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Palm kernel meal as a basal diet for molt induction in commercial laying hens

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ABSTRACT

Induced molting is a process that stimulates natural molting events. When birds return to full feed, a new plumage develops and the birds resume egg production at a higher rate with better egg quality. Induced molting extends the productive life of commercial chicken flocks and results in substantial reduction in the number of chickens needed to produce the nation's egg supply. However, molting induced by feed withdrawal (FW) cause discomfort and stress in hens. This study involved feeding palm kernel meal mixed with layer ration at different ratios to hens to determine their ability to induce molt. The treatment ratios were 90% palm kernel meal and 10% layer ration (PKM90), 80% palm kernel meal and 20% layer ration (PKM80) and 70% palm kernel meal and 30% layer ration (PKM70). In addition, a fully fed (FF) nonmolted control and a FW negative control were used. Results show that the highest percentage of body weight loss was in FW (23.96%) molted hens during 12-d molt induction period, but their differences with palm kernel meal molted hens were not significant. Also different levels of palm kernel meal in diet were equally effective as feed withdrawal in causing ovary weight regression in birds. Feeding 90% palm kernel meal in diet during molt period significantly improved post molt egg laid quality similarly to FW. Molted hens induced by palm kernel meal exhibit postmolt levels of egg production over a twelve week period that were significantly more than hens molted by feed withdrawal ($P < 0.05$). Palm kernel meal is an insoluble, high fiber feedstuff that can be used as a viable alternative to conventional FW methods for induced molting program of commercial laying hens.

Key words: Molting, Palm kernel meal, Egg quality, Egg production, Laying hen

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INTRODUCTION

In nature, all adult avian species undergo annual bird molting to renew their feathers. This results in BW losses up to 40% of their mass and a pause in oviposition due to regression of the reproductive tract [21]. In commercial systems, this process is often induced in older egg laying hens to increase egg production and egg quality. Although there are several molting methods, feed withdrawal (FW) has been the most popular due to ease of application, economic benefits, and agreeable postmolt performance [16, 4]. It is becoming more apparent that an alternative to this approach is needed because public awareness of bird stress due to feed deprivation molt induction has increased over the years [27]. In addition, researchers [15] suggest that molting by feed deprivation leads to greater intestinal colonization by Salmonella enterica subspecies enterica serovar Enteritidis (S. enteritidis). Researchers have attempted to find alternatives to feed deprivation that would still provide the same economical benefits to producers while improving the health and stress levels of the animals.

General dietary modification strategies have involved constructing diets that are deficient in some nutrients such as sodium [6] or contain an excess of a particular compound such as zinc [4]. However, such diets have yielded inconsistent results, are costly, and can cause negative behavior such as cannibalistic pecking [36, 7]. Low calcium diets have also been used; however, ovary and oviducts did not regress to a nonproductive state, and production did not cease completely and has been shown to cause osteoporosis and temporary paralysis [36]. Recently, the use of insoluble plant fibers have been investigated and successful alternative molt induction diets have been developed from jojoba meal [33], wheat middlings [29], grape pomace [16], cottonseed meats [9] and alfalfa [18, 10]**.**

Palm kernel meal is defined as what is left after oil extraction from the meat of the palm nuts. There is an economic incentive to investigate the use of palm kernel meal in broiler diets in four regions of the world (Asia, Pacific, South America and Africa) due to its cost effectiveness, compared to conventional feedstuffs [31]. Palm kernel meal production is one of the fastest growing processed feedstuff markets [30].

Palm kernel meal is aflatoxin free, palatable and has considerable potential as a carbohydrate and protein source [31]. Chemical analysis of these feedstuff shows that their nutrient contents and qualities rang widely, depending upon how well the oil extraction process has been done, materials, storage condition and the amount of shell content removed [30]. Palm kernel meal protein content is in the ranges of 13 to 22% [32, 23]. Due to low concentration of several essential amino acids such as: lysine, methionine and tryptophane and possibly due to heat damage, their protein digestibility is low (60%) [23]. A detailed description of the carbohydrate fraction in PKM has been reported by Knudsen (1997). This author found that total carbohydrate of palm kernel meal, excluding lignin, was about 50%, of which only 2.4% was of low molecular weight and 1.1% was starch while the rest (42%) was in the form of non-starch polysaccharides (NSPs) [17]. Of the NSPs present, it has been found that 78% is linear mannan with very low galactose substitution, 12% cellulose, 3% glucoronoxylans and 3% arabinoxylans [11].

Oligosaccharides have been substances of choice to replace antibiotics due to their capacity to block the colonization of pathogen bacteria in the intestine of broilers. Among oligosaccarides, fructo-oligosaccharides [34] and mannooligosachharides [12] have been of greatest interest. β-mannan in palm kernel meal has been reported to have similar properties to the mannan from yeast to increase immunity [31].

The mechanism of the improvement in the immune system due to consumption of palm kernel meal is still unclear. It may be through several modes of action in which mannose based carbohydrates, either β-mannan or manno-oligosaccharides, in the palm kernel meal are fermented in the caeca due to indigestibility of this fraction. This has beneficial effects in promoting the growth of desirable bacteria [13]. One of the products of fermentation in the caeca is an increased concentration of lactic acid [35, 22] and this prevents the growth of pathogenic species such as salmonellae. The ability of palm kernel meal to reduce the population of pathogenic bacteria in the gut has been found in four week old broilers [13].

The aim of this study was to evaluate the effectiveness of different rations of palm kernel meal combined with layer ration on the induction of molt, post molt production, and post molt egg quality for early phase (first 12 weeks) of the second cycle of egg production.

MATERIALS AND METHODS

Molting procedure

A total of 250 White Single Comb Leghorn laying hens aged 75 weeks were obtained from a commercial laying facility and birds were placed 1 bird/cage. The hens were provided ad libitum access to layer ration and water, and acclimated for two weeks. During this time, egg production was monitored to insure that all hens were healthy and in active production. After the acclimation was complete, 180 hens were moved to different cages (placed 2/cage) for molting procedure. The hens were then divided into 5 treatment groups with 36 birds per treatment: non molted control, full feed (FF); negative control, FW; 90% palm kernel meal and 10% layer ration (PKM90); 80% palm kernel meal and 20% layer ration (PKM80); and 70% palm kernel meal and 30% layer ration (PKM70). Birds were placed on a lighting program of 8 h light : 16 h dark for one week prior to the beginning of the molt [14] and were then molted for 12 d. During molt, bird weights were monitored at days 1, 4, 6, 8, 10 and 12. In accordance with standard animal use protocols, any hens reaching 25% weight loss prior to the end of the trial (day 12) were removed from their respective diet.

Collection of organs, egg production and quality parameters

At the end of the molt (day 12) 12 birds in each treatment were sacrificed by cervical dislocation. Organ weights were taken and expressed as a percentage of body weight. The remaining birds were provided layer ration on an ad libitum basis. The light program was changed to 16 h light : 8 dark to stimulate egg production. Egg production was measured daily, whereas egg quality parameters were measured twice per week. Egg production and quality were measured for 12 wk after molting.

Statistical analysis

This study was constructed as a completely randomized design (5 treatment and 6 replicate in each). Data were analyzed using the GLM procedure of SAS software [28]. Mean separation was assessed using the Duncan test. The level of significance used in all results was $P < 0.05$.

RESULTS AND DISSCUSSION

Body mass and egg arrest time:

No significant differences were found in body weight loss among hens molted by PKM70, PKM80, PKM90 and FW treatments over 12-d molt, but the differences between these groups with unmolted hens were significant ($P < 0.05$ table 1). Body mass loss has been shown to be directly related to postmolt performance. To optimize postmolt performance, a body mass loss of 25 to 30% should be achieved [3]. The weight loss exhibited by nonmolted (FF) hens could be explained by the reduced photoperiod, because photoperiod and nutrient deprivation have similar modes of action on the hypothalamic hypophyseal axis causing an inhibition of circulating reproductive hormone concentrations with subsequent ovary regression and weight loss [5]. The reduced photoperiod also leaves fewer daylight hours for feeding, which decreases feed consumption and causes weight loss as exhibited by all hens [2].
High percentage of weight loss in PKM70, PKM80 and PKM90 molted hens, is due by presece of high amount of palm kernel meal in diet. Palm kernel meal is a fibrous feedstuff with low digestibility for poultry [31]. It has been previously shown that alfalfa as a basal diet for molt induction of laying hens has similar effects with present study, on body weight loss of hens [18, 10].

There was a significant difference in egg arrest time among hens molted by experimental treatments ($P < 0.05$). On average FW treated hens took significantly shorter (4.83 d) to cease production than PKM 70, PKM80 and PKM90 molted hens (6.83, 6.33 and 6.17 d). This result is consistent with observation by Donalson et., al (2005) who also reported hens molted by feed deprivation were significantly sooner cease production than alfalfa molt diets.

Feed intake:

No significant differences were found in feed intake among hens fed different levels of palm kernel meal in diet during the molt (table 1), but the differences between these groups with unmolted hens were significant ($P <0.05$).

The reduction in feed intake could have been due to several factors, including appetite suppression in conjunction with the natural molting process [21], decreased feeding stimulation with reduced daylight hours [2] or high amount of fiber in diet and its negative effects on appetite. The water intake of birds fed palm kernel meal based diets due to presence of high amount of β-mannan is increased [25] and there is increased in moisture content of excreta [24]. Increased water intake by bird may also has limited appetite.

Table1. Effects of palm kernel meal-layer ration, feed withdrawal molt diets and a non molt diet on feed intake, body weight loss and date of cease of egg production during a 12-d molting period

Treatment[1]	Feed intake (gr/day)	Body weight loss (%)	Egg arrest time (# of days)
FF	72.53[a]	8.99[b]	N/A[2]
FW	N/A[2]	23.96[a]	4.83[b]
PKM70	33.67[b]	20.48[a]	6.83[a]
PKL80	32.25[b]	21.47[a]	6.33[a]
PKM90	30.92[b]	22.02[a]	6.17[a]
SE	1.46	1.11	0.43
P-value	0.0001	0.0001	0.022

[a-b] *Means within a column with no common superscripts differ significantly (P<0.05).*
[1]*FF= full feed; FW=feed withdrawal; PKM90= 90% palm kernel meal and 10% layer ration diet; PKM80= 80% palm kernel meal and 20% layer ration diet; PKM70= 70% palm kernel meal and 30% layer ration diet.*
[2]*N/A = Non-applicable.*

Organ weight:

The results of relative organ weight in experimental treatments are shown in table 2. Unmolted hens (FF) had higher ($P < 0.05$) ovarian weights than hens on all other molted treatments (2.1% BW). No significant differences were found in ovarian weights between among FW (0.36% BW), PKM70 (0.47% BW), PKM80 (0.45% BW) and PKM90 (0.37% BW) treatments. Ovarian weights loss occurs simultaneously with body mass loss due to the regression of the ovaries that is directly associated with the rejuvenation process [8]. Less dramatic ovary reductions have been noted in other molting regimens involving feed supplementation with zinc compounds [20, 26], alfalfa meal [18, 19] and alfalfa meal-layer ration combinations [10].

All treatments exhibit differences (P <0.05) in oviduct weight during the molt period. Unmolted hens had significantly (P < 0.05) higher oviduct weights when compared with all other treatments (1.85% BW) whereas PKM90-treated birds had significantly lower oviduct weights (1.06% BW) than all treatments except the FW (1.07% BW) and PKN80 (1.24% BW) groups. More reduction in oviduct weights in PKM90 and FW molted hens, probably was due to greater body weight loss in this treatments.

Liver weights in unmolted hens (FF) were higher (P < 0.05) than hens on all other molted treatments (2.93% BW). No significant differences were found in liver weights among FW (1.93% BW), PKM70 (1.97% BW), PKM80 (1.81% BW) and PKM90 (1.9% BW) treatments. Liver weight loss indicates a loss of liver energy sources, such as glycogen and lipids, which are metabolized in the liver [6]. Weight loss from the liver is also indicative of the loss of estrogen-dependent egg component synthesis, which is dependent on stimulation from ovarian steroids [6]. The most common ovarian steroids are the estrogens whose target organ is the liver where yolk phospholipoprotein synthesis occurs and is dependent primarily on estrogens [6]. Similar decrease in liver weight for feed deprivation hens have been reported for feed deprived molted hens [10, 19] and alfalfa molted hens [10, 19].

In the current study no differences were found among treatment when comparing heart and spleen weight. The minimum heart and spleen weight is consistent with previous report for hen either feed deprived, or molted with alfalfa and alfalfa-layer ration combinations as high fiber diet for molt induction [10].

Pancreas removed from full fed hens was significantly greater in weight percentage than those of either palm kernel meal-layer ration combinations or feed deprived molted hens. Similar decrease in pancreas weight for feed deprivation hens have been reported for feed deprived molted hens and alfalfa molted hens [19].

Table2. Effect of palm kernel meal-layer ration, feed withdrawal molt diets and a non molt diet on post molt organ weights (as % of body weight)

Treatment[1]	Ovary (%)	Oviduct (%)	Heart (%)	Spleen (%)	Liver (%)	Pancreas (%)
FF	2.1^{a}	1.85^{a}	0.53	0.11	2.93^{a}	0.27^{a}
FW	0.36^{b}	1.07^{c}	0.49	0.12	1.93^{b}	0.19^{ab}
PKM70	0.47^{b}	1.43^{b}	0.54	0.12	1.97^{b}	0.2^{ab}
PKM80	0.45^{b}	1.24^{bc}	0.52	0.11	1.81^{b}	0.23^{ab}
PKM90	0.37^{b}	1.06^{c}	0.59	0.11	1.9^{b}	0.17^{b}
SE	0.09	0.08	0.04	0.01	0.24	0.03
P-value	0.0001	0.0001	0.47	0.98	0.03	0.16

[a-b] *Means within a column with no common superscripts differ significantly (P<0.05).*
[1]*FF= full feed; FW=feed withdrawal; PKM90= 90% palm kernel meal and 10% layer ration diet; PKM80= 80% palm kernel meal and 20% layer ration diet; PKM70= 70% palm kernel meal and 30% layer ration diet.*

Egg quality response:
Egg qualities were examined in this study to determine if the different levels of palm kernel meal would alter postmolt quality of eggs. Treatment differences (*P* < 0.05) were identified for quality parameters, including egg weight, albumen height, yolk height, specific gravity, and shell breakage strength (Table 3).

No significant differences were found between molt treatments in egg weight laid of post molt but their differences with FF treatment were significant. FF hens had lowest egg weight among all treatments.

The FF albumen heights were significantly lower than all other treatments indicating a decrease in internal egg quality. Similar results were observed when alfalfa layer ration combinations were used as an alternative to feed deprivation for the induction of molt [10]. FW-treated birds had significantly higher albumen heights (9.5 mm) than all treatments except the PKM90 (9.43 mm) group.

Yolk heights were significantly higher for PKM90, PKM80 and FW-treated hens when compared with other treatments. FF-treated also had lowest yolk heights (P < 0.05).

Shell breakage was influenced significantly by different experimental treatments (P < 0.05). Shell breakage was significantly highest for FW hens when compared with other treatments. FF-treated also had lowest shell breakage (P < 0.05).

Egg laid by PKM90-treated hens had a specific gravity (1.081) that was significantly higher than other treatment hens. Higher specific gravity values are related to thicker eggshells, which is a desirable characteristic for the egg industry [16].

Table3. Effect of palm kernel meal-layer ration, feed withdrawal molt diets and a non molt diet on post molt egg quality and weight

Treatment[1]	Egg weight (gr)	Albumen height (mm)	Yolk height (mm)	Shell breakage (kgf/m^3)	Specific gravity (gr/cm^3)
FF	64.08[b]	8.67[c]	18.09[c]	2.804[d]	1.076[c]
FW	67.74[a]	9.5[a]	18.78[a]	3.158[a]	1.078[b]
PKM70	66.28[a]	9.1[b]	18.53[b]	2.91[c]	1.077[bc]
PKM80	66.69[a]	9.11[b]	18.61[ab]	2.972[c]	1.078[b]
PKM90	66.88[a]	9.43[ab]	18.71[ab]	3.081[b]	1.081[a]
SE	0.44	0.11	0.07	0.03	0.0005
P-value	0.0001	0.0001	0.0001	0.0001	0.0001

[a-b] *Means within a column with no common superscripts differ significantly (P<0.05).*

[1]*FF= full feed; FW=feed withdrawal; PKM90= 90% palm kernel meal and 10% layer ration diet; PKM80= 80% palm kernel meal and 20% layer ration diet; PKM70= 70% palm kernel meal and 30% layer ration diet.*

According to the results of this experiment, it was observed that treatments of FW and PKM90 were shown the most desirable effects on egg quality parameters post molt. Improved egg laid quality of postmolt in experimental treatments can be attributed with maximizing of body and organ weight loss of hens during the molt period. Results of previous study on feed deprived molted hen and alfalfa molted hens were consistent with these results [10, 18].

Egg production and date of reentry:

Postmolt egg production and date of reentry into second egg laying cycle are shown in Table 4. Unmolted hens fed layer ration had a significantly higher level of egg production (36.77%) than molted hens 0–4 weeks after the molt. While hens molted by PKM70 (29.17%), PKM80 (25.4%), PKM90 (27.46%) or feed withdrawal hens (25.55%) did not have significantly different levels of egg production with others.

Hens molted by PKM80 (74.92%), PKM90 (74.2%) and PKM70 (73.29%) showed no significant difference in egg production from 5 to 8 weeks after the molt (Table 4). Hens molted by all palm kernel meal diets yielded significantly higher egg production levels than hens molted by feed deprivation (65.09%) and unmolted hens (68.31%).

According to the result of this experiment, it was observed that the egg production of hens molted by PKM-diets rebounded more quickly than FW-molted hens in early weeks of post molt. Landers et al., (2005) reported that hens molted by alfalfa meal and alfalfa pellet appeared to rebound more quickly in the first few weeks after molting than feed deprived molted hens.

No significant differences were found on egg production of PKM70, PKM80, PKM90 and FW molted hens from 9 to 12 weeks after post molt. FF hens had significantly lower egg production than hens of other treatments.

Table4. Effect of palm kernel meal-layer ration, feed withdrawal molt diets and a non molt diet on post molt egg production and date of reentry

Treatment[1]	0-4 Week (%)	5-8 Week (%)	9-12 Week (%)	0-12 Week (%)	Date of reentry (# of days)
FF	36.77[a]	68.31[bc]	77.22[b]	60.77[ab]	N/A[2]
FW	25.55[b]	65.09[c]	81.47[ab]	57.37[b]	20.33[a]
PKM70	29.17[b]	73.29[ab]	87.48[a]	64.14[a]	16.67[b]
PKM80	25.4[b]	74.92[a]	87.03[a]	62.45[a]	16.67[b]
PKM90	27.46[b]	74.2[ab]	88.59[a]	63.41[a]	15.83[b]
SE	2.12	2.02	2.97	1.57	0.52
P-value	0.005	0.007	0.057	0.039	0.0001

[a-b] *Means within a column with no common superscripts differ significantly (P<0.05).*

[1]*FF= full feed; FW=feed withdrawal; PKM90= 90% palm kernel meal and 10% layer ration diet; PKM80= 80% palm kernel meal and 20% layer ration diet; PKM70= 70% palm kernel meal and 30% layer ration diet.*

[2]*N/A = Non-applicable.*

The results of egg production within 12 weeks after molt are shown in Table 4. Hens molted by PKM70 (64.14%), PKM80 (62.45%), PKM90 (63.41%) and full fed hens (60.77%) showed no significant difference in egg production within 12 weeks after the molt. FW hens had significantly ($P < 0.05$) lower egg production when compared with all other treatments within 12 weeks after molt. The more egg production content in hens molted by PKM diets imply that these treatments are well substitutable for feed withdrawal. The goal of a viable molting program is to increase post molt egg production and quality. After the molting period, hens improve their egg production due to the rejuvenation of the reproductive organs and overall BW loss [1].

No significant differences among hens molted by PKM70, PKM80 and PKM90 in date of reentry production (16.67, 16.67 and 15.83 respectively) were observed. Hens molted by FW returned significantly ($P < 0.05$) later than other treatments (20.33 d) which is consistent with observation by Landers et al., (2005) who also reported hens molted by feed deprivation return significantly later than alfalfa pellet to production.

CONCLUSION

The results of this study showed that, use of palm kernel meal mixed with layer ration proved to be effective in molt induction, increasing postmolt egg quality and postmolt egg production when com pared with conventional FW methods. Palm kernel meal is an insoluble, high fiber and low cost feedstuff that can be used as a prebiotic to improve chicken health. This feedstuff can be used as a viable alternative to conventional FW methods for induced molting program of commercial laying hens.

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