

The effects of broiler chickens diet containing Fermented Pineapple Peel Meal (FPPM) on the performance and Income Over Feed and Chicken Cost (IOFCC)

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ABSTRACT: The research herein aimed to compare the supplementation of fermented pineapple peel meal (FPPM) at different levels in broiler diets on the performance and income over feed and chicken cost (IOFCC). A total of 400 male broiler finishers with 1-day-old chick (Cobb-500 from 38-week-old breeders) were used in this experiment, divided into four treatment groups, and kept until the birds' final body weight reached 1.5 kg (market size). The FPPM was then incorporated into the experimental diets treatment at; T1 = 100% Commercial feed + 0% FPPM; T2 = 95% Commercial feed + 5% FPPM; T3 = 90% Commercial feed + 10% FPPM; T4 = 85% Commercial feed + 15% FPPM. The study was conducted in a completely random design (CRD), and the treatments were replicated four times each. Parameters were evaluated: feed intake, initial weight, final weight, average daily gain (ADG), body weight gain (BWG), feed conversion ratio (FCR), and IOFCC. Data were analyzed by analysis of variance (ANOVA), and Duncan's multiple range tested was used for mean comparisons. The results showed no significant differences ($P>0.05$) in the initial weight and ADG starter; Offered FPPM in the chicken diet significantly ($P<0.05$) increased feed intake; and showed highly significant differences ($P<0.01$) in the final weight, ADG finisher, BWG, and FCR. Therefore, it can be concluded that FPPM might be mixed up to 5% without any significant adverse effects on growth performance and improved the IOFCC. However, 15% of FPPM showed the highest IOFCC in any sales type compared to the control diet treatment.

Keywords: pineapple peel; fermented; broiler chicken; performance; IOFCC

Introduction

The livestock industry is a crucial component of its agricultural sector, contributing significantly to the country's economy and food security. The livestock industry produces various livestock products such as poultry, swine, cattle, and buffalo. The livestock feed business market is a source of competition for conventional ingredients. This competition drives up the price of final goods, affecting both feed quality and production costs. The use of agro-industrial wastes can be one of the options to decrease production costs. In Indonesia, one of the potential agro-industry wastes is pineapple peel. According to data from the Central Bureau of Statistics of Indonesia, the fruit production of pineapple in 2021 was 2,886,417.00 tons. Pineapple peel has relatively good nutrition, with 88.95% dry matter (DM), 8.78% crude protein (CP), 27.09% crude fiber (CF), 1.15% ether extract (EE), and 3.83% ash (Nurhayati, 2013). However, pineapple peel is wasted in pineapple fruit processing, which has not been well used for poultry. Due to its high CF content (27.09%) and low CP level (8.78%), pineapple peel cannot be used as poultry

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feed. As a result, we need to find treatments to be applied to the peels that can assist with decreasing crude fiber levels while raising crude protein levels.

Fermentation is a metabolic process that produces chemical changes in the organic substrates due to the breakdown of the material content. These changes can be in the form of pH, moisture, smell, and changes in nutritional value. It has been reported that significantly improved nutritional value through the fermentation of pineapple peel. It is well known that this has the potential to improve the sustainability of animal production significantly (Apedro et al., 2023). In a previous study by Lamidi et al. (2008), broilers could consume up to 10% of pineapple waste without adverse effects. The fermentation process will increase the protease enzyme, which breaks down protein in food into amino acids. Nurhayati (2013) reported that giving fermented feed at a level of 15% did not increase the weight gain of chickens. Hence, adding fermented feed containing lactic acid makes the feed digestible. However, the provision of fermented feed at a level of 15% does not affect the growth performance of chickens.

Income Over Feed and Chicken Cost (IOFCC) is a measure of profitability commonly used in the poultry industry to evaluate the financial performance of a poultry farm. IOFCC is calculated by subtracting the revenue from the total cost of feed and chick (Zulfan et al., 2021). A higher IOFCC indicates better profitability, while a lower IOFCC indicates lower profitability. Besides the use of feed supplementation from the agro-waste industry, one of the factors that might influence the IOFCC is the type of chicken sales. There are several types of chicken sales, which vary depending on the purpose of the sale and the kind of chicken being sold; hot carcass, market carcass, and live chicken sales, but there may be other types depending on the specific needs of the market.

Assuming fermented pineapple peel meal (FPPM) is acceptable and easily digested, it could be an additive in animal formula feed. This study was carried out to examine the effect of feeding FPPM on broiler performance and IOFCC. The studies indicate the hope of increasing farmers' knowledge regarding the utilization of FPPM in recovering feed additives through fermentation in order to lower production costs and improve environmental sustainability and utilization in animal feeds.

Material and methods

Materials and Experimental Design

This research was conducted at the Animal Science farm, Khon Kaen University, Khon Kaen, Thailand. The experiment involved 400 male broiler 1 Day-Old chicks (Cobb-500 from a 38-week-old breeder), who were split into four treatment groups and kept until the birds' final body weight reaches 1.5 kg (market size), chicks will be raised in a floor pen close-side home with a uniform floor, feeder and waterer space. The broiler starter and finisher diets were fed ad libitum to the birds from 1 to 20 and 21 until slaughter days of age, respectively. Uniform management schedules were followed for all birds.

Parameters were evaluated: feed intake, initial weight, final weight, average daily gain (ADG), body weight gain (BWG), feed conversion ratio (FCR), and IOFCC. The experiment was assigned to a Completely Randomized Design (CRD) with four treatments and four replications (25 chicks/replication). Data were analyzed by analysis of variance (ANOVA), and Duncan's Multiple Range Test tested the significant effect.

The FPPM was then incorporated into the experimental diets treatment at;

T1 = 100% Commercial feed + 0% FPPM

T2 = 95% Commercial feed + 5% FPPM

T3 = 90% Commercial feed + 10% FPPM

T4 = 85% Commercial feed + 15% FPPM

(the proximate analysis of the treatment's meal is presented in **Table 1**).

Table 1 The chemical composition of FPPM diet treatments

Nutrients	Treatments				
	T1	T2	T3	T4	Starter
Dry matter (%)	88.77	89.55	89.29	89.09	89.68
Crude protein (%)	18.73	18.59	18.54	17.63	22.19
Crude fiber (%)	2.43	2.46	2.78	3.92	1.61
Ether extract (%)	4.07	3.45	3.18	4.30	3.68
Ash (%)	6.63	6.60	6.53	7.52	6.53
Gross energy (kcal/kg)	4194.40	4119.68	4129.62	4106.01	4087.00

FPPM (fermented pineapple peel meal).

Fermentation of pineapple peel meal

Fresh pineapple peels were provided from fruit stores in the Khon Kaen University area, Khon Kaen, Thailand. Then it was cleaned and fermented in a black plastic container with a 15kg capacity. According to Apedro et al. (2023), fermentation was carried out anaerobically and opened three days after that, dried at 60°C for 24 hours, and ground into pellet size using a chopper machine (Hammer mill Retsch SK1, GmbH, Haan, Germany). In a previous study by Apedro et al. (2023), fermented pineapple peel had 88.36% DM, 8.14% CP, 13.62% CF, 5.56% ash, 1.15% EE and 3.98 pH.

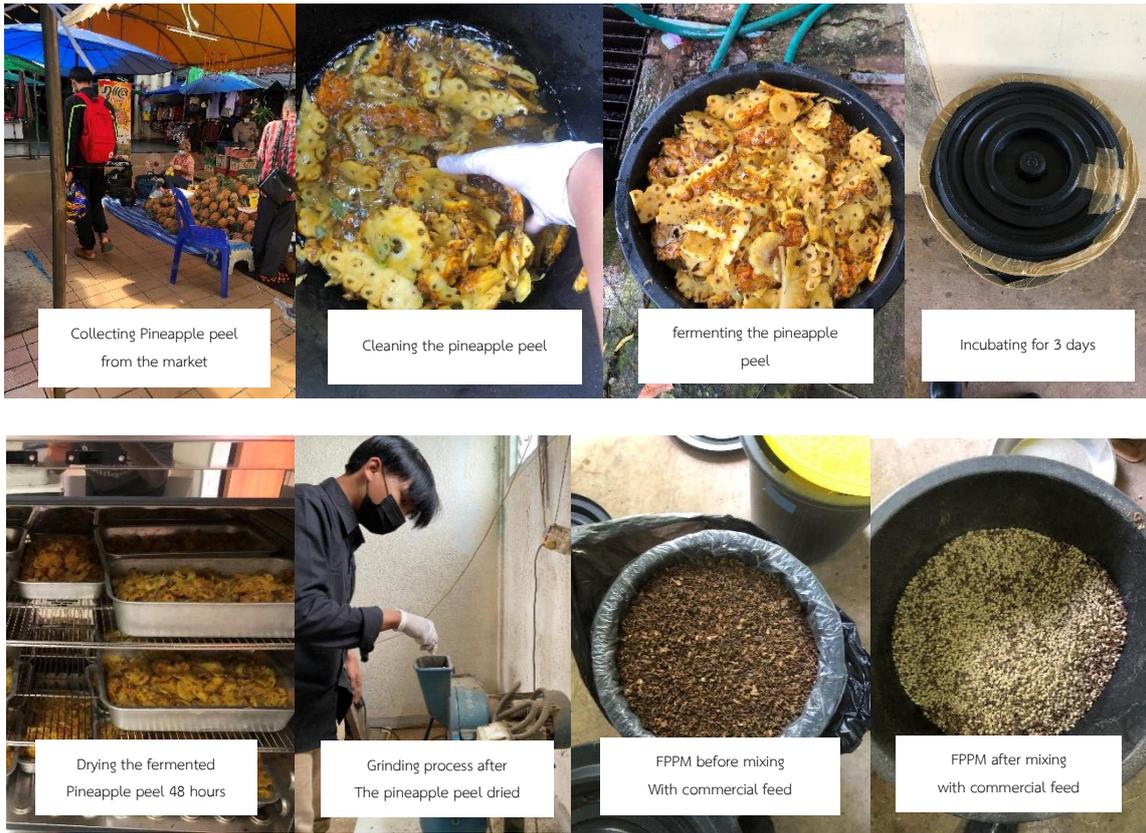


Figure 1 The fermentation of pineapple peel meal process

Growth Performance

Initial weight, final body weight (FBW), body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR), mortality, and survival rate (SR) will be recorded throughout the experiment.

Body weight gain (BWG) (g/h/d)

$$BWG = \frac{\text{Finished weight} - \text{start weight}}{\text{Number of chickens}}$$

Feed intake (FI) (g/h)

$$FI = \frac{\text{Offered feed} - \text{refused feed}}{\text{Number of chickens}}$$

Feed conversion ratio (FCR)

$$FCR = \frac{\text{Feed intake (kg)}}{\text{Body weight gain (kg)}}$$

Income over feed and chicken cost (IOFCC)**Feed cost (FC) (Baht/head)**

$$FC = \text{Feed intake (kg)} \times \text{Feed price (Baht/kg)}$$

(Price of feed 18.8 Baht/kg) (Aug. 23, 2022)

Salable bird returns (SBR) (Baht/head)

$$SBR = \text{Price of the chicken (Baht/kg)} \times \text{BW (kg)}$$

(Price Hot carcass 55 Baht/kg; Market carcass 50 Baht/kg; Live chicken 46 Baht/kg) (Sept. 27, 2022)

IOFCC (Baht/head)

$$IOFCC = (((\text{Final weight} \times \text{selling price/kg}) - (\text{Chick cost} + \text{Feed cost} + \text{FPPM cost})) / (\text{live weight})) \times \text{Liveability}$$

Source: (Veneranda et al., 2013)

(Price of FPPM 5 Baht/kg)

Data assessment

The data were analyzed using a completely randomized design (CRD) that was employed in a one-way analysis of variance, and Duncan's multiple range test was used to assess significant differences (Snedecor and Cochran, 1967). The significance levels used for all statements of differences were 1% and 5%. SAS performed an analysis of the observed data, and Duncan's multiple range test looked for significant differences across treatments.

Results and Discussion

The results (**Table 2**) showed that final weight, ADG Finisher, BWG, and FCR were highly significant ($P < 0.01$) affected by dietary treatments. However, the feed intake in this study showed a difference ($P < 0.05$); the 0% FPPM had the highest feed intake, and the 15% FPPM had the lowest. Initial weight and ADG starter period showed no significant difference ($P > 0.05$) among the treatments. No significant difference in the initial weight means all chicks are uniform before the treatment is applied. Aligned with Mandez et al. (2011), the most crucial elements of the broiler production process are flock uniformity and the size and weight of the birds on their first day of life. However, several factors determine the initial weight, including fasting time, nutrition, and environmental temperature during the first few days of life.

Table 2 Effects of FPPM in the diet on the growth performance of broiler chickens (1-slaughter day)

Variable	Treatments				SEM	P-values
	0% FPPM	5% FPPM	10% FPPM	15%FPPM		
Initial weight (g/h)	42.99	43.43	42.69	43.91	0.82	0.74
Final weight (g/h)	1618.00 ^a	1585.70 ^{a-b}	1558.10 ^{b-c}	1536.00 ^c	11.02	<0.01
Feed Intake (g/h/d)	89.84 ^a	89.43 ^{a-b}	89.49 ^{a-b}	89.07 ^b	0.16	0.04
ADG starter (g/h/d)	67.83	68.43	70.79	69.78	0.88	0.13
ADG Finisher (g/h/d)	142.67 ^a	133.94 ^b	136.24 ^b	133.86 ^b	0.94	<0.01
BWG (g/h)	1575.01 ^a	1542.28 ^{a-b}	1515.41 ^{b-c}	1492.09 ^c	11.17	<0.01
FCR	1.78 ^c	1.81 ^{b-c}	1.84 ^{a-b}	1.86 ^a	0.01	<0.01

FPPM (fermented pineapple peel meal); g/h/d=gram/head/day; ADG (Average daily gain); BWG (body weight gain); FCR (feed conversion ratio); ^{a-b-c} Means in the same row with different superscripts differ significantly (P<0.05).

Increased levels of pineapple peel in the diets significantly reduced (**Table 2**; P<0.05) the final weight and feed intake. The final weight in this study ranged from 1536.00 to 1618.00 g/h/d, and the consumption of rations in this study ranged from 89.07 to 89.84 g/h. The lowest feed intake was found in 15% FPPM treatment, and consumption decreased when the chicks became full quickly caused by bulky food substances such as fiber. The desire of chicks to consume the ration fell, giving the impact its final weight. The type of feed affects broiler growth performance and organ development. Pelletizing It is known to reduce the feed's particle size and alter the feed's structure. Pelletizing the feed may therefore change the response of broilers to fiber content. A similar trend was seen in the final weight; the 15% FPPM treatment had the lowest final weight. In contrast, a report by Rafiu et al. (2022) found that 60% pineapple waste supplementation for wheat offal in cockerel diets has no significant difference (P>0.05) in the final weight of the chicken. It has been established that poultry is generally less efficient at digesting fiber than ruminants (Joyce et al., 1971; Mateos et al., 2012). However, including moderation of different fiber sources in the diet, as has been established through research conducted in recent years, enhances digestive organ development (González-Alvarado et al., 2007; Hetland et al., 2005; Hetland and Svihus, 2007). The majority of studies showed variations in body composition after the fattening period (Fontana et al. 1993; Saleh et al. 2005; Mohammadalipour et al. 2017).

The difference in ADG and BWG Finisher results (**Table 2**; P<0.01) in these studies can be determined by the levels of FPPM factors in diet ingredients. In line with earlier findings, several factors influenced weight gain, including age, the levels of probiotics, diet ingredients, feed form, and interaction with environmental factors (Khan et al., 2011). Poultry diets containing fermented pineapple peel meal may affect organ weights. Affecting organ weight also affects ADG and BWG. In this study, fermented pineapple peel meal supplementation in diets decreased body weight gain. The difference could be the result of an unbalanced diet's nutrient composition, including its protein content and crude fiber (Mandey et al., 2017). As supported by a previous study by Jaeger et al. (1998), pineapple contained tannins and pectins, which affect growth, such as BWG. The type of ration used, the environment, and the strain of chicken all have an impact on broiler weight gain. Moreover, the consumption of feed and fulfilling the broiler's nutritional needs are two aspects that affect body weight gain in broilers. Chickens'

ability to gain body weight is significantly influenced by the quantity and quality of the feed they consume. (Baye et al. 2015; Ali et al. 2019).

The consumption of feed and the fulfillment of the broiler's dietary needs are indeed the factors that determine the broiler's weight gain. The fermented pineapple peel meal supplement reduces feed consumption, which impacts the chicken's weight gain, especially in the 15% FPPM treatment, the lowest weight gain compared with other treatments and the highest crude fiber contents in the diet. These results provide relevance to previous research by Janssen and Carré (1985) and Sklan et al. (2003), which found that an increase in the diet's CF content decreased performance. Additionally, body weight gain is always directly proportional to feed consumption; the higher the weight, the higher the feed intake level (Moreno et al., 2009). However, it is essential to provide a balanced diet that meets the nutrient requirements of the chickens to ensure optimal growth and body weight gain. Inadequate or imbalanced diets can lead to reduced feed intake, poor growth, and low body weight gain.

The feed conversion ratio (FCR) showed a significant increase (**Table 2**; $P < 0.01$) in the levels of fermented pineapple peel meal compared to the control feed, which was 0% fermented pineapple peel meal supplementation. Supported by the previous research using Rapeseed meal, fermented with *Lactobacillus fermentum* and *Bacillus subtilis*, enhanced the feed conversion ratio (FCR) and weight gain of broiler chicks in feeding trials (Chiang et al., 2010). The increased FCR values in this study were due to the associated increased palatability and decreased body weight of the chickens, thus increasing the FCR values. Therefore, the increased palatability of the FPPM diets should not be more debatable. The processing method used to prepare the FPPM can also affect its palatability. If the peel is properly cleaned, dried, and ground, it can be more palatable and easier for animals to digest. In general, the palatability of the birds to the ratio is inversely associated with body weight gain (Ibrahim et al., 2020). The best FCR values in this study were found in the control treatment (1.78), while the 15% FPPM treatment had the highest FCR (1.86) among the other FPPM diets treatments. According to research, a well-managed system should range between 1.9 and 2.15, depending on the nutritional composition of the broiler and feeding management (Kamran et al., 2008). The previous study by Ibrahim et al. (2020) found a higher FCR compared with this study of 1.88 and 2.09 in the 15% and 22.5% supplementation of FPPM-containing medicinal weeds in a broiler's diet, respectively. A similar finding with this study was that offering 15% of pineapple peel to the chickens did not increase feed consumption and conversion ratio (Nurhayati, 2013). One factor that could influence a farm business's profitability is the FCR values, particularly for broilers. The higher the FCR values, the lower the index performance efficiency, and the lower the FCR values, the more profitable the broiler production. Additionally, compared to broilers fed on non-fermented control diets, broiler performance improved when fed fermented feedstuffs, such as *Aspergillus oryzae* fermented soybean meal (Feng et al., 2007; Mathivanan et al., 2006) and lactobacilli-fermented wheat and barley (Skrede et al., 2003).

Table 3 Effects of FPPM in the diet on the live chicks sales type in IOFCC of broiler chickens

Variable	Treatments			
	T0	T1	T2	T3
Live chicken sales type				
Salable price (baht/head)	74.43	72.94	71.67	70.65
Total feed cost (baht/head)	54.05	51.11	48.45	45.55
IOFCC (baht/head)	4.26	4.82	5.33	6.18
Hot carcass sales type				
Salable price (baht/head)	78.95	75.36	75.68	74.68
Total feed cost (baht/head)	54.05	51.11	48.45	45.55
IOFCC (baht/head)	7.05	6.35	7.91	8.80
Market carcass sales type				
Salable price (baht/head)	79.71	76.50	76.83	75.69
Total feed cost (baht/head)	54.05	51.11	48.45	45.55
IOFCC (baht/head)	7.52	7.06	8.65	9.45

FPPM (fermented pineapple peel meal); IOFCC (Income over feed and chicken cost).

Table 3 describes the effects of FPPM in the diet on the IOFCC of broiler chickens. The results found that in live chicken sales type, the supplementation of FPPM at all treatments showed a decrease in the salable price (baht/head) of 72.94, 71.67, and 70.65 baht/head in T2, T3, and T4, respectively, when compared with the control 0% FPPM. Feed costs ranged from 45.55 to 54.05 baht/head. However, the result showed that the groups fed with supplementation of FPPM had the highest IOFCC.

In the hot carcass sales type variable (**Table 3**), the results found that supplementation of FPPM at all treatments showed decrease the salable price (baht/head) of 75.36, 75.68 and 74.68 in T2, T3 and T4, respectively when compared with control 0% FPPM. Feed cost ranged from 45.55-54.05 Baht/head. The highest IOFCC results was 15% FPPM treatment, while the lowest was control 0% FPPM treatment.

Moreover, **Table 3** in the market carcass sales type describes that supplementation of FPPM at all treatments decrease in the salable price (baht/head) of 76.50, 76.83 and 75.69 in T2, T3 and T4, respectively when compared with control 0% FPPM. Feed cost ranged from 45.55-54.05 Baht/head. However, the highest income was 15% FPPM treatment, while the lowest was control 0% FPPM treatment.

Income over feed and chicken cost (IOFCC) indicates the economic benefits return. The supplement of 15% FPPM showed an increase in benefits return (**Table 3**) compared with other treatments, while the lowest benefits return (**Table 3**) was the control treatment on live chicks sales type. However, the live chicken sales type showed

the lowest benefits amongst all the sales types, thus representing that there are marketing risks in chicken's live sales type because of unclear market access buyers, the low selling price, and the uncertain appointment time. The selling price can depend on the birds' breed, age, quality, and demand for a live chicken. Live chicken sales can be a profitable enterprise, especially if there is high demand. Additionally, the timing of chicken sales has to be planned in order to avoid the increasing number of days that broilers are reared. If it's happened, the feed has increased, affecting the poultry industry's income (Kurniawan et al., 2017; Singh et al., 2010). In line with previous research by Cobanoğlu et al. (2014), another factor contributing to the higher expenses is the longer slaughter age in the organic production system (81 days vs. 42 days) and the additional feed needed for these older chickens. Those studies show that feed costs were the most significant factor in overall variable costs across all sale types. In this study, the highest IOFCC was noted in the market carcass sale types with a 15% supplementation of FPPM. Both hot carcass and market carcass sale types have fixed market prices. Selling chickens at market price can gain access to a broader range of customers, including retailers, wholesalers, and individual consumers. It can help to expand the customer base and increase the sales volume. However, broiler carcass percentages range from 65-75% of body weight; the heavier the chicken is cut, the higher the carcass percentage (Jackson et al., 1982; Ralahalu et al., 2020).

Many variables, including final crop characteristics (brand name and product quality), feed price, climate considerations, and the genetic lines employed, might affect the cost of broiler production (FAO, 1999). Dziwornu (2013) examined the impact of feed costs on broiler production. The findings show that applying efficient feed management approaches may reduce feed costs, and make broiler production more profitable. Feed supplementation in broiler production can be considered a part of feed management. High voluntary feed intake produces high feed costs, contributing approximately 70% of production costs (Ralahalu et al., 2020). The earlier findings by Ariana et al., 2018 observed the same trend in the supplementation of fermented dragon fruit peel in a diet, which increased the IOFCC of broiler chicken. The results indicate that the improvement of IOFCC is in line with the level of FPPM in diets. The increase in IOFCC could be due to different diet compositions and the level of FPPM. Overall IOFCC showed that the groups fed with supplementation of FPPM had higher economic benefit return in all the sale types. The increase of the IOFCC between the control diets with the 15% supplementation of FPPM treatment. Similarly, Mandey et al., 2017 reported that using a fed diet containing 15% of fermented pineapple waste meal improved the 18.90% IOFCC from the control diet.

Conclusion

It can be concluded that FPPM could be mixed up to 5% without any significant adverse effects on final weight, feed intake, body weight gain, FCR, and improved of IOFCC. However, 15% of FPPM showed the highest IOFCC in any sales type return compared to the control diet treatment. The implication of the treatments, FPPM supplementation, could be an alternative feed treatment for farmers and broiler meat producers. However, a further comprehensive study should be conducted on the effects of FPPM supplementation in the diet of native chickens and laying hens on the performance, IOFCC, carcass, and meat quality components to meet the preferences of farmers, industries, and consumers.

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