

Effect of supplementing refined glycerol in broiler diet on feed production and pellet quality

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ABSTRACT

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The goal of this research was to study the effect of using refined glycerol in broiler diet on feed production and pellet quality. The manufacturing process comprised four experimental groups, each receiving a diet with different glycerol inclusion levels—0%, 2.5%, 5.0%, and 7.5%—formulated using a corn-soybean meal base. Each experimental diet was initially mixed as mash and processed into pellets. Subsequently, measurements were taken for energy consumption, hot pellet temperature, pellet durability index (PDI), bulk density, and pellet hardness. The results showed that the energy consumption of feed production increased with increasing levels of refined glycerol from 2.5 to 7.5%. The addition of refined glycerol in the diet up to 2.5% and 7.5% affected pellet hardness and bulk density. In conclusion, the utilization of refined glycerol in broiler diet resulted in increased energy consumption during the pelleting process. This increase in energy consumption did not have a significant effect on pellet quality, specifically in terms of the pellet durability index. However, increasing of glycerol levels in the diet resulted in significantly reduced pellet hardness and bulk density. The refined glycerol inclusion levels in the diet should not exceed 5% to maintain optimal feed quality and processing characteristics. Therefore, refined glycerol can be considered a viable ingredient in broiler diets without adversely affecting pellet durability. It should be noted, however, that the inclusion of refined glycerol in feed formulation increases energy consumption, which leads to higher electricity usage during feed production.

Keywords: refined glycerol; energy consumption; pellet quality

1. INTRODUCTION

Due to the dramatic increase of oil prices in 2008, the government of Thailand initiated the promotion of alternative energy sources, such as biodiesel, to replace fossil fuels. Glycerol or glycerin is a major byproduct (Ma & Hanna, 1999) in the biodiesel production process. During the biodiesel production process, approximately 10% of crude glycerol is produced as a by-product (Swiatkiewicz &

Koreleski, 2009). It can be refined to obtain 30–45% of refined glycerol depending on the quality of the raw materials. Refined glycerol has many uses in different industries, such as drugs and cosmetics, and it is considered a good energy source for animal feed. The qualities of refined glycerol are suitable for use as feedstuff in poultry diet. McKinney (2009) reported that the use of crude glycerol, at up to 5% of a broiler diet, had no effect on energy usage, but it increased the pellet durability index (PDI). Shield et al.

(2012) reported that supplementing more than 2.5% glycerol required lower pellet temperature, thereby increasing PDI. Groesbeck et al. (2007) conducted three experiments to evaluate the effects of glycerol on production efficiency of a pellet mill. The results showed that supplementation of glycerol consistently improved pellet quality, but did not affect the production rate; however, glycerol decreased total energy usage (KWh/t). Although glycerol can be used in the pharmaceutical, cosmetic, and food industries (Thompson & He, 2006), another possible use for glycerol is as a component of animal feed. Sriboonyong et al. (2025) reported that the inclusion of pure glycerol at up to 5% as an alternative energy source in the diet of broilers did not negatively impact production performance. The purpose of this study was to determine the effects of supplementation of refined glycerol in broiler diet on pellet production and pellet quality.

2. MATERIALS AND METHODS

2.1 Preparation of pelleted diet

The manufacturing process involved grinding, batching, mixing, heating or conditioning, pellet shaping, and packaging. The four experimental groups had varying glycerol levels: 0%, 2.5%, 5.0%, and 7.5%, with glycerol incorporated into a base diet of corn-soybean meal during the mixing stage. Each experimental diet was mixed into mash form before being compressed into pellets. The pellets were conditioned using moist heat at 80°C, until a steady-state temperature was reached. Steam pressure at the gauge was maintained at 262 kPa (38 psi) during conditioning and compression. Pelleting was performed using a die with a 50:3.0 die ratio and a 125-horsepower pellet mill (SZLH40 model; Jiang Zhengchang, China).

2.2 Feed milling and physical properties of pelleted diet

The target pelleting temperature was 80°C. If the inclusion of a high level of glycerol affected the feed production, the condition of the pelleting was adjusted to obtain good feed production and pellet quality. Hot conditioning mash samples and hot pellet samples were collected immediately after the conditioner and the pellet die, respectively, and placed into an insulated container equipped with a thermometer to measure the pellet temperature. After cooling, the pellets were collected to measure pellet quality. The PDI was used, utilizing a tumbling box according to ASAE Standard S269.3 (ASAE Standard, 1989) for standard PDI. Electrical current (A) was measured at the main drive using a recording power clamp meter (Model 5330A, BK precision electronic test instrument, Yorba Linda, CA) to calculate the energy consumption (Tuominen et al., 2014).

3. RESULTS AND DISCUSSION

3.1 Feed milling and physical properties of pelleted diet

From a previous study on supplementing glycerol in various levels of broiler diet, it was found that when increasing glycerol in diet, the temperature for conditioning and pelleting must be reduced. This is because the use of high conditioning and pelleting temperatures (approximately 80°C) can cause the diet to adhere to the pellet die.

Therefore, in this experiment, conditioning and pelleting temperatures were adjusted in formulations containing glycerol to ensure proper pelleting of the diet. Energy consumption increased during the production of feeds supplemented with of 2.5%, 5.0%, and 7.5% refined glycerol compared with the control group (Table 1). The increase in energy consumption during the pelleting process was attributed to the reduction of pelleting temperature caused by the addition of glycerol in the diet.

Interestingly, a cubic response trend was observed regarding the amount of glycerol supplementation in the diet. Specifically, the level of 2.5% glycerol supplementation resulted in the highest energy consumption during the pelleting process (Table 1). Amornthewaphat and Chatakanonda (2006) reported that increasing the temperature during pellet pressing resulted in a decrease in electricity current and energy usage during the pellet pressing process. This was due to the increase in temperature from steam conditioning, which causes the steam, acting as a source of heat and moisture, to serve as a lubricant that reduces friction during the pellet pressing process. Therefore, higher conditioning temperatures can lead to lower pellet temperatures due to the lubricating effect of steam, as observed in the experiment with refined glycerol in broiler diet. In this experiment, the amount of steam provided during the pelleting process affected the pelleting temperature, which decreased as the amount of glycerol increased. The amount of steam added to the pelleting process dropped in tandem with the drop in pelleting temperature. As a result, there was less moisture, which serves as a lubricant during the pelleting process, which raised the energy needed for the operation. Consequently, energy usage went up. This aligns with McKinney (2009), who investigated the effect of supplementing glycerol in pig feed on the efficiency of pellet feed production. Glycerol supplementation was done at levels of 0, 3, 6, and 9%, with pelleting temperatures set at three levels: 65, 77, and 88°C for all feed formulations. It was found that supplementing glycerol did not statistically significantly increase the electricity usage in production. However, there was a curvilinear response trend of energy consumption in production to the amount of glycerol supplemented in the feed. The highest energy consumption in production was observed at the 6% glycerol supplementation level. This contradicts the study by Groesbeck et al. (2008) regarding the supplementation of crude glycerol in corn-soy based diet for pelleting efficiency. In their study, pelleting temperature was set at 65.5°C, using a die thickness of 31.8 millimeters, and die orifice size of 3.96 millimeters. It was found that glycerol supplementation at levels of 3% and above in the feed formulation increased the production rate (t/h) and decreased the electricity consumption during production. This corresponds to the experiment conducted by Madrid et al. (2013), which investigated the supplementation of crude glycerol in pellet pig feed. They supplemented glycerol in feed at levels of 0, 2.5, and 5.0% and found that the energy consumption during production decreased with increasing levels of glycerol in the feed. However, a difference between this research and the study by Groesbeck et al. (2008) is that this experiment did not set a constant pelleting temperature at every level of glycerol supplementation. During pelleting process, the temperature was adjusted to facilitate the pelleting process, leading to changes in energy consumption in production in response to temperature variations during pelleting.

There was a decrease in temperature of hot powder in the production of broiler chicken feed with glycerol supplementation levels at 5.0 and 7.5%, compared to the control group and 2.5% of refined glycerol. This reduction was due to the lower temperature used for conditioning and pelleting, resulting from temperature adjustments to facilitate the pelleting process (Table 1). This led to a decrease in the temperature of the hot pellets, which is consistent with the experiment by Groesbeck et al. (2007), who studied the effects of glycerol supplementation in feed on pellet quality by supplementing glycerol in pig feed at

levels of 3, 6, 9, 12, and 15%. They found that it improved the quality of pellet in terms of appropriate pellet size, pellet hardness, and a statistically significant reduction in the percentage of fines in the feed ($p < 0.05$) compared to the control group. This also aligns with Shield et al. (2012), who found that using glycerol as a substitute for corn at levels of 2.5 and 5.0% in nursery pig feed resulted in a decrease in pellet temperature with an increase in the amount of glycerol in the feed formula due to the reduced pelleting temperature.

Table 1. Manufacturing data of broiler diet

Manufacturing data	Level of glycerol (%)				SEM	<i>p-value</i>
	0	2.5	5.0	7.5		
Energy consumption (kWh/t)	3.14 ^c	3.53 ^a	3.29 ^b	3.52 ^a	0.0054	<0.001
Gage temperature (°C)	82 ^a	75 ^b	64 ^c	63 ^c	0.4639	<0.001
Hot mash feed temperature (°C)	37.0	38.5	38.5	38.5	0.2819	0.2303
Hot pellet temperature (°C)	82.56 ^b	87.73 ^a	66.70 ^c	66.37 ^c	0.2407	<0.001

When considering the quality of the pellets, it was found that supplementing glycerol in the feed led to a reduction in pellet hardness (Table 2). It was observed that feed supplemented with glycerol at levels from 2.5% and above, when tested for hardness using a Kahl hardness tester (Thomas, 1998), did not break apart or crumble; it tended to crack and exhibit a flattened appearance due to incomplete pelleting resulting from the glycerol not mixing well with oil. This is consistent with Sanyang et al. (2015), who found that the addition of glycerol to starch increased moisture content. This is because the hydroxyl groups in glycerol form hydrogen bonds more effectively with water molecules, which allows glycerol to retain water within the matrix more efficiently. As a result, the hardness of the pellets decreased.

Glycerol supplementation had no impact on the PDI of the pellets. However, when the bulk density of the mash

feed was measured, it was found that supplementing glycerol in the feed at 7.5% significantly reduced the bulk density compared to the control group and glycerol supplementation at levels of 2.5 and 5.0%. Additionally, there was a linear response in the bulk density of the feed to increasing levels of glycerol supplementation. This was likely due to the fact that the moisture content in feed pellet components increases during the manufacturing process, which results from the incorporation of glycerol into the diet. During pelleting, glycerol is thoroughly mixed with the feed ingredients and becomes embedded within the pellet matrix (Mader, 2008). The moisture evaporates as the feed cools, leading to the formation of gaps between the particles and a subsequent reduction in bulk density. This suggests that higher levels of glycerol supplementation lead to a decrease in the bulk density of the feed, indicating potential changes in feed composition or packing efficiency.

Table 2. Supplementation of glycerol on pellet quality

Pellet quality	Level of glycerol (%)				SEM	<i>p-value</i>
	0	2.5	5.0	7.5		
Hardness (kg. Force)	1.57 ^a	1.21 ^b	1.22 ^b	0.88 ^c	0.0316	0.0005
PDI (%)	55.10	54.46	55.06	56.07	0.5441	0.9055
Density (g/L)	622.84 ^a	620.08 ^a	619.77 ^a	588.09 ^b	0.8026	<0.001

4. CONCLUSION

Based on the findings of this study, the optimal inclusion level of refined glycerol in broiler diets is 5%. Compared with 2.5% and 7.5%, the 5% level resulted in lower energy consumption, as well as improved pellet hardness and bulk density, relative to the 7.5% level.

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AUTHOR CONTRIBUTIONS

Y.R. and S.A. conceived the project, The main conceptual ideas and design the study. P.S. and Y.R. performed the experiments and analyzed the data. P.S. wrote the original draft. Y.R. and S.R. reviewed and edited the paper. Y.R. provided project administration and resources.

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