poultry Science*, 2014, 13(3): 168-172.
- [10] NASUTION R A P, ATMOMARSONO U, and SARENGAT W. Influence of katuk (*Sauropus androgynus*) leaf powder in the diet of broiler on performance. *Animal Agriculture Journal*, 2014, 3(2): 334-340. <https://ejournal3.undip.ac.id/index.php/aaj/article/view/11489>.
- [11] SANTOSO U. and SARTINI. Reduction of fat accumulation in broiler chickens by *Sauropus androgynus* (katuk) leaf meal supplementation. *Asian-Australasian Journal of Animal Sciences*, 2001, 14(3): 346-350. <https://doi.org/10.5713/ajas.2001.346>.
- [12] ANGGRAENI, MALIK B, WAHYUNI D, et al. Effects of the inclusion of star gooseberry (*Sauropus androgynus*) leaf meal in ration on physical and nutritional quality of KUB chicken breast meat. *Jurnal Ilmu-Illmu Peternakan*, 2022, 32(2): 210-217. <https://doi.org/10.21776/ub.jiip.2022.032.02.10>.
- [13] SANTOSO U. The usefulness of *Sauropus androgynus* leaf as a feed supplement for poultry. 1. Its effect on chicken performances. *Jurnal Sain Peternakan Indonesia*, 2018. 13(2): 151-156. <https://doi.org/10.31186/jspi.id.13.2.151-156>.
- [14] ANGGRAENI, HANDARINI R, SUDRAJAT D, MALIK B. and OKTAVIA V. Effects of inclusion of star gooseberry dried leaf extract in ration on egg organoleptic values of local duck. *Indonesian Journal of Applied Research*, 2021, 2(3): 192-195. <https://doi.org/10.30997/ijar.v2i3.157>.
- [15] LETIS Z.M, SUPRAYOGI A, and EKASTUTI D.R. Supplementation of various preparations katuk leaves in feed causing a decrease of abdominal fat, fat, and cholesterol levels to carcass of broiler chickens. *Jurnal Veteriner*, 2017, 18(3): 461-468. <https://doi.org/10.19087/jveteriner.2017.18.3.461>.
- [16] HENKE A, WESTREICHER-KRISTEN E, MOKKENTIN J, DICKHOEFER U, KNAPPSTEIN K, HASLER M, and SUSENBETH A. Effect of dietary quebracho tannin extract on milk fatty acid composition in cows. *Journal of Dairy Science*, 2017, 100: 6229-6238. <https://doi.org/10.3168/jds.2016-12149>.
- [17] HUANG Q, LIU X, ZHAO G, HU T, and WANG Y. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. *Animal Nutrition*, 2018, 4: 137-150. <https://doi.org/10.1016/j.aninu.2017.09.004>.
- [18] SYAHRUDDIN E, HERAWATY R, and NINGRAT R W S. Effect fermented katuk leaf (*Sauropus androgynus*) in diets on cholesterol content of broiler chicken carcass. *Pakistan Journal of Nutrition*, 2013, 12(11): 1013-1018. <https://doi.org/10.3923/pjn.2013.1013.1018>.
- [19] SANTOSO U, FENITA Y, KUSUSIYAH, BIDURA I G N G. Effect of fermented *Sauropus androgynus* leave on meat composition, amino acid, and fatty acid compositions in broiler chicken. *Pakistan Journal of Nutrition*, 2015, 14(11): 799-807. <https://doi.org/10.3923/pjn.2015.799.807>.
- [20] BIDURA I G N G, PARTAMA I B G, PUTRI B R T, and WATINIASIH N L. Effect of water extract of two leaves (*Allium sativum* and *Sauropus androgynus*) on egg production and yolk cholesterol levels in egg laying hens. *Pakistan Journal of Nutrition*, 2017, 16: 482-487. <https://doi.org/10.3923/pjn.2017.482.487>.
- [21] YASNI S, KUSNANDAR F, and HARTINI. Mempelajari cara ekstraksi dan fraksinasi komponen aktif alkaloid daun katuk (*Sauropus androgynus* (L.) Merr). *Bulletin Teknologi dan Industri Pangan*, 1999, 10: 43-48.
- [22] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMIST (AOAC). Official Methods of Analysis of the Association of Official Analytical Chemists. Maryland USA, 2005.
- [23] KLEINER I S, and DOTTI L B. Laboratory Instruction in Biochemistry. 6th Ed. Mosby Company, New York, 1962.
- [24] ESTERBAUER H, and CHEESEMAN K H. Determination of aldehydic lipid peroxidation products: Malonaldehyde and 4-hydroxynonenal. *Methods in Enzymology*, 1990, 186: 407.
- [25] FOLCH J, LEES M, STANLEY G H S. A simple method for the isolation and purification of total lipides from animal tissues. *The Journal of Biological Chemistry*, 1957, 226(1): 497-509. [https://doi.org/10.1016/s0021-9258\(18\)64849-5](https://doi.org/10.1016/s0021-9258(18)64849-5).
- [26] GALLARDO M A, PÉREZ D D, and LEIGHTON F M. Modification of fatty acid composition in broiler chickens fed canola oil. *Biological Research*, 2012, 45(2): 149-161. <https://doi.org/10.4067/S0716-97602012000200007>.
- [27] BARROETA A.C. Nutritive value of poultry meat: relationship between vitamin E and PUFA. *World's Poultry Science Journal*, 2007, 63: 277-284. <https://doi.org/10.1017/S0043933907001468>.
- [28] MORALES-BARRERA J E, GONZALEZ-ALCORTA M J, CASTILLO-DOMINGUEZ R M, et al. Fatty acid deposition on broiler meat in chickens supplemented with tuna oil. *Food and Nutrition Sciences*, 2013, 4: 16-20. <https://doi.org/10.4236/fns.2013.49A1003>.
- [29] BELICHOVSKA D, PEJKOVSKI Z, NIKOLOVA A S, et al. Chemical and fatty acid composition of poultry meat and pork fatback as a raw material for the production of frankfurters. *Macedonian Journal of Animal Science*, 2020, 10(1-2): 23-28. <https://doi.org/10.54865/mjas20101-2023b>.
- [30] GOLIOMYTIS M, TSOUREKI D, SIMITZIS P.E, et al. The effects of quercetin dietary supplementation on broiler growth, performance, meat quality, and oxidative stability. *Poultry Science*, 2014, 93: 1-6. <https://doi.org/10.3382/ps.2013-03585>.
- [31] SOHAIB M, BUTT M S, SHABBIR M A, SHAHID M. Lipid stability, antioxidant potential and fatty acid composition of broilers breast meat as influenced by quercetin in combination with α -tocopherol enriched diets.

- Lipids in Health and Disease*, 2015, 14: 61. <https://doi.org/10.1186/s12944-015-0058-6>.
- [32] DZOYEM J P, KUETE V, and ELOFF J N. Biochemical parameters in toxicological studies in africa: significance, principle of methods, data interpretation, and use in plant screenings. In: KUETE V. (Editor). *Toxicological Survey of African Medicinal Plants*. Elsevier, The Netherlands. 2014: 659-715. <https://doi.org/10.1016/B978-0-12-800018-2.00023-6>.
- [33] BOSE R, KUMAR M S, MANIVEL A, and MOHAN S C. Chemical constituents of *Sauropus androgynus* and evaluation of its antioxidant activity. *Research Journal of Phytochemistry*, 2018, 12: 7-13. <https://doi.org/10.3923/rjphyto.2018.7.13>.
- [34] NGUYEN N H K, TIEN H T C, TRUC, T T, and QUOC, L P T. Chlorophyll content and antioxidant activity from folium sauropi (*Sauropus androgynus* (L.) Merr) with microwave-assisted extraction. *IOP Conference Series: Materials Science and Engineering*, 2020, 991: 012036. <https://doi.org/10.1088/1757-899X/991/1/012036>.
- [35] LESTARI D, RUKMIASIH, SURYATI T, et al. Komposisi asam lemak dan kadar malondialdehidida daging itik lokal yang diberi antioksidan alami. *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*. 2020, 8(3): 117-123. <https://doi.org/10.29244/jipthp.8.3.117-123>.
- [36] KASMIRAH D, FENITA Y, and SANTOSO U. Effect of katuk (*Sauropus androgynus*) meal supplementation on egg cholesterol level of mojosari (*Anas javanica*). *Jurnal Sain Peternakan Indonesia*, 2013, 8(2): 77-86. DOI: 10.31186/jspi.id.8.2.77-86.
- [37] NORTH M K, ZOTTE A D, HOFFMAN L C. The use of dietary flavonoids in meat production: A review. *Animal Feed Science and Technology*, 2019. 257: 114291. <https://doi.org/10.1016/j.anifeedsci.2019.114291>.
- [38] ISMOYOWATI, INDRASANTI D, and SUMARMONO J. Blood biochemical profile, growth performance, carcass characteristics and meat quality of mallard and muscovy ducks fed diet supplemented with bay leaves (*Syzygium polyanthum*). *International Journal of Poultry Science*, 2016, 15: 21-26. <https://doi.org/10.3923/ijps.2016.21.26>.
- [39] TUGIYANTI E, SETIANTO N.A, HARISULISTYAWAN I, et al. Effect of breadfruit leaf powder (*Artocarpus altilis*) on performance, fat and meat cholesterol level and body immune of male native tegal duck. *International Journal of Poultry Science*, 2016, 15: 227-234. <https://doi.org/10.3923/ijps.2016.227.234>.
- 参考文献:**
- [1] BATJO R, ASSA YA 和 TIHO M. 山姆·拉图兰吉万鸦老大学医学院 2011 年学生血液中低密度脂蛋白胆固醇水平的描述, 体重指数为 18.5 – 22.9 公斤/平方米. 电子生物医学杂志, 2013, 1(2): 843-848. <https://doi.org/10.35790/ebm.v1i2.5470>.
- [2] AGRAWAL S K, KARTHIKEYAN V, PARTHIBAN P 和 NANDHINI R. 多种维生素植物: 其叶子的药理学标准化和植物化学概况. 药学研究杂志, 2014, 8(7): 920-925.
- [3] RAHAYU N. 和 ARDIGURNITA F. 通过植物化学筛选, 卡图克叶作为降低家禽产品脂肪含量的潜力. 阿格里韦农牧学报, 2021, 9(2): 136-139. <https://doi.org/10.31949/agrivet.v9i2.1697>.
- [4] ANDARWULAN N, KURNIASIH D, APRYADI R.A 等. 未充分利用的药用蔬菜中的多酚、类胡萝卜素和抗坏血酸. 功能食品杂志, 2012, 4: 339-347. <https://doi.org/10.1016/j.jff.2012.01.003>.
- [5] PUTRA A, SANTOSO U, LEE MC 和 NAN FH. 卡图克叶提取物对石斑鱼生长性能、摄食行为和水质的影响. 亚齐国际科技期刊, 2013, 2(1): 17-25. <https://doi.org/10.13170/aijst.2.1.488>.
- [6] MARWAH MP, SURANINDYAH YY 和 MURTI TW. 雕刻杂交山羊的产奶量和奶组成, 饲喂卡图叶(雌雄蜥(升.) 梅尔)作为泌乳早期的补充剂). 畜牧公报, 2010, 34(2): 94-102. <https://doi.org/10.21059/buletinpeternak.v34i2.95>.
- [7] SURIASIH K, SUCIPTA N, SITI W 和 SUKMAWATI M.S. 添加卡图叶(雌雄蜥)提取物对饲喂稻草和天然草基础日粮的巴厘岛奶牛的牛奶质量和产量的影响. 生物学、农业和医疗保健杂志, 2015, 5(24): 74-79.
- [8] SUBEKTI S, SUMARTI S S 和 MURDIATI T.B. 日粮中添加卡图克叶(雌雄蜥大号.梅尔)对鹌鹑繁殖功能的影响. 印度尼西亚动物和兽医科学杂志. 2008. 13(3): 167-173. <https://doi.org/10.14334/jitv.v13i3.580>.
- [9] HERMANA W, TOHARMAT T, SUMIATI 和 MANALU W. 鹌鹑的性能和质量提供含有来自卡图克(雌雄蜥)和桑(桑树)叶粉的甾醇的饲料. 国际家禽科学杂志, 2014, 13(3): 168-172.
- [10] NASUTION RAP, ATMOMARSONO U 和 SARENGAT W. 肉鸡日粮中的卡图克(雌雄蜥)叶粉对生产性能的影响. 畜牧业杂志, 2014, 3(2): 334-340. <https://ejournal3.undip.ac.id/index.php/aaj/article/view/11489>.
- [11] SANTOSO U. 和 SARTINI. 通过补充 雌雄蜥(卡图克)叶粉减少肉鸡的脂肪积累. 亚洲-澳大利亚动物科学杂志, 2001, 14(3): 346-350. <https://doi.org/10.5713/ajas.2001.346>.
- [12] ANGGRAENI, MALIK B, WAHYUNI D 等. 按比例添加星醋栗(雌雄蜥)叶粉对 KUB 鸡胸肉物理和营养品质的影响. 畜牧科学杂志, 2022, 32(2): 210-217. <https://doi.org/10.21776/ub.jiip.2022.032.02.10>.
- [13] SANTOSO U. 雌雄蜥叶作为家禽饲料补充剂的使用. 1、对鸡生产性能的影响. 印度尼西亚畜牧科学杂志, 2018, 13 (2): 151-156. <https://doi.org/10.31186/jspi.id.13.2.151-156>.
- [14] ANGGRAENI, HANDARINI R, SUDRAJAT D, MALIK B. 和 OKTAVIA V. 日粮中加入星醋栗干叶提取物对本地鸭蛋感官值的影响. 印度尼西亚应用研究杂志, 2021, 2(3): 192-195. <https://doi.org/10.30997/ijar.v2i3.157>.
- [15] LETIS Z.M, SUPRAYOGI A 和 EKASTUTI D.R.在饲料中添加各种卡图叶制剂可降低肉鸡胴体的腹部脂肪、脂肪和胆固醇水平. 兽医杂志, 2017, 18(3): 461-468. <https://doi.org/10.19087/jveteriner.2017.18.3.461>.
- [16] HENKE A, WESTREICHER-KRISTEN E, MOLKENTIN J, DICKHOEFER U, KNAPPSTEIN K,

- HASLER M 和 SUSENBETH A. 日粮白坚木单宁提取物对奶牛乳脂肪酸组成的影响。乳业科学杂志, 2017, 100: 6229-6238. <https://doi.org/10.3168/jds.2016-12149>。
- [17] HUANG Q、LIU X、ZHAO G、HU T 和 WANG Y. 单宁作为家畜生产中饲料抗生素替代品的潜力和挑战。动物营养, 2018, 4: 137-150。 <https://doi.org/10.1016/j.aninu.2017.09.004>。
- [18] SYAHRUDDIN E、HERAWATY R 和 NINGRAT R W S. 日粮中发酵卡图克叶(雌雄蜥)对肉鸡胴体胆固醇含量的影响。巴基斯坦营养学杂志, 2013, 12(11): 1013-1018. <https://doi.org/10.3923/pjn.2013.1013.1018>。
- [19] SANTOSO U、FENITA Y、KUSUSIYAH、BIDURA I G N G. 发酵的雌雄蜥叶对肉鸡肉成分、氨基酸和脂肪酸成分的影响。巴基斯坦营养学杂志, 2015, 14(11): 799-807. <https://doi.org/10.3923/pjn.2015.799.807>。
- [20] BIDURA I G N G、PARTAMA I B G、PUTRI B R T 和 WATINIASIH N L. 两片叶子(大蒜和雌雄同体)的水提取物对产蛋母鸡产蛋量和蛋黄胆固醇水平的影响。巴基斯坦营养学杂志, 2017, 16: 482-487。 <https://doi.org/10.3923/pjn.2017.482.487>。
- [21] YASNI S、KUSNANDAR F 和 HARTINI. 了解如何提取和分离卡图克叶生物碱(雌雄蜥(大号)梅尔)的活性成分。食品技术与工业通报, 1999, 10: 43-48。
- [22] 官方分析化学家协会(航空航天局)。官方分析化学家协会的官方分析方法。美国马里兰州, 2005。
- [23] KLEINER IS 和 DOTTI LB. 生物化学实验室指导。第 6 版莫斯比公司, 纽约, 1962。
- [24] ESTERBAUER H 和 CHEESEMAN K H. 醛类脂质过氧化产物的测定: 丙二醛和 4-羟基壬烯醛。酶学方法, 1990, 186: 407。
- [25] FOLCH J、LEES M、STANLEY G HS. 一种从动物组织中分离和纯化总脂质的简单方法。生物化学杂志, 1957, 226(1): 497-509。 [https://doi.org/10.1016/s0021-9258\(18\)64849-5](https://doi.org/10.1016/s0021-9258(18)64849-5)。
- [26] GALARDO M A、PÉREZ D D 和 LEIGHTON F M. 饲喂菜籽油的肉鸡脂肪酸组成的改变。生物学研究, 2012, 45(2): 149-161. <https://doi.org/10.4067/S0716-97602012000200007>。
- [27] BARROETA A.C. 禽肉的营养价值: 维生素 E 和 PUFA 之间的关系。世界家禽科学杂志, 2007, 63: 277-284. <https://doi.org/10.1017/S0043933907001468>。
- [28] MORALES-BARRERA J E、GONZALEZ-ALCORTA M J、CASTILLO-DOMINGUEZ R M, 等。补充金枪鱼油的鸡的肉鸡肉上会沉积脂肪酸。食品与营养科学, 2013, 4: 16-20. <https://doi.org/10.4236/fns.2013.49A1003>。
- [29] BELICHOVSKA D、PEJKOVSKI Z、NIKOLOVA AS 等。作为法兰克福香肠生产原料的禽肉和猪肥肉的化学和脂肪酸成分。马其顿动物科学杂志, 2020, 10(1-2): 23-28. <https://doi.org/10.54865/mjas20101-2023b>。
- [30] GOLIOMYTIS M、TSOUREKI D、SIMITZIS P.E 等。槲皮素膳食补充剂对肉鸡生长、性能、肉质和氧化稳定性的影响。家禽科学, 2014, 93: 1-6. <https://doi.org/10.3382/ps.2013-03585>。
- [31] SOHAIB M、BUTT MS S、SHABBIR MA、SHAHID M. 受槲皮素和富含 α -生育酚日粮影响的肉鸡胸肉的脂质稳定性、抗氧化潜力和脂肪酸组成。健康与疾病中的脂质, 2015, 14: 61. <https://doi.org/10.1186/s12944-015-0058-6>。
- [32] DZOYEM JP、KUETE V 和 ELOFF J N. 非洲毒理学研究中的生化参数: 意义、方法原理、数据解释和在植物筛选中的应用。在: KUETE V. (编辑)。非洲药用植物毒理学调查。爱思唯尔, 荷兰。2014: 659-715. <https://doi.org/10.1016/B978-0-12-800018-2.00023-6>。
- [33] BOSE R、KUMAR MS、MANIVEL A 和 MOHAN S C. 雌雄同体的化学成分及其抗氧化活性评价。植物化学研究, 2018, 12: 7-13. <https://doi.org/10.3923/rjphyto.2018.7.13>。
- [34] NGUYEN N H K、TIEN H T C、TRUC、TT 和 QUOC、L P T. 微波辅助提取的叶绿素(雌雄蜥(大号)梅尔)的叶绿素含量和抗氧化活性。眼压会议系列: 材料科学与工程, 2020, 991: 012036。 <https://doi.org/10.1088/1757-899X/991/1/012036>。
- [35] LESTARI D、RUKMIASIH、SURYATI T 等。添加天然抗氧化剂的土鸭肉脂肪酸组成及丙二醛含量[J]. 畜产品生产科技学报。2020, 8(3): 117-123。 <https://doi.org/10.29244/jipthp.8.3.117-123>。
- [36] KASMIRAH D、FENITA Y 和 SANTOSO U. 卡图克(雌雄蜥)膳食补充剂对莫霍萨里(爪哇语)卵胆固醇水平的影响。印度尼西亚畜牧科学杂志, 2013, 8(2): 77-86. DOI: 10.31186/jspi.id.8.2.77-86。
- [37] NORTH MK、ZOTTE AD、HOFFMAN LC. 膳食类黄酮在肉类生产中的应用: 综述。动物饲料科学与技术, 2019, 257: 114291. <https://doi.org/10.1016/j.anifeedsci.2019.114291>。
- [38] ISMOYOWATI、INDRASANTI D 和 SUMARMONO J. 野鸭和番鸭饲喂月桂叶(蒲桃)饲料的血液生化特征、生长性能、胴体特征和肉质。国际家禽科学杂志, 2016, 15: 21-26. <https://doi.org/10.3923/ijps.2016.21.26>。
- [39] TUGIYANTI E、SETIANTO N.A、HARISULISTYAWAN I, 等。面包果叶粉(高果木)对雄性本地直甲鸭性能、脂肪和肉胆固醇水平以及身体免疫的影响。国际家禽科学杂志, 2016, 15: 227-234. <https://doi.org/10.3923/ijps.2016.227.234>。