Effect of feeding 3 zero-tannin faba bean cultivars at 3 increasing inclusion levels on growth performance, carcass traits, and yield of saleable cuts of broiler chickens

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ABSTRACT A trial was conducted to evaluate how rapidly one could introduce faba bean in broiler diets and to what maximum level one could feed 3 zero-tannin faba bean cultivars to broiler chickens based on growth performance, carcass traits, and yield of carcass cuts. A total of 662 male broiler chickens (Ross 708) were fed one of 10 dietary treatments over 3 growth phases (starter [Str], day 0–12; grower [Gwr], day 13–25; and finisher [Fnr], day 26–41). Treatment diets included 3 different zero-tannin faba bean cultivars (Snowbird, Snowdrop, and Tabasco), each fed at 3 different inclusions: low inclusion level of 5% in Str, 10% in Gwr, and 20% in Fnr; medium inclusion level of 10% in Str, 20% in Gwr, and 30% in Fnr; and high inclusion level of 15% in Str, 30% in Gwr, and 40% in Fnr. Wheat grain–soybean meal (SBM) diets were fed as control. Faba bean cultivars replaced SBM and wheat grain in phase diets. Neither cultivar nor inclusion level affected overall trial or growth phase BW, ADFI, ADG, G:F, slaughter weight (WT), chilled carcass WT, and proportion of saleable cuts. Carcass dressing was 0.6% units lower for high vs. medium or low faba bean inclusion level (P < 0.05). There was no effect on overall trial or growth phase ADFI and there were only slight reductions (P < 0.05) in BW, ADG, G:F, slaughter WT, chilled carcass WT, dressing percentage, and percentage of drumstick yield in broilers fed the treatment diets including faba bean compared with those fed the wheat–SBM control diet. The control diet’s advantage was largely attributed to dehulling and the greater extent of processing to produce SBM vs. feeding raw, merely rolled, faba bean. In conclusion, broiler producers can feed any of the 3 zero-tannin faba bean cultivars evaluated as the most aggressive of the 3 inclusion levels tested (15, 30, 40% for the starter, grower, finisher phase) to maximize faba bean inclusion in broiler diets.

Key words: broiler chicken, carcass cut, dietary inclusion, growth performance, zero-tannin faba bean cultivar

INTRODUCTION

Feed represents approximately 70% of the cost of broiler chicken meat production for human consumption (Alltech, 2018). Both starch as a source of energy, and protein as a source of amino acids (AA), are the 2 most costly components of broiler feed. Faba bean (Vicia faba L.) is a high-yield pulse (low-fat legume) crop that shows potential as the substitute for conventional feedstuffs in broiler feed. Faba bean grain is rich in both starch (33%) and crude protein (CP; 28%; Crépon et al., 2010) and grows well in temperate climate zones (north of 50° parallel) where neither corn nor soybean meal (SBM) cultivation is optimal (Henriquez et al., 2018). Benefits of faba bean as the crop are numerous, which includes greater grain yield than field pea, a high protein content realized through symbiotic nitrogen fixation, breaking crop disease and pest cycles owing to crop rotation with cereals and oilseeds, diversification of soil microbial ecosystems, and the ability to reduce greenhouse gas emission because of reduced crop inputs (Strydhorst et al., 2008; Köpke and Nemecek, 2010). Besides, slow digestible starch found in faba bean (Hejdysz et al., 2016) can contribute to the improvement of gut health and function in poultry and thereby possibly aid in reducing the need of in-feed antibiotics for therapeutic use (Regassa and Nyachoti, 2018). Surplus food- and
feed-quality faba bean tonnage is available regionally. Depending on the price, locally grown faba bean represents an opportunity to producers in those regions to reduce feed cost by displacing higher priced ingredients such as imported SBM. The European Commission in 2013 created a Focus Group to enhance the range of protein crops, mainly legumes, to improve the sustainability of European agricultural systems and reduce importation of SBM (Schreuder and Visser, 2014). In general, there is little information on feeding pulses to poultry in comparison with other traditional feedstuffs (e.g., corn, wheat, SBM, fish meal).

Feeding faba bean to poultry also has its downsides: Faba bean contains antinutritional substances (ANS) in the form of tannins, trypsin inhibitors, lectins, vicine, convicine, and saponins (Jezierny et al., 2010). The presence of ANS in poultry diets can reduce feed intake and consequently growth (Iji et al., 2004) or egg production. The inclusion of ANS in poultry diets can reduce feed intake and affect the absorption of other nutrients (Crépon et al., 2010). However, lectin and trypsin inhibitor (Valdebeouze et al., 1980; Jezierny et al., 2010) as well as saponin levels (Makkar et al., 1997) are substantially lower in faba bean than in SBM. Tannin levels, on the other hand, are considerably greater than in SBM (El-Shemy et al., 2000; Jezierny et al., 2010).

Ingested quantity appears to regulate the effect of tannins (Flores et al., 1994). To mitigate the negative effects of tannins on feed intake and nutrient digestibility, white-flowered, low-tannin, (so-called zero-tannin) cultivars of faba bean have been developed (Duc, 1997; Crépon et al., 2010). Zero-tannin faba bean cultivars showed greater apparent ileal digestibility of AA than tannin-containing cultivars and may therefore be a better source of both starch and protein for broiler chickens (Woyengo and Nyachoti, 2012).

Limited information exists on how rapidly or aggressively one can introduce faba bean in broiler diets, what maximum inclusion levels broilers can tolerate according to age, and effects of feeding different zero-tannin faba bean cultivars especially on the yield of carcass meat components. Therefore, the objective of this study was to evaluate the effect of feeding zero-tannin faba bean cultivars at different introduction rates or inclusion levels on growth performance, carcass traits, and yield of saleable cuts. The hypothesis of this study was that broiler chickens fed 3 zero-tannin faba bean cultivars at different introduction rates (increasing inclusion levels) would perform, dress, and yield saleable cuts not different from broilers fed control diets without faba bean.

**MATERIALS AND METHODS**

Animal use was approved and study procedures were reviewed by the University of Alberta Animal Care and Use Committee for Livestock. Study conduct followed principles established by the Canadian Council on Animal Care (CCAC, 2009). The study was carried out at the Poultry Research and Technology Centre located at the University of Alberta, South Campus (Edmonton, Alberta, Canada).

**Animals and Housing**

In total, 662 male Ross 708 broiler chickens (Lilydale Hatchery, Spruce Grove, Alberta, Canada) originating from the same flock and hatched on the same day were used in the experiment. Chicks were individually weighed and randomly distributed among 64 cages, with 10 to 11 chicks per cage (initial BW 41.0 ± 3.2 g). Two Specht cage batteries (Specht-Ten Elsen GmbH, Sonsbeck, Germany) were used. Each battery provided 32 cages arranged in 4 tiers, with 2 sides and 4 cages per side. Cages (1.2 m [length] × 0.53 m [width] × 0.43 m [height]) were equipped with metal wire mesh (0.02 × 0.02 m) flooring. Initially, flat plastic mesh (0.01 × 0.01 m) mats covering the entire floor area of each cage were laid on top of the metal flooring to prevent chicks’ feet from going through but were subsequently removed on day 7. Broilers had continuous access to water from adjustable height bars that provided 4 nipple drinkers per pen. Cages were also equipped with feed troughs located at the front running the entire length of the cage. From day 0 to 4, parchment paper was placed on the cage floor with test feed sprinkled on top next to the cage feed trough to encourage consumption. During the trial, feed in the troughs was pushed down by hand 2 to 3 times per day as birds aged and consumed more feed, ensuring birds had continuous access to feed at all times. On day 25, up to 2 birds (less if mortality had occurred) with the lowest BW per cage were removed to reduce stocking density to 8 birds per cage. The temperature of the room was reduced as birds aged as per the Ross 708 Production Manual (Aviagen, 2018) and adjusted for low relative humidity in the air. The lighting schedule in the windowless barn conformed to Code of Practice Requirements of National Farm Animal Care Council (NFACC, 2016) and recommendations in the Ross 708 Production Manual (Aviagen, 2018). Broilers were therefore provided 30 to 40 lux, with 23 h of light and 1 h of darkness from day 0 to 2, 22 h of light and 2 h of darkness on day 3, and 21 h of light and 3 h of darkness on day 4; and a minimum 10 to 15 lux, with 20 h of light and 4 h of darkness from day 5 to 41. Automated controllers and timers specific to the test room adjusted temperature, ventilation, and lighting as programmed.

**Experimental Design and Diets**

Sixty of the 64 cages were divided into 6 area blocks of 10 cages each by location (i.e., battery, tier, side of the battery). In total, 10 different dietary treatments were fed. Each treatment appeared once in each block for a Randomized Complete Block design, with 6 replicate cages per treatment. Birds in the remaining 4 cages were fed the control diets, resulting in 10 replicate cages for the control group only. Cages in blocks 1 and 2 and 2 of the extra control cages had 11 birds per cage; all other cages had 10 birds per cage. Dietary treatments were fed over 3 growth phases (starter, day 0 to 12; grower, day 13 to 25; and finisher, day 26 to 41) for the entire 41-day growth cycle. Control diets were wheat grain–SBM...
Measurement and Calculations

To calculate cage ADFI, the amount of feed added during each phase andorts remaining at the end were weighed back on day 12, 25, and 41. To calculate cage ADG, the birds were individually weighed on day 0, 12, 25, and 41. Gain-to-feed ratio (G:F) was calculated by dividing cage ADG by ADFI.

Throughout the trial, broilers found dead, ill, or injured were promptly removed, euthanized, and individually weighed, and the suspect reason for death or removal was written down. On day 41 or 42 (late afternoon), the broilers were crated and transported (500 m) to the site abattoir, where they had no access to feed or water overnight. The broilers were slaughtered early the following morning and processed following commercial conditions (day 42–43 of age). Before slaughter, antemortem weight (WT) of individual broilers was measured. Broilers were euthanized by electrically stunning, bled out and then scalded, defeathered, and eviscerated. Carcasses were blast chilled to 4°C (measured in breast) and weighed to calculate the dressing percentage. One half of the carcasses randomly selected from each cage were then broken down into saleable cuts (breast including Pectoralis major and minor, thighs, drumsticks, and wings) and weighed to calculate yield relative to chilled carcass WT.

Chemical Analyses

Feedstuffs and diets were ground through a 0.5-mm screen in a centrifugal mill (ZM 200; Retsch GmbH, Haan, Germany). Feedstuffs and diets were analyzed using the Association of Official Analytical Chemists (AOAC, 2016), American Oil Chemists’ Society (AOCS, 2017), or Ankom Technology (2017) methods for moisture (AOAC 930.15), CP (AOAC 990.03[M]), AA (AOAC 994.12), starch (enzymatic UV method, Cat. No. 10207748035; R-Biopharm, Darmstadt, Germany), crude fiber (AOCS BA 6a-05), neutral detergent fiber (NDF; Ankom method 13[M]), acid detergent fiber (ADF; Ankom method 12[M]), crude fat (AOCS Am 5-04), and ash (AOAC 923.03) as well as calcium, phosphorus, sodium, chloride, magnesium, and potassium content (AOAC 985.01 [M], AOAC 968.08 [M], and AOAC 935.13a [M]) at Central Testing Laboratory Ltd. (Winnipeg, Manitoba, Canada). Gross energy for diet and feed ingredient samples was measured in duplicate by bomb calorimetry (model 6050; Parr Instrument Company, Moline, IL) in our laboratory (Alberta Agriculture and Forestry, Edmonton, Canada). Feed ingredient and diet particle size was determined in-house using a Ro-Tap (model RX-29; W.S. Tyler, Ontario, Canada) equipped with 13 sieves and a pan, following the method of American Society of Agricultural and Biological Engineers (2008).

Statistical Analyses

Growth performance, carcass traits, and saleable meat cut data were analyzed using a generalized linear model (GLIMMIX procedure) in SAS 9.4 (SAS Institute, Cary, NC) using a normal distribution and the identity link function (SAS Institute, 2017). Cage was the experimental unit for all variables. Data were analyzed as a 3 × 3 factorial design excluding the control; a contrast statement compared all faba bean treatments with the control diet. Models for the factorial design included the fixed effects of faba bean cultivars (Snowbird, Snowdrop, and Tabasco), faba bean
Table 1. Ingredient composition, particle size, and analyzed nutrient content of starter diets\(^1\) including 3 zero-tannin faba bean grain cultivars (Snowbird, Snowdrop, Tabasco) fed at 3 different levels\(^2\) and control diet.

| Ingredient                  | Control | Low\(^2\) | Medium\(^2\) | High\(^2\) | Low | Medium | High | Low | Medium | High |
|-----------------------------|---------|-----------|-------------|------------|-----|--------|------|-----|--------|------|
| Wheat, rolled               | 55.72   | 52.57     | 49.41       | 46.37      | 52.56| 49.42  | 46.27| 52.56| 49.41  | 46.26|
| Soybean meal                | 20.70   | 18.50     | 16.30       | 14.00      | 18.50| 16.30  | 14.10| 18.50| 16.30  | 14.10|
| Snowbird, rolled            | 5.00    | 10.00     | 15.00       |            | 5.00 | 10.00  | 15.00|     |        |      |
| Tabasco, rolled             | 12.00   | 12.00     | 12.00       | 12.00      | 12.00| 12.00  | 12.00| 12.00| 12.00  | 12.00|
| Canola seed, rolled         | 0.30    | 0.30      | 0.30        | 0.30       | 0.30 | 0.30   | 0.30 | 0.30 | 0.30   | 0.30 |
| Lysine                      | 0.18    | 0.19      | 0.20        | 0.21       | 0.19 | 0.20   | 0.21 | 0.19 | 0.20   | 0.21 |
| Choline chloride, 60%       | 0.10    | 0.10      | 0.10        | 0.10       | 0.10 | 0.10   | 0.10 | 0.10 | 0.10   | 0.10 |
| Salt                        | 0.92    | 0.93      | 0.94        | 0.95       | 0.94 | 0.95   | 0.95 | 0.94 | 0.93   | 0.93 |
| Indispensable amino acids   |         |           |             |            |     |        |      |     |        |      |
| Arginine                    | 0.58    | 0.67      | 0.76        | 0.86       | 0.76 | 0.86   | 0.86 | 0.76 | 0.86   | 0.86 |
| Leucine                     | 1.25    | 1.25      | 1.25        | 1.25       | 1.25 | 1.25   | 1.25 | 1.25 | 1.25   | 1.25 |
| Lysine                      | 0.95    | 0.97      | 0.98        | 0.99       | 0.98 | 0.99   | 0.99 | 0.98 | 0.99   | 0.99 |
| Valine                      | 0.15    | 0.15      | 0.15        | 0.15       | 0.15 | 0.15   | 0.15 | 0.15 | 0.15   | 0.15 |
| Aspartic acid               | 1.57    | 1.57      | 1.57        | 1.57       | 1.57 | 1.57   | 1.57 | 1.57 | 1.57   | 1.57 |
| Cysteine                    | 0.83    | 0.83      | 0.83        | 0.83       | 0.83 | 0.83   | 0.83 | 0.83 | 0.83   | 0.83 |
| Glutamic acid               | 1.43    | 1.43      | 1.43        | 1.43       | 1.43 | 1.43   | 1.43 | 1.43 | 1.43   | 1.43 |
| Alanine                     | 0.80    | 0.80      | 0.80        | 0.80       | 0.80 | 0.80   | 0.80 | 0.80 | 0.80   | 0.80 |
| Tryptophan                  | 0.35    | 0.35      | 0.35        | 0.35       | 0.35 | 0.35   | 0.35 | 0.35 | 0.35   | 0.35 |
| Serine                      | 0.70    | 0.70      | 0.70        | 0.70       | 0.70 | 0.70   | 0.70 | 0.70 | 0.70   | 0.70 |
| Tyrosine                    | 0.88    | 0.88      | 0.88        | 0.88       | 0.88 | 0.88   | 0.88 | 0.88 | 0.88   | 0.88 |

1. Starter diets fed from day 0–12.
2. Faba bean grain inclusion: low, 5%; medium, 10%; high, 15%.
3. Galloway Seeds (Fort Saskatchewan, Alberta, Canada).
4. Showluh Seeds (Blaine Lake, Saskatchewan, Canada).
5. Riddell Seed Co. (Warren, MB, Canada).
6. Provided per kg of diet: vitamin A, 10,000 IU; vitamin D3, 4,000 IU; vitamin E, 50 IU; menadione, 4 mg; biotin, 0.2 mg; folic acid, 2 mg; niacin, 65 mg; pantothenic acid, 15 mg; pyridoxine, 5 mg; riboflavin, 10 mg; thiamine, 4 mg; vitamin B12, 0.02 mg; copper, 20 mg; iodine, 1.65 mg; iron, 80 mg; manganese, 120 mg; selenium, 0.3 mg; and zinc, 100 mg.
7. Provided per kg of diet, units: amylase, 12,000; cellulase, 500; glucanase, 150; invertase, 700; mannanase, 60; phytase, 1,000; protease, 1,200; and xylanase, 1,200.
8. Central Testing Laboratory Ltd. (Winnipeg, Manitoba, Canada). Standardized to 11% moisture.
9. Alberta Agriculture and Forestry (Edmonton, Alberta, Canada).

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5. Riddell Seed Co. (Warren, MB, Canada).
6. Provided per kg of diet: vitamin A, 10,000 IU; vitamin D3, 4,000 IU; vitamin E, 50 IU; menadione, 4 mg; biotin, 0.2 mg; folic acid, 2 mg; niacin, 65 mg; pantothenic acid, 15 mg; pyridoxine, 5 mg; riboflavin, 10 mg; thiamine, 4 mg; vitamin B12, 0.02 mg; copper, 20 mg; iodine, 1.65 mg; iron, 80 mg; manganese, 120 mg; selenium, 0.3 mg; and zinc, 100 mg.
7. Provided per kg of diet, units: amylase, 12,000; cellulase, 500; glucanase, 150; invertase, 700; mannanase, 60; phytase, 1,000; protease, 1,200; and xylanase, 1,200.
8. Central Testing Laboratory Ltd. (Winnipeg, Manitoba, Canada). Standardized to 11% moisture.
9. Alberta Agriculture and Forestry (Edmonton, Alberta, Canada).
Table 2. Ingredient composition, particle size, and analyzed nutrient content of grower diets including 3 zero-tannin faba bean grain cultivars (Snowbird, Snowdrop, Tabasco) fed at 3 different levels and control diet.

| Ingredients, % as-fed | Control | Snowbird<sup>a</sup> | Snowdrop<sup>a</sup> | Tabasco<sup>a</sup> |
|-----------------------|---------|---------------------|---------------------|---------------------|
|                       |         | Low<sup>b</sup>     | Medium<sup>b</sup>  | High<sup>b</sup>    |
| Wheat, rolled         | 54.22   | 48.04               | 41.73               | 35.75               |
| Soybean meal          | 22.50   | 18.00               | 13.60               | 9.00                |
| Snowbird, rolled      | 10.00   | 20.00               | 30.00               |                     |
| Snowdrop, rolled      | 10.00   | 20.00               | 30.00               |                     |
| Tabasco, rolled       | 10.00   | 20.00               | 30.00               |                     |
| Fish meal             | 4.00    | 4.00                | 4.00                | 4.00                |
| Canola oil            | 0.90    | 1.50                | 2.10                | 2.60                |
| Snowbird, rolled      | 0.70    | 0.71                | 0.74                | 0.74                |
| Snowdrop, rolled      | 0.70    | 0.71                | 0.74                | 0.74                |
| Tabasco, rolled       | 0.70    | 0.71                | 0.74                | 0.74                |
| Broiler premix<sup>c</sup> | 0.50 | 0.50                | 0.50                | 0.50                |
| Salt                  | 0.50    | 0.50                | 0.50                | 0.50                |
| Sodium bicarbonate    | 0.30    | 0.30                | 0.30                | 0.30                |
| L-Lysine HCl          | 0.25    | 0.25                | 0.25                | 0.25                |
| DL-Methionine         | 0.20    | 0.25                | 0.29                | 0.34                |
| L-Threonine           | 0.13    | 0.15                | 0.18                | 0.20                |
| Choline chloride 60%  | 0.075   | 0.075               | 0.075               | 0.075               |
| L-Valine              | 0.03    | 0.07                | 0.11                | 0.11                |
| Superzyme Plus<sup>d</sup> | 0.025 | 0.025               | 0.025               | 0.025               |
| Total                 | 100.00  | 100.00              | 100.00              | 100.00              |

Analyzed nutrients, %

|                    | Control | Snowbird<sup>a</sup> | Snowdrop<sup>a</sup> | Tabasco<sup>a</sup> |
|--------------------|---------|---------------------|---------------------|---------------------|
|                    |         | Low<sup>b</sup>     | Medium<sup>b</sup>  | High<sup>b</sup>    |
| Crude protein      | 23.30   | 24.43               | 24.00               | 23.29               |
| Neutral detergent fiber | 10.09 | 10.81               | 11.13               | 9.59                |
| Acid detergent fiber | 4.33    | 5.15                | 4.79                | 4.75                |
| Crude fiber        | 3.96    | 4.67                | 4.07                | 4.17                |
| Ether extract      | 8.81    | 9.80                | 10.37               | 10.68               |
| Calcium            | 0.99    | 0.95                | 0.95                | 0.95                |
| Potassium          | 0.96    | 0.99                | 0.98                | 0.94                |
| Phosphorus         | 0.77    | 0.77                | 0.77                | 0.77                |
| Chloride           | 0.48    | 0.43                | 0.45                | 0.44                |
| Sodium             | 0.29    | 0.26                | 0.28                | 0.27                |
| Magnesium          | 0.20    | 0.20                | 0.19                | 0.18                |

Indispensable amino acids

|                    | Control | Snowbird<sup>a</sup> | Snowdrop<sup>a</sup> | Tabasco<sup>a</sup> |
|--------------------|---------|---------------------|---------------------|---------------------|
|                    |         | Low<sup>b</sup>     | Medium<sup>b</sup>  | High<sup>b</sup>    |
| Arginine           | 1.50    | 1.54                | 1.52                | 1.57                |
| Histidine          | 0.67    | 0.66                | 0.66                | 0.66                |
| Isoleucine         | 1.09    | 1.09                | 0.90                | 1.02                |
| Leucine            | 1.77    | 1.78                | 1.68                | 1.70                |
| Lysine             | 1.33    | 1.42                | 1.29                | 1.43                |
| Methionine         | 0.62    | 0.61                | 0.71                | 0.77                |
| Phenylalanine      | 1.23    | 1.17                | 1.15                | 1.08                |
| Threonine          | 0.78    | 0.79                | 0.89                | 0.85                |
| Tryptophan         | 0.34    | 0.35                | 0.31                | 0.36                |
| Valine             | 1.26    | 1.32                | 1.14                | 1.32                |

Dispensable amino acids

|                    | Control | Snowbird<sup>a</sup> | Snowdrop<sup>a</sup> | Tabasco<sup>a</sup> |
|--------------------|---------|---------------------|---------------------|---------------------|
|                    |         | Low<sup>b</sup>     | Medium<sup>b</sup>  | High<sup>b</sup>    |
| Alanine            | 0.97    | 1.00                | 0.93                | 0.95                |
| Aspartic acid      | 2.01    | 2.14                | 1.99                | 2.05                |
| Cysteine           | 0.65    | 0.61                | 0.61                | 0.66                |
| Glutamic acid      | 4.89    | 4.85                | 4.34                | 4.40                |
| Glycine            | 1.23    | 1.18                | 1.18                | 1.13                |
| Proline            | 1.79    | 1.66                | 1.63                | 1.48                |
| Serine             | 0.79    | 0.76                | 1.04                | 0.84                |
| Tyrosine           | 0.85    | 0.83                | 0.87                | 0.79                |

Particle size, μm

|                    | Control | Snowbird<sup>a</sup> | Snowdrop<sup>a</sup> | Tabasco<sup>a</sup> |
|--------------------|---------|---------------------|---------------------|---------------------|
|                    |         | Low<sup>b</sup>     | Medium<sup>b</sup>  | High<sup>b</sup>    |
| Particle size      | 821     | 907                 | 968                 | 968                 |
| Particle size standard deviation, μm | 2.04 | 1.99               | 1.94               | 1.96               |
| Gross energy, MJ/kg | 18.04  | 18.34              | 18.35              | 18.38              |
Table 3. Ingredient composition, particle size, and analyzed nutrient content of finisher diets\(^1\) including 3 zero-tannin faba bean grain cultivars (Snowbird, Snowdrop, Tabasco) fed at 3 different levels\(^2\) and control diet.

| Ingredients, % as fed | Control | Snowbird\(^3\) | Snowdrop\(^4\) | Tabasco\(^5\) |
|-----------------------|---------|----------------|----------------|--------------|
|                       |         | Low\(^6\)     | Medium\(^6\)  | High\(^6\)  |
|                       |         | Low           | Medium         | High         |
| Wheat, rolled         | 58.45   | 46.13         | 43.05          | 33.91        |
| Soybean meal          | 22.80   | 13.80         | 9.30           | 4.80         |
| Snowbird, rolled      | 20.00   | 20.00         | 30.00          | 30.00        |
| Snowdrop, rolled      | 20.00   | 30.00         | 40.00          | 40.00        |
| Tabasco, rolled       | 20.00   | 30.00         | 40.00          | 40.00        |
| Canola seed, rolled   | 15.00   | 15.00         | 15.00          | 15.00        |
| Monocalcium/dicalcium phosphate | 1.00   | 0.95          | 0.90           | 0.86         |
| Limestone             | 0.87    | 0.90          | 0.92           | 0.93         |
| Broiler premix\(^6\) | 0.50    | 0.50          | 0.50           | 0.50         |
| Salt                  | 0.50    | 0.50          | 0.50           | 0.50         |
| Canola oil            | 0.20    | 1.40          | 1.90           | 2.45         |
| Sodium bicarbonate    | 0.20    | 0.20          | 0.20           | 0.20         |
| L-Lysine HCl          | 0.11    | 0.20          | 0.25           | 0.29         |
| DL-Methionine         | 0.07    | 0.11          | 0.13           | 0.16         |
| L-Threonine           | 0.05    | 0.05          | 0.05           | 0.05         |
| Choline chloride 60%  | 0.05    | 0.05          | 0.05           | 0.05         |
| L-Valine              | 0.01    | 0.01          | 0.05           | 0.10         |
| Total                 | 100.00  | 100.00        | 100.00         | 100.00       |

| Analyzed nutrients, % | Snowbird\(^3\) | Snowdrop\(^4\) | Tabasco\(^5\) |
|-----------------------|----------------|----------------|--------------|
|                       | Low\(^6\)     | Medium\(^6\)  | High\(^6\)  |
|                       | Low           | Medium         | High         |
| Crude protein         | 22.10         | 20.98         | 21.19        |
| Neutral detergent fiber | 9.93     | 10.61         | 10.35        |
| Acid detergent fiber  | 4.83          | 5.48          | 7.01         |
| Ether extract         | 10.72         | 9.93          | 10.48        |
| Ash                   | 5.35          | 5.06          | 5.12         |
| Calcium               | 0.88          | 0.82          | 0.82         |
| Potassium             | 0.91          | 0.86          | 0.85         |
| Phosphorus            | 0.69          | 0.61          | 0.60         |
| Chloride              | 0.45          | 0.44          | 0.44         |
| Sodium                | 0.24          | 0.23          | 0.26         |
| Magnesium             | 0.19          | 0.17          | 0.16         |

Indispensable amino acids

| Arginine              | 1.35         | 1.40         | 1.36         |
| Histidine             | 0.63         | 0.59         | 0.59         |
| Isoleucine            | 0.91         | 0.84         | 0.77         |
| Leucine               | 1.62         | 1.54         | 1.48         |
| Lysine                | 1.19         | 1.26         | 1.21         |
| Methionine            | 0.47         | 0.52         | 0.62         |
| Phenylylalanine       | 1.12         | 0.98         | 0.95         |
| Threonine             | 0.78         | 0.85         | 0.79         |
| Tryptophan            | 0.31         | 0.28         | 0.30         |
| Valine                | 1.06         | 1.01         | 0.96         |

Dispensable amino acids

| Alanine               | 0.86         | 0.84         | 0.81         |
| Aspartic acid         | 1.90         | 1.95         | 1.85         |
| Cysteine              | 0.54         | 0.59         | 0.62         |
| Glutamic acid         | 4.73         | 4.73         | 4.14         |
| Glycine               | 1.01         | 0.93         | 0.93         |
| Proline               | 1.66         | 1.45         | 1.39         |
| Serine                | 1.00         | 1.01         | 0.98         |
| Tyrosine              | 0.80         | 0.72         | 0.71         |

Particle size, \(\mu m\)

| 911 | 885 | 966 | 1,004 | 980 | 975 | 1,021 | 918 | 987 | 1,098 |

Particle size standard deviation, \(\mu m\)

| 1.92 | 1.96 | 1.95 | 1.92 | 1.86 | 1.89 | 1.89 | 1.92 | 1.90 | 1.85 |

Gross energy, MJ/kg

| 17.76 | 17.92 | 17.95 | 18.15 | 18.04 | 18.19 | 18.26 | 18.08 | 17.94 | 18.04 |

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\(^1\)Finisher diets fed from day 26–41.

\(^2\)Faba bean grain inclusion: low, 20%; medium, 30%; high, 40%.

\(^3\)Galloway Seeds (Fort Saskatchewan, Alberta, Canada).

\(^4\)Shewchuk Seeds (Blaine Lake, Saskatchewan, Canada).

\(^5\)Riddell Seed Co. (Warren, MB, Canada).

\(^6\)Provided per kg of diet: vitamin A, 10,000 IU; vitamin D3, 4,000 IU; vitamin E, 50 IU; menadione, 4 mg; biotin, 0.2 mg; folic acid, 2 mg; niacin, 65 mg; pantothenic acid, 15 mg; pyridoxine, 5 mg; riboflavin, 10 mg; thiamine, 4 mg; vitamin B12, 0.02 mg; copper, 20 mg; iodine, 1.65 mg; iron, 80 mg; manganese, 120 mg; selenium, 0.3 mg; and zinc, 100 mg.

\(^7\)Provided per kg of diet, units: amylase, 12,000; cellulase, 500; glucanase, 150; invertase, 700; mannanase, 60; phytase, 1,000; protease, 1,200; and xylanase, 1,200.

\(^8\)Central Testing Laboratory Ltd. (Winnipeg, Manitoba, Canada). Standardized to 11% moisture.

\(^9\)Alberta Agriculture and Forestry (Edmonton, Alberta, Canada).
inclusion levels (low, medium, and high), and interaction. Block was the random term in the model. Overall growth performance variables (ADFI, ADG, and G:F) were analyzed using closeout data. Live performance data were also analyzed as per growth phase. For carcass data, the sampling unit was individual carcasses. The model for carcass-related data included cage (cultivar, inclusion level) for the 3 × 3 factorial design or cage (treatment) for the contrast analysis as a random effect to take into account that the sampling unit (individual carcasses) was not the same as the experimental unit (cage). To test hypotheses, $P < 0.05$ was considered significant; $P < 0.10$ was considered a trend.

## RESULTS AND DISCUSSION

A major reason for not feeding locally grown feed commodities is lack of information on the effect of feeding pulses including faba bean to broiler chickens. Information such as the maximum level to feed by age, how fast to introduce, and effects on carcass traits and proportional yield of saleable cuts is nonexistent. Research published on broilers feeding diets containing faba bean has focused on live bird performance and digestibility (Gous, 2011; Woyengo and Nyachoti, 2012; Ivarsson and Wall, 2017), not on carcass traits, meat yield, or quality attributes. The present trial therefore looked at live growth performance, carcass traits, and yield of saleable cuts. Besides, previous research often fed pelleted diets (Farrell et al., 1999; Nalle et al., 2010). Pelleted diets increase digestibility of both protein and starch, resulting in greater AMEn values (Lacassagne et al., 1988). Ivarsson and Wall (2017) reported greater feed intake feeding pelleted diets containing zero-tannin faba bean than feeding the same in mash form. Broiler producers that mix feed on farm often do not have pellet mills. Our broilers were fed mash diets to replicate how local producers feed their flocks.

### Diet Formulation

Different introduction rates or increasing dietary inclusion levels of faba bean were fed to broilers in this experiment instead of just comparing graded inclusion levels that would not change with feeding phase or remain constant throughout the trial (Cho et al., 2019). The reason

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**Table 4.** Analyzed nutrient content (as-fed basis) and particle size of zero-tannin Snowbird, Snowdrop, and Tabasco faba bean grain cultivars, wheat grain, soybean meal (SBM), and canola seed.

| Analyzed nutrients, % | Snowbird¹ | Snowdrop² | Tabasco³ | Wheat | SBM | Canola seed |
|-----------------------|-----------|-----------|----------|-------|-----|-------------|
| Moisture              | 12.61     | 10.86     | 12.26    | 12.53 | 11.46| 8.07        |
| Starch                | 40.39     | 40.17     | 37.47    | 55.64 | 0.40 | 0.51        |
| Crude protein         | 24.85     | 24.31     | 27.09    | 13.91 | 46.44| 21.89       |
| Neutral detergent fiber| 9.49     | 11.48     | 12.45    | 9.91  | 7.51 | 20.49       |
| Acid detergent fiber  | 6.75      | 10.24     | 10.94    | 2.17  | 6.03 | 18.62       |
| Crude fiber           | 5.29      | 8.15      | 8.70     | 2.05  | 3.48 | 14.09       |
| Ether extract         | 1.18      | 1.18      | 0.96     | 1.96  | 1.47 | 40.37       |
| Ash                   | 2.69      | 2.46      | 2.57     | 1.82  | 5.59 | 3.44        |
| Potassium             | 1.21      | 1.07      | 1.16     | 0.42  | 2.28 | 0.71        |
| Phosphorus            | 0.41      | 0.39      | 0.50     | 0.36  | 0.67 | 0.60        |
| Calcium               | 0.11      | 0.13      | 0.09     | 0.11  | 0.25 | 0.41        |
| Magnesium             | 0.12      | 0.12      | 0.13     | 0.12  | 0.26 | 0.31        |
| Chloride              | 0.07      | 0.06      | 0.05     | 0.06  | 0.01 | 0.01        |
| Sodium                | 0.01      | 0.01      | 0.00     | 0.01  | 0.01 | 0.03        |

**Indispensable amino acids**

| Arginine          | 2.01   | 2.17   | 2.54   | 0.66   | 3.03  | 1.31 |
| Histidine         | 0.69   | 0.74   | 0.69   | 0.41   | 1.12  | 0.65 |
| Isoleucine        | 0.98   | 1.08   | 1.05   | 0.55   | 1.10  | 0.77 |
| Leucine           | 1.84   | 1.89   | 1.86   | 0.96   | 3.23  | 1.53 |
| Lysine            | 1.56   | 1.46   | 1.46   | 0.36   | 2.53  | 1.20 |
| Methionine        | 0.25   | 0.25   | 0.25   | 0.29   | 0.70  | 0.48 |
| Phenylalanine     | 1.11   | 1.18   | 1.10   | 0.71   | 2.22  | 0.95 |
| Threonine         | 0.83   | 0.81   | 0.76   | 0.31   | 1.56  | 0.86 |
| Tryptophan        | 0.26   | 0.27   | 0.31   | 0.20   | 0.68  | 0.27 |
| Valine            | 1.12   | 1.22   | 1.22   | 0.67   | 1.65  | 1.00 |

**Dispensable amino acids**

| Alanine           | 1.00   | 1.00   | 0.98   | 0.47   | 1.86  | 0.92 |
| Aspartic acid     | 2.73   | 2.69   | 2.66   | 0.71   | 5.15  | 1.52 |
| Cysteine          | 0.50   | 0.51   | 0.52   | 0.57   | 0.93  | 0.88 |
| Glutamic acid     | 4.01   | 4.02   | 3.99   | 3.98   | 7.95  | 3.74 |
| Glycine           | 1.11   | 1.22   | 1.13   | 0.64   | 1.96  | 1.19 |
| Proline           | 1.11   | 1.22   | 1.16   | 1.56   | 2.45  | 1.54 |
| Serine            | 1.20   | 1.11   | 1.02   | 0.41   | 2.37  | 0.96 |
| Tyrosine          | 0.88   | 0.91   | 0.87   | 0.48   | 1.66  | 0.76 |

**Particle size, 4 μm**

|                                      | Snowbird³ | Snowdrop³ | Tabasco³ | Wheat | SBM | Canola seed |
|--------------------------------------|-----------|-----------|----------|-------|-----|-------------|
| Particle size standard deviation, μm | 951       | 1,019     | 1,052    | 814   | 785 | 1,099       |

**Gross energy, 4 MJ/kg**

|                                      | Snowbird³ | Snowdrop³ | Tabasco³ | Wheat | SBM | Canola seed |
|--------------------------------------|-----------|-----------|----------|-------|-----|-------------|
| 1Galloway Seeds (Fort Saskatchewan, Alberta, Canada). |           |           |          |       |     |             |
| 2Shewchuk Seeds (Blaine Lake, Saskatchewan, Canada). |           |           |          |       |     |             |
| 3Riddell Seed Co. (Warren, MB, Canada). |           |           |          |       |     |             |
| 4Alberta Agriculture and Forestry (Edmonton, Alberta, Canada). |           |           |          |       |     |             |
for this was to challenge the birds and determine to what maximum level and how fast one could introduce faba bean, but also to determine if feeding broilers faba bean at different inclusion rates would result in reduced growth performance. Tolerance to ANS appears to increase as birds age (Farrell et al., 1999). By feeding faba bean at different inclusion levels instead of constant levels that would not increase by phase, broilers were given the opportunity to progressively adapt to high inclusions of faba bean, their effect at the gut level and the challenge that the increasing level of ANS in the diet implied.

An issue feeding faba bean is the lack of reliable nutritional information. Although information on the AME and the variability thereof in faba bean fed to broilers is lacking, it is not completely unknown. Availability of reliable energy values is, however, far more limiting than AA digestibility values, and cultivar effects are unknown. As mentioned earlier, most AA ratios met or exceeded the required ratios to lysine even at high faba bean inclusions (30–40%). However, the required ratios were not always met using the AMINODat 5.0 matrix of digestible AA coefficients. Arginine (only in starter) and branched-chain AA were deficient in formulations. For this reason, L-valine, now commercially available in Canada, was added to faba bean diets. Branched-chain AA are known to be limiting in faba bean, but overall, analyzed contents in diet were not found to be retrospectively lower in the experimental diets (Tables 1–3) than levels recommended in the Ross 708 Production Manual (Aviagen, 2019). Protein content was about 3% points lower than expected.

Particle size was measured for all experimental diets, faba bean cultivars, wheat grain, SBM, and canola seed (Tables 1–4). The recommended particle size should be between 600 and 800 μm. Chickens are known to prefer larger feed particles, and such preference increases with age (Nir et al., 1994). Uniform particle size diets should result in less time spent searching for and selecting preferred particle sizes, which would lead to superior broiler performance. In the present study, particle size was slightly greater than recommended for grower and finisher but not for starter diets (Tables 1–3). However, the standard deviation of the particle size of our diets was lower than the typically observed 2.7 μm, likely owing to rolling. The increase in particle size with the feeding phase in our experiment is explained by increasing faba bean and canola seed inclusions as the trial progressed and broilers grew older.

**Growth Performance**

Throughout the trial, 36 birds were either found dead or removed and euthanized because illness, leg or wing injury. Because of this low removal rate (lack of replication), no statistical analysis was conducted. Reasons for assumed death or removal seemed not to be related to dietary treatment.

There were no interactions between faba bean cultivar and dietary inclusion level on growth performance or carcass traits. The most important finding in this experiment was that neither faba bean cultivars nor inclusion levels had an effect on overall trial or individual growth phase ADFI, ADG, G:F, or BW (Table 5). Ivarsson and Wall (2017) showed that broiler growth performance was maintained by feeding pelleted diets with 20% zero-tannin faba bean inclusion, but reduced ADFI and BW was observed at an inclusion level of 30%. According to that study, a lower level of available AA because of lower digestibility might explain the decrease in the growth rate at high inclusion levels. In that study, at the 30% inclusion level, the feed conversion ratio was improved, compared with the 20% inclusion level and the control diet. This finding indicated that decreased feed intake was responsible for the lower BW. In the present study, no effects on feed intake were observed, and hence, faba bean cultivars or inclusion levels had no effect on growth performance. The difference between our study and that of Ivarsson and Wall (2017) could be due to phase feeding. Ivarsson and Wall (2017) fed a single-phase diet throughout the trial, whereas our study implemented phase feeding. Our results indicate that zero-tannin cultivars Snowbird, Snowdrop, and Tabasco introduced at the high inclusion level (15, 30, and 40% for the starter, grower, and finisher phase, respectively) can be fed to broilers without affecting growth performance (Table 5).

The controls were heavier at the end of the grower and finisher phases, had greater ADG for the overall trial (66.7 vs. 63.3 g/day) and at the starter and grower phases, and had greater G:F for the overall trial (0.612 vs. 0.581 g/g) and the finisher phase than broilers fed faba bean (P < 0.05; Table 5). No effects on ADFI were observed (Table 5), indicating that the broilers did not prefer control over faba bean–containing phase diets. In our study, broilers were fed raw faba bean merely rolled that was not processed to the same extent as SBM. Production of SBM involves many processing steps including flaking, dehulling, heating, pressing, hexane washing, and desolventizing (Wright, 1981). Seed heating steps reduce trypsin inhibitor levels and increase AA digestibility of SBM (Wright, 1981; Rada et al., 2017). Hence, it was not surprising to us to observe somewhat reduced growth performance in broilers fed raw, rolled-only faba bean compared with those fed highly processed SBM. We showed similar small reductions in growth performance in a recent study that fed broilers with whole or dehulled zero- or high-tannin faba bean cultivars compared with a SBM–wheat control diet (Cho et al., 2019). Processing of faba bean might nullify the reductions observed in growth performance. Indeed, when Laudadio et al. (2011) fed broilers processed, dehulled, and micronized zero-tannin faba bean as replacement for SBM at 31% inclusion level, growth performance was not affected up to 49 days of age.

**Carcass Traits**

Faba bean cultivar or inclusion level had no effect on antemortem WT or chilled carcass WT, but the high
Table 5. Effect of feeding 3 zero-tannin faba bean grain cultivars at 3 dietary inclusion levels on live body weight (BW), average daily feed intake (ADFI), weight gain (ADG), and feed efficiency (ADG/ADFI; G:F) of broiler chickens to 41 days of age.

| Variable         | Cultivar                  | Inclusion | P-value |
|------------------|---------------------------|-----------|---------|
|                  | Control | Snowbird | Snowdrop | Tabasco | Low    | Medium   | High     | SEM<sup>2</sup> | Cultivar | Inclusion | Contrast<sup>3</sup> |
| BW day 0, g/bird | 40.8    | 41.1<sup>a,b</sup> | 41.5<sup>c</sup> | 40.1<sup>b</sup> | 41.1 | 40.9 | 41.1 | 0.3 | 0.0244 | 0.8039 | 0.5883 |
| BW day 12, g/bird| 399.6   | 386.2    | 383.6    | 381.0   | 382.2 | 389.3 | 379.3 | 3.8 | 0.6037 | 0.1495 | 0.0273 |
| BW day 25, g/bird| 1,369.2 | 1,276.5  | 1,283.5  | 1,278.5 | 1,277.8 | 1,289.4 | 1,271.2 | 29.0 | 0.9588 | 0.6990 | 0.0035 |
| BW day 41, g/bird| 3,011.1 | 2,875.7  | 2,881.8  | 2,868.7 | 2,883.6 | 2,899.9 | 2,842.8 | 33.0 | 0.9617 | 0.4587 | 0.0359 |
| ADFI day 0–12, g/bird | 37.3 | 37.3    | 37.5    | 38.6    | 37.8 | 37.9 | 37.7 | 1.1 | 0.3935 | 0.9702 | 0.7284 |
| ADFI day 13–25, g/bird | 103.9 | 98.9    | 98.6    | 98.8    | 99.8 | 97.4 | 99.2 | 2.0 | 0.9941 | 0.6192 | 0.1356 |
| ADG day 0–12, g/bird | 29.8 | 28.8    | 28.4    | 28.3    | 28.4 | 28.9 | 28.2 | 0.3 | 0.5013 | 0.2761 | 0.0199 |
| ADG day 13–25, g/bird | 71.9 | 66.0    | 65.9    | 65.8    | 65.4 | 69.4 | 65.9 | 1.3 | 0.9294 | 0.8256 | 0.0098 |
| ADG day 26–41, g/bird | 96.9 | 94.0    | 92.7    | 93.4    | 94.1 | 95.0 | 91.1 | 1.7 | 0.8531 | 0.2706 | 0.2655 |
| ADG day 41–60, g/bird | 66.7 | 63.6    | 63.0    | 63.2    | 63.3 | 64.2 | 62.4 | 0.9 | 0.8679 | 0.3039 | 0.0330 |
| G:F day 0–12, g:g | 0.800 | 0.774    | 0.764    | 0.738    | 0.756 | 0.764 | 0.757 | 0.021 | 0.1815 | 0.9951 | 0.1126 |
| G:F day 13–25, g:g | 0.693 | 0.676    | 0.669    | 0.682    | 0.677 | 0.685 | 0.666 | 0.014 | 0.7895 | 0.5867 | 0.4638 |
| G:F day 26–41, g:g | 0.528 | 0.501    | 0.495    | 0.503    | 0.504 | 0.508 | 0.487 | 0.009 | 0.7267 | 0.1163 | 0.0388 |
| G:F day 41–60, g:g | 0.612 | 0.584    | 0.579    | 0.581    | 0.580 | 0.590 | 0.574 | 0.010 | 0.8646 | 0.2074 | 0.0097 |

<sup>a,b</sup>Means within a row and fixed effect without a common superscript differ (P < 0.05).
<sup>1</sup>Least squares means based on 6 replicate cages per faba bean treatment and 10 replicate cages for control.
<sup>2</sup>3 × 3 factorial analysis.
<sup>3</sup>Faba bean treatments vs. control.

Snowbird, Snowdrop, Tabasco, Low, Medium, High, Cultivar, Inclusion, Contrast.

Table 6. Effect of feeding 3 zero-tannin faba bean grain cultivars at 3 dietary inclusion levels on antemortem weight (WT), chilled carcass WT, dressing percentage, and yield of saleable meat cuts as percentage of chilled carcass WT of broiler chickens at 42 or 43 days of age.

| Variable         | Cultivar                  | Inclusion | P-value |
|------------------|---------------------------|-----------|---------|
|                  | Control | Snowbird | Snowdrop | Tabasco | Low    | Medium   | High     | SEM<sup>2</sup> | Cultivar | Inclusion | Contrast<sup>3</sup> |
| Antemortem WT, g | 2,938.4 | 2,786.9  | 2,795.8  | 2,781.4 | 2,790.7 | 2,818.7 | 2,754.7 | 30.7 | 0.9480 | 0.3690 | 0.0163 |
| Carcass WT, g    | 2,205.8 | 2,071.2  | 2,087.6  | 2,093.2 | 2,095.4 | 2,123.6 | 2,032.9 | 50.2 | 0.8150 | 0.0690 | 0.0230 |
| Dressing, %      | 75.6    | 74.7     | 74.6     | 74.8     | 74.9<sup>a</sup> | 74.9<sup>a</sup> | 74.3<sup>c</sup> | 0.3 | 0.7470 | 0.0340 | 0.0088 |
| Saleable cuts, % |                     |           |           |           | 30.62 | 30.41 | 30.47 | 0.47 | 0.7010 | 0.8520 | 0.2972 |
| Pectorals major  | 31.01   | 30.68    | 30.44    | 30.37    | 30.62 | 30.41 | 30.47 | 0.47 | 0.7010 | 0.8520 | 0.2972 |
| Pectorals minor  | 6.11    | 6.06     | 6.07     | 6.06     | 6.01 | 6.05 | 6.13 | 0.11 | 0.9830 | 0.4170 | 0.6607 |
| Wings            | 9.95    | 10.13    | 10.07    | 10.24    | 10.14 | 10.14 | 10.15 | 0.14 | 0.2670 | 0.9950 | 0.1615 |
| Thighs           | 16.44   | 15.80    | 15.86    | 15.99    | 15.86 | 15.83 | 15.97 | 0.33 | 0.7510 | 0.8710 | 0.1037 |
| Drumsticks       | 12.74   | 13.22    | 13.15    | 13.28    | 13.21 | 13.20 | 13.25 | 0.24 | 0.7950 | 0.9600 | 0.0314 |

<sup>a,b</sup>Means within a row and fixed effect without a common superscript differ (P < 0.05).
<sup>1</sup>Least squares means based on 6 replicate cages per faba bean treatment and 10 replicate cages for control.
<sup>2</sup>3 × 3 factorial analysis.
<sup>3</sup>Faba bean treatments vs. control.
values may have been overestimated in our study, and this may have resulted in reduced antemortem WT, carcass WT, and dressing percentage in broilers fed faba bean vs. those fed the wheat–SBM diet. These findings highlight the need for further AA digestibility work to maximize inclusion levels of faba bean in broiler diets without affecting carcass traits.

**Carcass Cuts**

Faba bean cultivar or inclusion level had no effect on the yield of saleable carcass cuts (Table 6). The yield of drumsticks was greater ($P < 0.05$) for broilers fed with faba bean grain than for the controls (13.22 vs. 12.74%, respectively; Table 6) likely because the controls achieved greater antemortem BW. We have previously also reported greater drumstick yield feeding zero- or high-tannin faba bean cultivars than with feeding a wheat–SBM control diet (Cho et al., 2019). There was an interaction between faba bean cultivar and inclusion level for yield of the largest breast muscle (*Pectoralis major*) as the percentage of chilled carcass weight. The yield of saleable cuts indicates that broilers can be progressively fed greater levels up to 40% of the 3 zero-tannin faba bean cultivars tested.

**CONCLUSIONS**

In conclusion, there was no effect of either faba bean cultivar (Snowbird, Snowdrop, Tabasco) or increasing dietary inclusion level (5, 10, and 20%; 10, 20, and 30%; 15, 30, and 40% for the starter, grower, and finisher phases, respectively) on growth performance, carcass traits, or proportional yield of carcass components. Broiler producers can therefore feed the most aggressive micronized zero-tannin faba bean as replacement for SBM at the 31% inclusion level. This inclusion level did not affect dressing percentage, breast or drumstick yield. Although the design of their study seems comparable to ours, caution should be taken when comparing results of both studies especially regarding the yield of breast as percentage of BW at slaughter. Laudadio et al. (2011) found no effect on breast yield, but breast yield percentage differed largely from that in our study. Their article did not specify how breast muscles (i.e., *Pectoralis major and minor*) were measured. Their findings were about 3% greater minor breast muscle yield than ours. The reason for the difference is not clear but is likely related to differences in the calculation method or breed. Our finding that there was no cultivar or inclusion level effect on the carcass WT, dressing percentage, and yield of saleable cuts indicates that broilers can be progressively fed greater levels up to 40% of the 3 zero-tannin faba bean cultivars tested.

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