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Effect of Crud and Processed Canola Seed in the Finisher Diet on the Growth Performance and Meat Quality of Broiler Chickens

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ABSTRACT

This study investigated the effect of different levels of crude and processed canola seeds in the finisher's diet on broiler chickens' growth performance and meat quality traits. A total of 1056 Ross-308 broiler chickens, comprising both sexes, were used in a completely randomized design with 16 treatments. Each treatment had 6 replicates, and each replicate consisted of 11 birds. Treatment 1 involved a basal diet adjusted with corn-soybean meal, while treatments 2-16 involved the replacement of three types of canola seeds (crude, micronized, and super-conditioned) at five levels (3%, 6%, 9%, 12%, and 15%). The growth performance of broiler chickens was not affected by the crude and processed canola seeds added to the finisher diet in the experimental treatments ($p>0.05$). Additionally, at the end of the experimental period (42 days), the effect of the experimental treatments on measuring the quality indices of breast and thigh meat was examined. The results showed that the drip loss of breast and thigh meat was influenced significantly by the processing of canola seed ($p<0.01$). Furthermore, the main effects of super-conditioned and crude canola seed processing in the diet had a significant impact on the decrease in breast and thigh meat quality, with super-conditioning having the most significant effect and crude having the least effect, and there were no significant interactions between them on other quality measurement indices ($p<0.01$). Based on the results obtained from this experiment, canola seed processing using the super-conditioning method was more effective in drip loss compared to the micronized method.

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Introduction

Canola is an oilseed containing approximately 55% fat, with more than 85% being 18-carbon fatty acids. Among these, 60% comprises 18:1 oleic acid (Ackman 1990). Additionally, canola has 20.6% crude protein (Murphy, Uden, et al., 1987), with lysine, threonine, tryptophan, and sulfur-containing amino acids being its most abundant essential amino acids (Szymeczko, Topolinski, et al., 2010). Therefore, it can serve as a suitable energy source and protein in poultry diets (Salmon, Stevens et al., 1988). Glucosinolate and erucic acid are the most significant anti-nutritional compounds in canola and other Brassica plants. However, the amount of these compounds has decreased in new varieties of canola compared to old varieties (Bell 1993). Other undesirable compounds in canola include phytates, polyphenols, substances that cause unpleasant smells and bitterness, indigestible carbohydrates, and unknown anti-nutritional factors(Maheshwari, Stanley, et al., 1981; Liang, Huang et al., 2002). Researchers have reported that it is possible to use these food items in diets by applying processing techniques to food items with high glucosinolate content (Smithard and Eyre, 1986; Liang et al., 2002). Thermal processing, for example, reduces the content of glucosinolates (Fenwick, Spinks, et al., 1986). Furthermore, thermal processing not only reduces glucosinolates in canola but also inactivates the enzyme myrosinase, which is responsible for hydrolyzing glucosinolates into toxic metabolites such as isothiocyanate, oxazolidine-2-thione, and nitriles (Huang, Liang, et al., 1995). It has been reported that thermal processing improves the palatability of canola in rat food (Smithard and Eyre 1986). Conditioning processing affects the molecular structure of protein, starch crystallinity, the accessibility of digestive enzymes to starch, and the destruction of bacterial and fungal toxins in food (Attar, Kermanshahi et al., 2017; Netto, Massuquetto et al., 2019). Several studies have shown that the processing of feed components or the entire diet using conditioning methods improves growth performance indicators in broilers (Abdollahi, Ravindran et al., 2010; Liu, Selle et al., 2013; Attar, Kermanshahi et al., 2017; Teymouri and Hassanabadi 2021). Micronization has been found to enhance the nutritional value of diets for growing pigs (Savage, Smith et al., 1980) and broilers(Douglas, Sullivan et al., 1991). In another experiment involving the micronization of chickpeas, their nutritional value improved in growing chickens (Igbasan, Guenter et al., 1997). Raw and processed beans have been shown to have no adverse effect on the meat quality of chickens (Hejdysz, Kaczmarek, et al., 2019; Kuźniacka, Banaszak et al., 2020) and vice versa, the use of micronized pea seeds instead of soybean meal has a positive effect on the fatty acid composition of chicken breast meat (Kiczorowsk et al., 2016) Ducks fed with different protein combinations (yellow lupine, rapeseed meal, narrow leaf lupine, chickpea) exhibited similar meat quality to ducks fed with soybean meal (Kuźniacka et al., 2020).

Therefore, feed is considered one of the critical factors affecting the quantity and quality of poultry meat, accounting for more than 30% of the feed content and significantly influencing chicken meat production (Rede and Petrovic, 1997; Stanacev, Milic, et al., 2012). Another factor that affects meat quality is the ability to retain water, which in turn affects the taste characteristics of meat (Huff-Lonergan and Lonergan 2005). Increased cooking loss results in decreased moisture content of meat (Lambert, Nielsen, et al., 2001). Based on the information above, this experiment investigates the effect of different levels of raw and processed canola seeds (micronized and super-conditioned) in the final ration on broiler chickens' growth performance and meat quality.

Literature Review

Canola seeds are very similar to canola meal. However, the high oil content in canola seed compared to canola meal causes the seed to dilute other nutrients and anti-nutrients. This can result in the undesirable effects of inhibitors and anti-nutrients being reduced in canola seed (Najib and Al-Khateeb 2004). On the other hand, a study reported feeding broilers for 6 weeks with a diet containing 3-12% canola seeds; no significant difference in body weight gain was observed. However, feed consumption increased, leading to an unfavorable feed conversion ratio (Talebali and Farzinpour 2005). Also, in another study, adding 3-10% canola had no significant effect on broilers' body weight, feed consumption, and feed conversion ratio (Bielecka et al., 2006). Decreased feed consumption is one of the main reasons for reduced growth (Roth-Maier and Kirchgeßner 1988). Increasing the level of canola seed in the broiler diet leads to a gradual decrease in feed consumption (Szymeczko, Topolinski et al., 2010).

Canola contains the enzyme myrosinase, which, If activated during grinding or crushing, acts on glucosinolates and causes their hydrolysis (Kondra and Stefansson 1970). Glucosinolates and their hydrolytic products possess goitrogenic properties. The presence of glucosinolates in diets can cause abnormal thyroid gland activity in animals, resulting in a decrease in the levels of thyroid hormones and an alteration in the ratio between triiodothyronine (T3) and thyroxine (T4) in the blood (Bell, Keith, et al., 1991).

Grain processing is widely used for human and animal consumption (Shiau and Yang 1982, McCurdy 1992). Processing feed components or the entire ration using conditioning methods improves growth performance indicators in broilers (Attar, Kermanshahi et al., 2017; Abdollahi, Zaefarian et al., 2020). Diets containing up to 200 g/kg of low-weight rapeseed meal (RSM) glucosinolates showed no side effects on carcass and breast meat yield or the meat quality of broiler chickens. However, including 180 g/kg of RSM resulted in more adverse changes, including increased meat yellowness, dripping and cooking loss, and a decrease in meat firmness (Mikulski, Jankowski, et al., 2012).

Materials and Methods

To experiment, 1056 one-day-old Ross-308 broiler chickens (mixed sexes) were obtained from the nearest hatchery institution. The chickens were reared under the same diet and conditions until they reached 24 days of age. The room temperature was initially set at 32-35°C when the chickens were introduced. After 3 days, the temperature was gradually reduced by 0.5°C until it reached 20-23°C by the time the chickens reached 24 days. The light schedule for the first three days was 24 hours, followed by 23 hours of light and one hour of blackout until the end of the test period. At 24 days of age, 11 birds with the highest weight uniformity were selected from each experimental unit after removing birds with heavy and light weights. From the age of 24-42 days, the birds were fed experimental diets. The experiment was conducted using a completely randomized design with 16 treatments. Treatment 1 consisted of the control final ration based on the corn-soybean meal.

In contrast, treatments 2-16 replaced three types of canola seed (raw, micronized, and super-conditioned) at five levels (3%, 6%, 9%, 12%, and 15%) in the final ratio. Each treatment had six replications, with 11 chickens in each replication (Talebali and Farzinpour 2005). The experimental rations were adjusted to ensure equal energy and nutrient content. These rations were provided to the birds ad libitum from 24 to 42 days. After the experimental period, which was at 42 days of age, one bird from each pen (a total of 6 birds per treatment) that closely matched the average weight of the pen was selected. These birds were weighed and then slaughtered by cutting the neck between the first and second vertebrae. Subsequently, the birds were dressed. Various measurements were taken at the end of the experimental period, including the weight at the end, daily growth, feed consumption, and feed conversion ratio.

The breast and thigh meat were separated and stored in the refrigerator at 4 degrees Celsius. Subsequently, various measurements were conducted on both the breast and thigh meat, such as loss due to cooling, cooking loss, and water retention capacity. The cooking loss was assessed following Honikel's method (Honikel 1998). Half of the breast muscle was cooked in a plastic bag using a Bain-Marie machine at a temperature of 80 degrees Celsius for 1 hour. After cooling and removing it from the plastic bag, the surface was dried with a napkin and weighed. The cooking loss was calculated using the equation (1) below.

Equation (1): cooking loss = $(\omega 1 - \omega 2) / \omega 1 \times 100$

In Equation (1), $\omega 1$ represents the initial weight of the meat, and $\omega 2$ represents the weight of the meat after cooking.

To measure the water holding capacity (WHC), a method based on measuring the moisture content of the meat sample was utilized, as it is inversely proportional to WHC (Van Laack, Kauffman et al., 1995). Following this method, 3 grams of minced breast meat was placed on Whatman filter paper No. 1. Two plastic plates (talaq) were positioned beneath and on top of the sample, and a 2 kg weight was applied to exert pressure for 5 minutes. After this duration, the meat sample was carefully separated from the filter paper, and the filter paper containing any residual blood was weighed. The percentage of water removed was calculated using equation (2).

Equation (2): water holding capacity = $(\omega 1 - \omega 2) / \omega s \times 100$

In Equation (2), the variables are defined as follows:

ωs - represents the weight of the meat sample (approximately 3 grams minced), $\omega 1$ - represents the initial weight of the Whatman filter paper, and $\omega 2$ - represents the weight of the filter paper after separating the meat.

Therefore, in Equation (2), the calculation of the percentage of water removed takes into account the weight of the meat sample (ωs), the initial weight of the filter paper ($\omega 1$), and the weight of the filter paper after the meat has been separated ($\omega 2$).

The method described by (Disetlhe, Marume et al., 2019) was employed to measure the drip loss. According to this method, the samples were cut and then placed on hooks to cool at 4 degrees Celsius for 72 hours. The loss due to cooling was calculated using Equation (3).

Equation (3): Drip loss = (loss of weight) / (initial meat weight) x 100)

In Equation (3), drip loss is determined by dividing the weight loss by the meat's initial weight and multiplying the result by 100.

The drip loss, cooking loss, and water-holding capacity were calculated for breast and thigh meat at the end of the experimental period. The data obtained for each parameter, including the effects of canola seed processing and the canola seed level in the diet (percentage), as well as their interaction, were analyzed using statistical software (SAS 9.1) and the general linear model (GLM) procedure (SAS 2003).

Statistical comparisons of the means related to each parameter's main effects and interactions were conducted using Tukey's test at a significance level of 5% ($p>0.05$). Linear regression and quadratic analysis were performed for all observations to evaluate the effects of processing and the level of canola seed in the diet (percentage)(Steel and Torrie 1981).

Results and discussion

The impact of canola seed processing type and level on the growth performance indicators of broiler chickens during the final period of 24-42 days is presented in Table 1. The results indicate that the experimental treatments did not significantly affect the 24-day live weight, 42-day live weight, daily weight gain, daily feed consumption, and feed conversion ratio ($p>0.05$). Including full-fat canola seed at levels of 0%, 3%, 6%, 9%,12%, and 15% in the broiler diets did not result in any significant differences in body weight compared to the control group. These findings align with the conclusions of other researchers (Talebali and Farzinpour 2005).

Table 1. Presents the effect of raw and processed canola seed surface in the final diet on the growth performance of broiler chickens aged 24-42 day

Type of processing	Canola surface	Live weight(g) (24-day)	Live weight(g) (42-day)	Weight Gain (g)	Feed intake (g)	Feed conversion ratio(g:g)
Control group		734	2039	68.7	129.7	1.931
Crud	3	708	2057	64.9	131.6	2.147
	6	760	2046	67.3	132.8	1.990
	9	729	2041	68.5	128.3	1.898
	12	734	2074	70.1	126.1	1.805
	15	737	2086	70.6	130.1	1.882
Super-conditioner	3	749	2003	65.4	129.3	1.987
	6	719	2079	71.8	127.9	1.784
	9	723	2062	70.3	133.6	1.929
	12	727	2079	71.3	131.1	1.844
	15	744	2009	67.1	135.1	2.037
Micronized	3	727	2026	68.6	131.1	1.916

6	725	1947	64.2	128.6	2.014
9	729	2141	74.6	137.9	1.853
12	718	2091	72.2	135.5	1.894
15	810	2143	74.5	130.5	1.762
Standard error	16.01	54.39	3.31	3.29	0.105
Significant probability level					
effects of treatment	0.761	0.644	0.574	0.570	0.552
Effects of the type of process	0.466	0.785	0.545	0.373	0.686
Effects of canola level	0.969	0.447	0.230	0.746	0.344
Effects of interrelation	0.387	0.393	0.577	0.333	0.341

It has been reported that the expansion process of canola seed did not significantly impact feed consumption (Breytenbach 2005), which is consistent with the findings of this study. Several studies have indicated that an increase in the level of canola seed leads to a reduction in feed consumption, which can be attributed to the presence of bittering agents such as glucosinolates and phenolic compounds (Roth-Maier 1999, Kocher, Choct, et al., 2001). It has been reported that using a processed mixture of canola seed and corn in a ratio of 50:50 has significantly increased the live weight of broilers (PIK 2011). Conversely, heat treatment through canola seed expansion did not affect body weight (Salmon, Stevens, et al., 1988), which aligns with the results obtained in this experiment.

It has also been reported that including 20% canola meal in the diet did not affect feed intake but significantly reduced body weight gain (Gopinger et al., 2014). Additionally, it has been reported that consuming a processed mixture of canola seed and corn in a ratio of 50:50 increased the feed conversion factor from 2.5% to 3.5% (Salmon et al., 1988; PIK, 2011). Compared to the dry heat treatment of diets containing 20% canola seeds, pelleting and extruding resulted in an improved feed conversion ratio in turkeys fed with this feed until the age of 6 weeks (Salmon, Stevens, et al., 1988). However, this finding does not align with the results obtained in the current experiment. On the contrary, thermal processing through canola seed expansion did not affect the feed conversion ratio. The results obtained in this experiment align with the findings of (Breytenbach 2005). However, it has been reported that incorporating 0%, 3%, 6%, 9%, and 12% of full-fat canola seed in the diet of broiler chickens improved the feed conversion ratio from 22 to 42 days (Talebali and Farzinpour 2005), which contradicts the results of this experiment. The effect of different levels of raw and processed canola seed on the water holding capacity and cooking loss of broiler chickens at the age of 42 days is reported in Table 2. According to the results, the experimental treatments did not significantly affect the loss caused by breast drip loss, breast cooking loss, breast meat water holding capacity, thigh meat cooking loss, and thigh meat water holding capacity ($p > 0.05$). However, the experimental treatments significantly affected the decrease caused by drip loss in thigh meat ($p < 0.05$). Additionally, the losses caused by drip loss in the breast and thigh meat, as shown in Graph 1, were significantly affected by canola seed processing at the ($p < 0.01$) level. The largest effect was observed in the drip loss caused by conditioner processing, while the lowest effect was observed in the raw. Specifically, the drip lost values for breast meat were 12.39 and 8.05, and for thigh meat, they were 10.91 and 14.60, respectively. It has been reported that the loss caused by drip loss is affected by feed (Biesek et al., 2020; Razmaitė et al., 2022), which is consistent with the results of this experiment. Additionally, similar to the findings of this experiment, previous studies have reported that feeding birds with canola seeds does not affect the cooking loss of breast meat (Behnan et al., 2020).

Table 1 presents the effect of raw and processed canola seed surface in the final diet on the meat quality of broiler chickens aged 24-42 days.

Type of processing	Canola surface	Breast Drip loss (%)	Breast water holding capacity (%)	Breast cooking loss (%)	thigh meat drip loss (%)	thigh meat cooking loss (%)	thigh meat water holding capacity (%)
Control group		10.99	81.78	30.15	12.14^{bc}	38.68	80.17
Crud	3	8.86	81.53	28.18	9.74^{c}	44.79	79.15
	6	8.84	81.07	30.62	10.35^{bc}	35.15	80.03
	9	8.29	79.23	35.05	11.61^{abc}	34.10	80.42
	12	8.94	79.94	32.79	10.28^{bc}	40.02	80.91
	15	9.34	81.69	33.29	10.33^{bc}	40.95	79.44
Super-conditioned	3	11.23	81.75	37.03	14.12^{bc}	38.99	81.46
	6	11.10	76.83	31.55	13.59^{abc}	41.95	78.92
	9	10.78	79.46	30.93	12.60^{abc}	39.17	77.96
	12	11.29	80.75	27.04	15.56^{a}	40.82	79.87
	15	10.55	78.15	35.61	15.02^{a}	40/45	78.65
Micronized	3	9.33	80.43	35.02	11.46^{abc}	40.96	80.81
	6	9.89	78.84	32.06	14.76^{a}	40.89	79.70
	9	11.13	79.02	31.93	13.92^{abc}	36.40	75.11
	12	10.06	79.58	33.34	12.28^{abc}	40.22	79.06
	15	10.64	79.08	33.48	12.99^{abc}	41.44	77.42
Standard error		1.89	1.34	3.53	0.82	3.68	1.25
Significant probability level							
effects of treatment		0.070	0.330	0.880	0.002	0.830	0.134

Effects of the type of process	0.001	0.317	0.875	0.001	0.758	0.165
the level of canola	0.419	0.369	0.821	0.920	0.496	0.097
effects of interrelation	0.411	0.529	0.667	0.124	0.770	0.385

During meat production, meat water may be lost due to evaporation or due to drip loss. After cutting the carcass, drip loss becomes a significant factor contributing to water loss. Additionally, several factors, such as the degree of muscle cut, storage method, size of meat pieces, time after slaughter, and the meat's final pH, can influence the lost drip (OFFER 1988). Contrary to the results obtained from this experiment, it has been reported that, in general, thigh meat exhibits lower loss due to drip loss and higher water-holding capacity compared to breast meat. However, it has also been reported that cooking thigh meat results in lower water-holding capacity than breast meat (Northcutt, Foegeding et al., 1994). However, based on the results obtained from this experiment, it has been reported that thigh meat exhibits higher loss due to drip loss and cooking loss and lower water holding capacity compared to breast meat (Amato, Hamann, et al., 1989). Many researchers believe that meat water content is primarily influenced by age and genotype, while the impact of food ingredients is relatively weak (Baéza, Guillier, et al., 2022). Furthermore, it has been reported that different feeding regimens do not affect the loss due to drip loss (Kuźniacka, Biesek, et al., 2020), which contradicts the present study's findings. It has also been reported that food ingredients do not impact cooking loss, which aligns with the results of the present study.

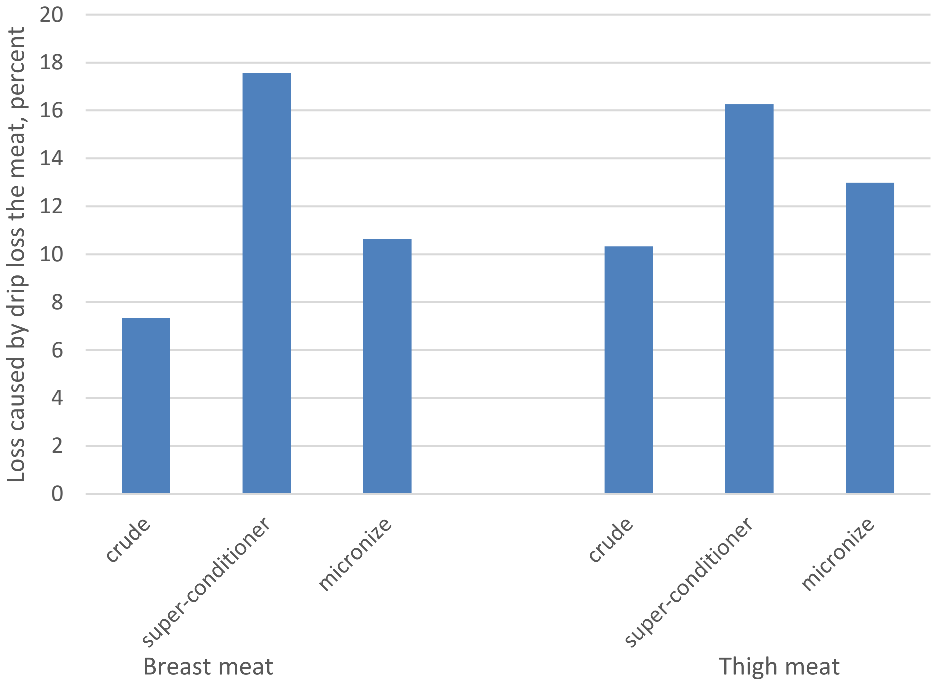

Figure 1. The effect of processing canola seed on the loss caused by drip loss of thigh and breast meat

Conclusion

Including canola seed did not affect weight gain or bird feed intake during the finisher growth period. During the same periods, breast drip loss and thigh meat drip loss were significantly affected by experimental treatments ($P < 0.05$). More research is needed to clarify the response of the chickens when canola seed is used in raw, micronized, or conditioned forms.

Conflict of Interest: The author(s) declared no conflict of interest.

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