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تأثير التحول الغذائي في أعلاف الدجاج البياض من كسب فول الصويا إلى التغذية على أعلاف تحتوي على مستويات عالية من كسب السمسم المعامل ببعض الأنزيمات وأثره على الأداء الإنتاجي للدجاج الأبيض في المرحلة المبكرة

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Effects on early-phase White Leghorn performance of switching from sesame meal (Sesamum indicum) to soybean meal level enhanced with enzymes.

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الملخص

تم إجراء هذه الدراسة لتحديد القيم الغذائية لوجبة السمسم في الدراسات الغذائية، تم التحقيق في تأثير تضمين مستويات مختلفة من وجبة السمسم في النظام الغذائي لتربية دجاج البيض الأبيض (دجاج اللجهورن الابيض) خلال الفترة من 12 إلى 28 أسبوعًا من العمر كهدف رئيسي. تمت دراسة ثلاثة مستويات من كسب السمسم: تمثل 0.0 (تحكم)، 15، و30% في نظام التغذية لتربية دجاج اللجهورن خلال 12-28 أسبوعًا من العمر. كان هناك 4 معاملات فرعية لمستويات 15 و30% من كسب السمسم بما في ذلك مجموعة التحكم السلبية، الفيتاز، أوبتيزيم، والفيتاز مع أوبتيزيم.

الصفات التي تم دراستها كانت الأداء الإنتاجي وإنتاج البيض.

اظهرت النتائج كالتالي:

عليقة العلف التي تحتوي على السمسم بنسبة 15% و30% لم يكن لها تأثير سلبي على النمو واستهلاك العلف المكعب خلال الفترة من 12 إلى 24 أسبوعًا من العمر. لم يتأثر النمو واستهلاك العلف خلال فترة 12-24 أسبوعًا بشكل كبير بإضافات الإنزيمات. ومع ذلك، أظهرت تفاعلاً كبيراً في زيادة الوزن الجسم خلال الفترة بأكملها (12-24 أسبوعاً من العمر)، مما يشير إلى أن الفيتاز ادى الى زيادة الوزن الجسم للدجاجات الصغيرة التي تناولت نظاماً غذائياً يحتوي على 30% من كسب السمسم. بشكل عام لم تؤثر مستويات السمسم ومكملات الإنزيمات سلبًا على عمر أول بيضة وضعت، ومعدل وضع البيض بنسبة 30% و60%. معدل وضع البيض، وزن البيض، وكتلة البيض خلال فترة 22-28 أسبوعًا من العمر لم تتأثر بشكل كبير بتغذية مستويات مختلفة من كسب السمسم تصل إلى 30%. كما أن الإنزيمات لم تؤثر على أداء وضع البيض خلال فترة العمر من 22 إلى 28 أسبوعًا. معدل وضع البيض وكتلة البيض خلال فترة 22-28 أسبوعًا من العمر تحسنت بشكل كبير بسبب إضافة الإنزيمات المتعددة إلى الاعلاف التي تحتوي على 30% من كسب السمسم.

الخلاصة:

قد يعكس هذا أهمية هذا التفاعل من وجهة نظر اقتصادية. تم الاستنتاج أنه يمكن إطعام 30% من كسب السمسم لكتاكيت اللجهورن الابيض خلال الفترة من 12 إلى 28 أسبوعًا من العمر عند إضافة انزيم الاوبتيزيم في اعلاف الدجاج التي تحتوي على كسب السمسم دون حدوث تأثيرات سلبية على الأداء الإنتاجي.

الكلمات الدالة: السمسم، وجبة دجاجات صغيرة منتجة ، أداء إنتاج البيض.

Abstract

This study was conducted to determine the nutritive values of sesame meal (SM). In the feeding studies, the effect of including different levels of SM in the diet for rearing White Leghorn pullets (WL) during 12-28 weeks of age was investigated as the main goal. Three levels of SM representing 0.0 (control), 15, and 30% in the rearing diets for WL hens during 12-28 weeks of age were studied. There were 4 sub-treatments for 15 and 30% SM levels, including a negative control group, phytase, Optizyme, and phytase plus Optizyme.

The criteria studied were productive performance and egg production. Sesame meal at 15 and 30% had no negative effect on growth and feed consumption of pellets during 12-24 weeks of age. Growth and feed intake during 12-24 weeks of age were not significantly affected by enzyme additions. However, a significant interaction was shown in BWG for the whole period (12-24 weeks of age), indicating that phytase increased BWG of pullets fed 30% SM diet. In general, SM level and/or enzyme supplementations did not adversely affect age at 1st egg laid, 30 and 60% laying rate. Laying rate, egg weight, and egg mass during 22-28 weeks of age were not significantly affected by feeding different SM levels up to 30%. Also, enzymes did not affect laying performance during the 22-28 week age period. Laying rate and egg mass during 22-28 weeks of age were significantly improved due to the addition of multienzymes to diets containing 30% SM.

This may reflect the importance of this interaction from an economic point of view. It was concluded that 30% SM could be fed to WL pullets during 12-28 weeks of age when supplemented with Optizyme without adverse effects on performance.

Keywords: Sesame meal-Pullets-Productive performance-Egg production

1- INTRODUCTION

There is no doubt that the shortage of soybean meal in many countries, including Egypt and most developing countries, is a significant issue as it is a crucial component in poultry feed. Moreover, the rising costs of soybean meal are also driving up the expenses associated with poultry feed. This has led individuals involved in poultry production to seek out viable substitutes for this key feed component. The areas cultivated with sesame in Egypt by 2024 range between 150,000 feddans, and Egypt's total sesame production reaches about 480,000 ardb annually if the yield per feddan is 8 ardb. If 150,000 feddans are used for sesame cultivation, they will produce 90,000 tons of seeds, and if used for oil production, approximately 50,000 tons of oil can be produced. The oil extraction rate from sesame crop reaches 55%.

Sesame seed meal (SSM) is a byproduct of oil extraction from sesame seeds and is considered a good feed material for poultry due to its high plant protein content, comparable to soybean meal. Soybean meal is rich in amino acids (Mamputu and Buhr, 1995), but it lacks lysine and has a high methionine content, affecting its nutritional value. The quality of sesame meal is influenced by seed quality, preparation method, extraction process, and environmental conditions during cultivation (Olaiya *et al.*, 2015). The high phytate levels in sesame meal reduce amino acid availability in poultry diets (Farran *et al.,* 2000), while increased oxalate levels can decrease mineral element availability for birds (Pettersson and Pontoppidan, 2013).

Sesame meal can be an alternative to soybean meal in quail feed at a level of 150g or less per kg of feed (Bell *et al.*, 1990). While there are numerous studies on the use of sesame seed meal and its impact on broiler chicks and laying hens, there is limited research on its use in quail diets, especially with local quail breeds.

Therefore, this study aimed to investigate the effects of different levels of locally produced sesame seed meal as a partial replacement for soybean meal treated by some enzymes to improve the utilization of feed on laying hens' performance and egg production traits.

2-MATERIALS AND METHODS

The present study was carried out at Poultry Research Station belonging to Animal Production Research Institute, Agriculture Research Center, and Ministry of Agriculture during November 2022 and December 2023.

<u>Sesame seed meal evaluation:</u>

Sesame seed meal (SM) was obtained from a private company located in North El Tahrer, El Behera Governorate, Egypt. The SM was dried and ground to prepare it for diet formulation. The proximate analysis of the SM was conducted following the methods outlined in the A. O. A. C. (2012) guidelines.

Table 1: Chemical analysis of Soybean and sesame meal.

Nutrients	Dry Matter	Crude protein	Ether extract	Crude Fiber	Ash	Metabolizable Energy
Soybean meal	94.1	43,6	2,29	6.58	5.11	3175
Sesame meal	94.8	34.8	8.71	14,93	11.98	3380

This experiment aimed to investigate the impact of replacing varying levels of SM (0%, 15%, and 30%) with soybean meal (Table 1) with or without formulating the diet based on phytase and/or Optizyme supplementation on pullet performance during the rearing period from 12 to 28 weeks of age.

A total of 540 12-week-old White Leghorn (WL) pullets were utilized in this study. The pullets were individually weighed to the nearest gram, leg banded, and randomly assigned to 9 experimental diets in a 3×2 factorial arrangement using a completely randomized design. Each replicate consisted of four cages, with the hens housed in individual cages measuring 40×25×40 cm.

The diets during the rearing period from 12 to 28 weeks of age contained SM at levels of 0%, 15%, and 30%. The experimental design included a control group fed a diet with 0% SM. The diets were formulated to be nearly isocaloric and isonitrogenous, with two levels of SM at 15% or 30%.

Within each SM-containing diet, four groups were fed either an unsupplemented diet or diets supplemented with microbial phytase (625 U of Ronozyme phytase®), 0.1% Optizyme-p5®, or a combination of both phytase and Optizyme at the same dosages.

The experimental diets were formulated to meet the recommended levels of protein, metabolizable energy, calcium, available phosphorus, lysine, and total sulfur amino acids as per the NRC (1994) guidelines.

During the rearing period from 12 to 22 weeks of age, the pullets were fed a diet containing 14.5% CP and 2600 kcal ME/kg. From 22 to 28 weeks of age, they were switched to a layer diet containing 17.25% CP and 2775 kcal ME/kg. Feed and water were provided ad libitum.

The performance traits assessed during the rearing period included body weight and feed consumption. Additionally, age at sexual maturity, age at 30% and 60% egg-laying rate, egg production, egg weight, and egg mass were evaluated during the early laying period from 23 to 28 weeks of age.

Table 2: shows the percentage composition of calculated and analyzed nutrients, as well as the metabolizable energy (ME) contents of the diets fed to Leghorn pullets from 12 to 22 weeks of age.

	SM level in the pullets diets (12-22 week of age)			SM level in the Hens diets (22 – 28 week of age)		
Ingredients	0.0	15%	30%	0.0	15%	30%
Yellow corn	634.4	654.1	654	626	626	626
Soybean meal	200	170	140	240	204	168
Wheat bran	136	116	116	49.7	49.1	48.8
Sesame meal	0	30	60	.	36	72
Dicalcium phosphate	15	15	15	16	16	16
Limestone	8	8	8	60	60	60
NaCl	3	3	3	3	3	3
Vit+Min Mix.[1]	3	3	3	3	3	3
Dl-methionine	0.3	0.3	0.3	0.9	1.2	1.3
Lysine	0.3	0.6	0.7	1.4	1.7	1.9
1. Calculated analysis[2], (%)				2.	3.	4.
ME kcal/kg	2601	2606	2602	2775	2781	2791
Methionine	0.26	0.26	0.27	0.39	0.40	0.41
TSAA	0.52	0.52	0.53	0.65	0.65	0.66
Lysine	0.79	0.84	0.91	0.96	0.94	0.96
Calcium	0.90	0.93	0.94	2.98	2.99	2,98
Available phosphorus	0.34	0.34	0.34	0.45	0.48	0.46

5. Determined analysis[3] (%)				6.	7.	8.
Dry matter	90.64	90.22	90.30	91	92,1	90.9
CP	14.82	14.69	14.50	17.38	17.20	17.17
EE	3.21	3.43	3.87	3.34	3.45	3.48
CF	3.89	3.587	4.37	3.29	3.50	3.94

The Vitamin and Minerals mixture in the diet contains the following per kilogram: vitamin A (12000 IU), vitamin E (20 IU), menadione (1.3 mg), Vitamin D3 (2500 ICU), riboflavin (5.5 mg), Ca pantothenate (12 mg), nicotinic acid (50 mg), choline chloride (600 mg), vitamin B12 (10 *g), vitamin B6 (3 mg), thiamine (3 mg), folic acid (1.0 mg), and d biotin (50 *g). The Trace minerals per kilogram of diet are: Mn (80 mg), Zn (60 mg), Fe (35 mg), Cu (8 mg), and Se (0.60 mg).[2]Calculated values (NRC, 1994). [3]Determined values (AOAC, 2012).

Statistical analysis:

Data were statistically analyzed using the General Linear Model procedure of the Statistical Analysis System (SAS, 2001). Data obtained were tested by analysis of variance with one-way design to test the treatment, sub treatment and interaction group differences at each sampling according to the following model:

$$Y_{ijk}=\mu+T_i+\delta_j+(T\delta)_{ij}+E_{ijk}$$

where:

μ represents the overall mean effect

T_i is the effect of the i th level of factor A ($i=1,2,\ldots n_b$)

δ_j is the effect of the j th level of factor B ($j= 1,2, \ldots n_b$)

$(T\delta)_{ij}$ represents the interaction effect between A and B

E_{ijk} represents the random error terms (which are assumed to be normally distributed with a mean of zero and variance of δ) and the subscript K denotes the m replicates (k = 1, 2, ……m).

Values were given as mean. The significant differences among groups were subjected to Duncan's Multiple Range Test (1955).

3-RESULTS AND DISCUSSION

Effect of phytase and/or multienzymes on nutritional value of diets containing different levels of SM for pullets:

Body weight and body weight gains

The primary effects of SM on changes in body weight during the raising period (12–22 weeks of age) were displayed in Table 3. The pullets were randomly spread among the treatments, and the results showed that there were no significant variations in the birds' starting body weight. Before reaching 20 weeks of age, there was no discernible difference in the body weight of WL pullets fed 15% or 30% SM compared to the control diet.

Table 3: Effect of dietary levels of SM and addition of phytase, Optizyme or their combination on body weight (g) and body weight gain (g) during 12-24 week of age of leghorn chickens.

Treatments	Body weight at week of age				Body weight gain 12-24 week of age
	12	16	20	24	
Effect of SM levels					
0.0	1001.7	1112.5	1215.4	1252.7[ab]	250.9[ab]
15	1003.1	1108.9	1209.2	1247.2[b]	244.0[b]
30	1003.4	1113.4	1214.3	1262.3[a]	258.8[a]
SEM	1.77	2.29	2.63	3.34	3.67
P value	0.09	0.056	0.128	0.001	0.004
Effects of additives					
Unsupplemented control	1002.2	1113.3	1214.1	1249.4[b]	247.2
Phytase	1005.7	1112.1	1213.7	1262.9[a]	257.3
Optizyme	1004.5	1110.2	1209.7	1256.5[ab]	251.9
Phytase +Optizyme	1000.7	1108.8	1210.1	1251.8[b]	251.1

SEM	2.05	2.64	3.05	3.85	4.24
P value	0.098	0.231	0.920	0.05	0.065
Sesame meal × additive					
P value	0.919	0.072	0.098	0.08	0.04

[a-c] Means within a column with different superscripts are significantly different (P<0.05).

On the other hand, the study found that feeding diets with 30% SM significantly increased the body weight of 24-week-old pullets and their overall weight gain compared to diets with 15% SM. Adding up to 30% SM to pullet diets among 12 and 24 weeks of age did not have any negative effects on the birds' growth. Earlier revisions by Kanani *et al.* (2020) and Boling *et al* (2000) also observed weight gains in fast-growing chicks when date pits were included in their feeds, supporting the findings of this study. The current findings show that SM did not have a negative impact on pullet growth, consistent with previous studies by (Olaiya *et al.,* 2015; Ngele *et al.,* 2011). They found that with a minor drop in feed intake, broiler diets containing 5 to 15% raw sesame seeds showed decreased body weight gain and feed efficiency. Additionally, Al Harthi and El-Deek (2009) found that broilers fed a diet containing 5% SM had significantly higher body weight and daily weight gain (DWG) compared to the control group.

The results for the main effects of enzymes on body weight and body weight gain for the entire experimental period are presented in Table 3. The growth values of WL pullets among 12-20 weeks of age were not significantly affected by the addition of phytase and/or multienzymes. However, at 24 weeks of age, pullets supplemented with phytase showed a significant improvement in body weight by 1.1% compared to the unsupplemented control group. The group supplemented with multienzymes had similar body weight to the phytase-supplemented group and the unsupplemented control group, indicating that multienzymes had an insignificant effect on body weight. It is worth noting that the group supplemented with a combination of phytase and multienzymes had significantly lower body weight than the phytase-supplemented group, but similar to the unsupplemented control group and the multienzyme-supplemented group. This suggests a lack of cumulative effect among phytase and multienzymes.

There was no significant effect of phytase and/or multienzymes on body weight gain of pullets among 12-24 weeks of age compared to the control diet. The inclusion of phytase resulted in a notable improvement in pullet development, suggesting that phytase alone improved the nutrients available for pullet growth. Which could indicate that the unnutritional component of SM is phytic acid? However, the other ingredients in the experimental meals, such as maize and soybean meal, may also have contributed to this improvement in addition to the increased nutrient availability of SM. It should be mentioned that phytase supplemented diet containing reduced levels of Ca and P (according to the suggested equivalent value by producing company), indicated non mineral effect of phytase due to its positive impact on protein and ME availability (Cozannet *et al.,* 2023). On the other hand, the positive impact of phytase may be due also to other side activities of the enzymes produced by phytase-producing organisms. In a study by Habib (2017), it was found that a microbial phytase was as effective as xylanase in enhancing the performance of broiler chickens fed wheat-based diets.

The study showed that the impact of phytase on performance is not solely due to its mineral effects, but also due to reduced digesta viscosity, increased apparent metabolizable energy (AME), and a decrease in the relative weight and length of the small intestine. Additionally, the study found that phytase supplementation led to increased villus height in the duodenum and reduced goblet cells in the jejunum, indicating improved absorptive capacity of the digestive tract. These results suggest that phytase can enhance the gut environment and positively impact the performance of broiler chickens.

The data in Figure 1 show the interrelation among SM levels and enzymes on body weight and body weight gains. There was no significant interrelation among SM levels and enzymes on pullet body weight until 20 weeks of age, but there was an approaching significant effect (P<0.08) at 24 weeks of age. Additionally, there was a significant interrelation among SM and enzymes on body weight gain throughout the entire experimental periodIt is evident that pullets fed diets with 0%, 15%, and 30% SM experienced a decrease in body weight, with the most significant decrease observed in pullets fed only 15% SM. However, supplementation with multienzymes, with or without phytase, improved the growth of hens fed a 15% SM diet by 5.3% and 4.4%, respectively, reducing the differences from the positive control (Fig 1). Additionally, within the 30% SM diets, only phytase supplementation resulted in improved growth by 8.9% and 10.1% compared to the negative control and positive control, respectively.

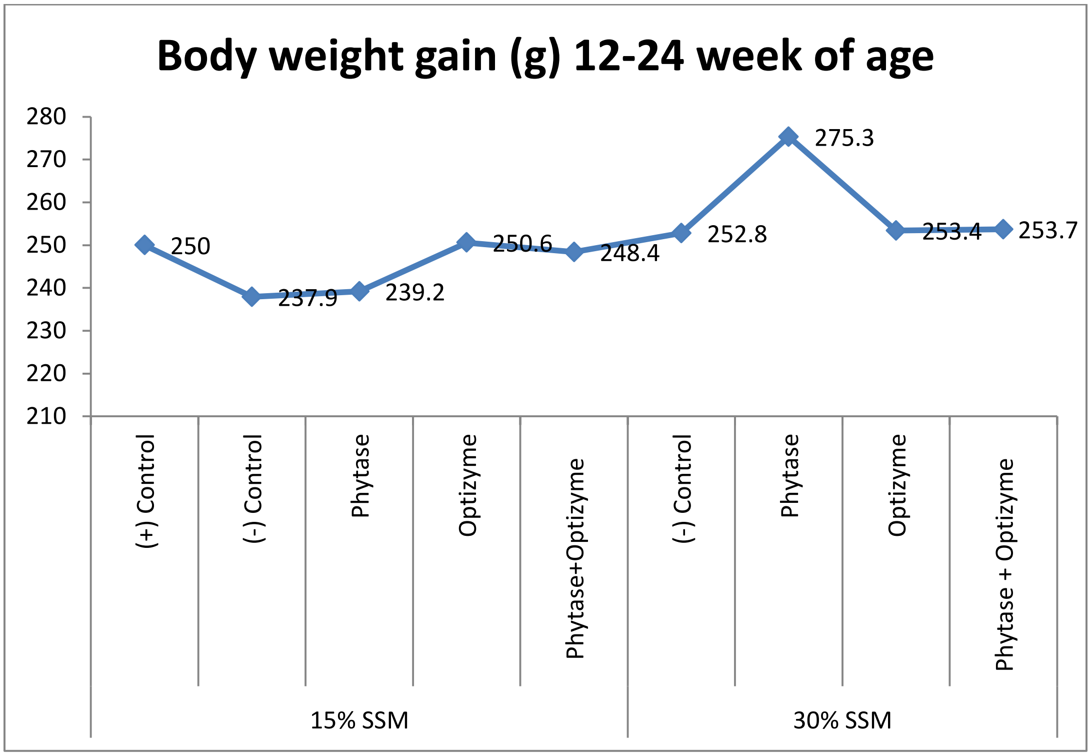

Figure 1: The interrelation among SM level and enzymes in body weight gains

The results showed that enzyme responses are dependent on the level of SM, with multienzymes being most effective in diets with 15% SM and phytase showing greater responses in diets with 30% SM. The combination of phytase and multienzymes did not have a superior effect compared to each enzyme alone at each SM level, indicating a lack of cumulative effect among phytase and carbohydrates. The present results are in line with those observed by Lourenco *et al.* (2020) they indicated that enzymes are a useful tool for improving performance of growing chicks.

Feed intake

The results in Table 4 show the main effect of SM on the feed intake of WL pullets among 12-24 weeks of age.

There was a significant impact of SM on feed intake during weeks 12-16. Feeding diets with 30% SM led to a significant decrease in feed intake by approximately 1.6% compared to the control group or the group fed a diet with 15% SM. These findings suggest that 30% SM affects the palatability of the diet, which is consistent with the results observed by Passi *et al*. (2019), who found that a dietary level of 30% SM significantly reduced feed intake in growing chicks.

Table 4: shows the impact of different dietary levels of SM and the inclusion of phytase, Optizyme, or a combination of both on the feed intake (in grams per bird per period) of leghorn chickens between 12 and 24 days of age.

Items	Feed intake during age intervals (week)			
	12-16	16-20	20-24	12-24
Effect of SM levels				
0.0	1874.0	2271.7	2458.3	6604.0
15	1876.6	2304.2	2480.3	6661.0
30	1844.9	2297.9	2494.4	6637.3
SEM	10.05	11.17	14.20	17.37

P value	0.05	0.061	0.059	0.90
Effect of additives				
Unsupplemented control	1860.7	2299.7	2486.2	6646.6
Phytase	1859.5	2291.5	2521.7	6672.7
Optizyme	1865.3	2294.5	2457.5	6617.3
Phytase +Optizyme	1864.2	2304.5	2470.0	6638.7
SEM	11.64	12.94	16.44	20.12
P value	0.056	0.109	0.07	0.092
Sesame meal × additive				
P value	0.34	0.07	0.09	0.065

[a-c] Means within a column not sharing similar superscripts are significantly different (P<0.05).

The findings showed that the SM level had no discernible impact on the pullets' feed intake during the 16–24 week age range or throughout the whole study period. In contrast to the pullets fed the control diet, there was a minor increase in feed intake because the diets of the 16–24 week old pullets contained either 15% or 30% SM.

Data on the main effect of enzymes on feed intake are shown in Table 4. Feed intake of WL pullets from 12-16 and 16-20 weeks of age, as well as from 12-24 weeks of age, did not show significant differences with enzyme supplementation. However, during the 20-24 week period, pullets fed a diet with added phytase consumed more feed (P<0.07) compared to the control group (1.4%), as well as the group fed a diet with multienzymes alone (2.6%) or in combination with phytase (2.1%). These changes in feed intake due to enzyme supplementation during the study period are consistent with the findings of Rahimiana *et al* (2013).

On the other hand, Mehmet *et al.* (2005) indicated that phytase stimulated feed intake of broiler chicks fed corn-soybean meal diet. On the other hand, Peter *et a*l (2007) found that addition of phytase and multienzymes to broiler diets decreased significantly feed intake compared to the control group, with phytase caused severe reduction in feed intake compared to Avizyme®.

Sexual maturity:

The results in Table 4 demonstrated the significant influence of varying levels of SM inclusion on the age at first egg, as well as the ages at 30% and 60% laying rates. It is important to note that all experimental groups were transitioned to a laying hen diet (17.5% CP) with identical additives at the beginning of the laying period. This transition was carried out to assess the effects of SM in the rearing diets on the age at sexual maturity and early laying performance.

Table 5: Impact of varying dietary levels of date stone and the inclusion of phytase, Optizyme, or a combination of both on the age of (1st egg lay, 30% laying rate, and 60% laying rate).

Treatments	Age at		
	1st laying	30% laying rate	60% laying rate
Effect of SM levels			
0.0	152.3	157.0	164.6
15	147.1	155.9	163.7
30	151.6	157.7	164.8
SEM	1.62	0.96	0.93
P value	0.09	0.12	0.101
Effects of additives			
Unsupplemented control	150.6	158.7	166.1
Phytase	148.0	156.6	163.1
Optizyme	149.8	155.6	163.8
Phytase +Optizyme	150.0	155.3	163.3

SEM	1.88	1.11	1.08
P value	0.09	0.07	0.129
Sesame meal× additive			
P value	0.08	0.067	0.108

[a-c] Means within a column not sharing similar superscripts are significantly different (P<0.05).

The age at which the first egg was laid declined somewhat but not dramatically when 15% SM was added to the pullets' meals, although age at 30 and 60% laying rates remained unaffected. On the other hand, Age at first egg laid, age at 30 and 60% laying rates, and the presence of 30% SM in hen diets did not significantly affect any of these parameters. However, the estrogenic effect of dates was reported (Hussein, 1998). These findings showed that when SM was fed in isocaloric isonitrogenous diets for WL pullets among the ages of 12 and 21 weeks, there was no difference in the age of first egg laid, 30 or 60% laying rate. These findings are consistent with the fact that SM had no detrimental effects on pullet growth among the ages of 12 and 21 weeks, which is when sexual maturity occurred. Arrazola *et al.* (2022) came to the same conclusion as the current data, which show that energy sources have no influence on the age at sexual maturity. They also found that energy allotments in the diet of laying hens had no effect on age at 50% or peak production. Similarly, Xin *et al.* (2024) found that the age at which broiler breeder hens reached a 40% laying rate was significantly impacted by energy level, but not by energy source.

Data on the effects of enzymes on the age at first egg laid, age at 30% and 60% laying rate are presented in Table 5. There were no significant effects of phytase and/or multienzymes on the age at first egg laid and 60% laying rate. However, the age at 30% laying rate was slightly reduced by 2.1, 3.1, and 3.4 days, respectively, due to the supplementation of phytase and/or multienzymes. A similar trend was observed for the age at 60% laying rate. This could be attributed to increased nutrient availability, leading to faster follicle growth in the ovary and consequently earlier egg laying, resulting in earlier maturation of pullets. In partial agreement with the present results, According to research by Rehman *et al.* (2015), the use of enzymes such as phytase or Avizyme, which break down cell walls, drastically lowered age at a 40% laying rate. El-Sanhoury and Ahmed (2017) indicated that age at 50% or at peak production was not significantly affected by enzymes addition to broiler breeder diets.

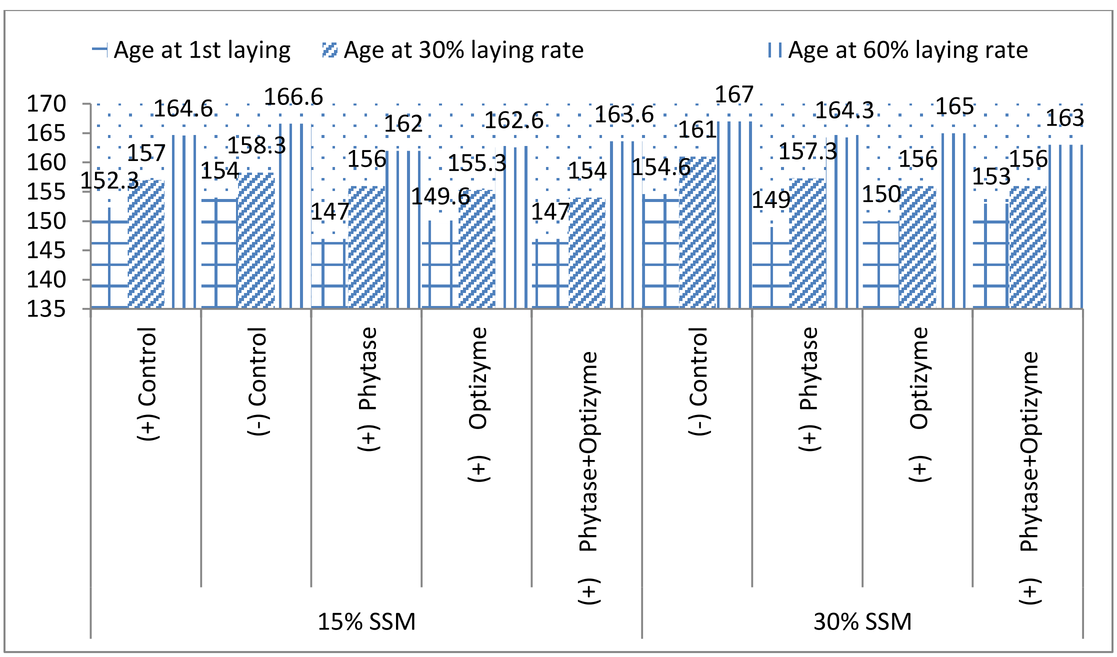

Figure 2: shows the impact of different dietary levels of Sesame seed meal and the inclusion of phytase, Optizyme, or a combination of both on the age of first egg laying, age at 30% laying rate, and age at 60% laying rate.

Results for the effect of the interrelation between SM levels and enzyme supplementation on age at 1st egg laid, age at 30% and 60% laying rate are shown in Fig 2. There was no significant relationship between SM levels and enzyme supplementation on these parameters. However, there was a trend for age at 1st egg laid, 30% and 60% laying rate to increase when comparing unsupplemented levels with the positive control. The increase was 1.7 and 2.3 days, 1.3 and 4.0 days, and 2.0 and 2.4 days for age at 1st egg laid, age at 30% and 60% laying rate in groups fed diets containing 12.5% and 25% SM levels, respectively, compared to the positive control. Additionally, within each level of SM, enzymes decreased ages at 1st egg laid, 30% and 60% laying rate with no significant differences between phytic acid degrading enzyme and multienzyme mixture.

Laying performance

Egg production

Results in Table 6 demonstrated the impact of different levels of SM inclusion on laying rate during the early part of the laying period.

Table 6: shows the impact of different dietary levels of SM and the inclusion of phytase, Optizyme, or a combination of both on the egg production of White Leghorn hens between 23-28 days of age.

Items	Egg production, % 23-24	25-26	27-28	23-28
Effect of SM levels				
0.0	24.7	40.7	58.3[a]	41.2
15	27.9	44.9	52.6[b]	41.8
30	24.6	45.2	58.8[a]	42.8
SEM	1.66	1.30	1.52	0.9
P value	0.08	0.09	0.005	0.06
Effect of additives				
Unsupplemented control	23.1	44.4[ab]	58.0	41.8
Phytase	26.9	43.2[b]	53.4	41.1
Optizyme	28.5	48.6[a]	57.2	44.8
Phytase + Optizyme	27.3	42.1[b]	54.4	41.3
SEM	1.91	1.50	1.76	1.02
P value	0.12	0.02	0.076	0.066
Sesame meal × additive				
P value	0.08	0.008	0.09	0.02

[a-c] Means within a column not sharing similar superscripts are significantly different (P<0.05).

Laying rate during weeks 23-24 and 25-26 was not significantly influenced by SM levels. However, a notable decrease in laying rate was observed in the group fed a diet containing 15% SM during weeks 27-28 compared to the control group and the group fed diets with 25% SM level. Throughout the early laying period (weeks 23-28), laying rate was not significantly affected by SM level, with similar rates observed among the experimental groups. This suggests that incorporating SM up to 30% in pullets' diets during weeks 12-21 did not negatively impact laying rate during this stage. These findings align with previous studies by Mamputu and Buhr (1995) and Kanani *et al*. (2020), which indicated that SM levels below 40% in laying hens' diets had no significant effect on laying rate. These findings suggest that SM, up to 30% of the total amount fed to pullets between the ages of 12 and 21 weeks, might be used as an energy source in isocaloric, isonitrogenous diets without having a negative impact on laying rate.

Data on the impact of enzymes on laying rate during the early part of the laying period (23-28 weeks of age) are presented in Table 6. The results showed that enzymes did not have a significant effect on laying rate during weeks 23-24 and 27-28, as well as over the entire 23-28 week period, compared to the control group without enzyme supplementation. However, during weeks 25-26, the group supplemented with multienzymes showed a significant improvement in laying rate, with increases of

12.5% and 15.4% compared to the groups fed diets with phytase alone or with phytase and multienzymes. Overall, the multienzyme supplemented groups had the highest laying rate throughout the study period, with an increase of approximately 7.0% compared to the other experimental groups. Similar to the current findings, a multienzyme mixture was reported to cause a small increase in the number of eggs by Khan *et al*. (2011), El-Faham *et al*. (2016), and Sun and Kim (2019).
Results for the effect of the interrelation among SM level and enzymes on laying rate are presented in Figure 3.

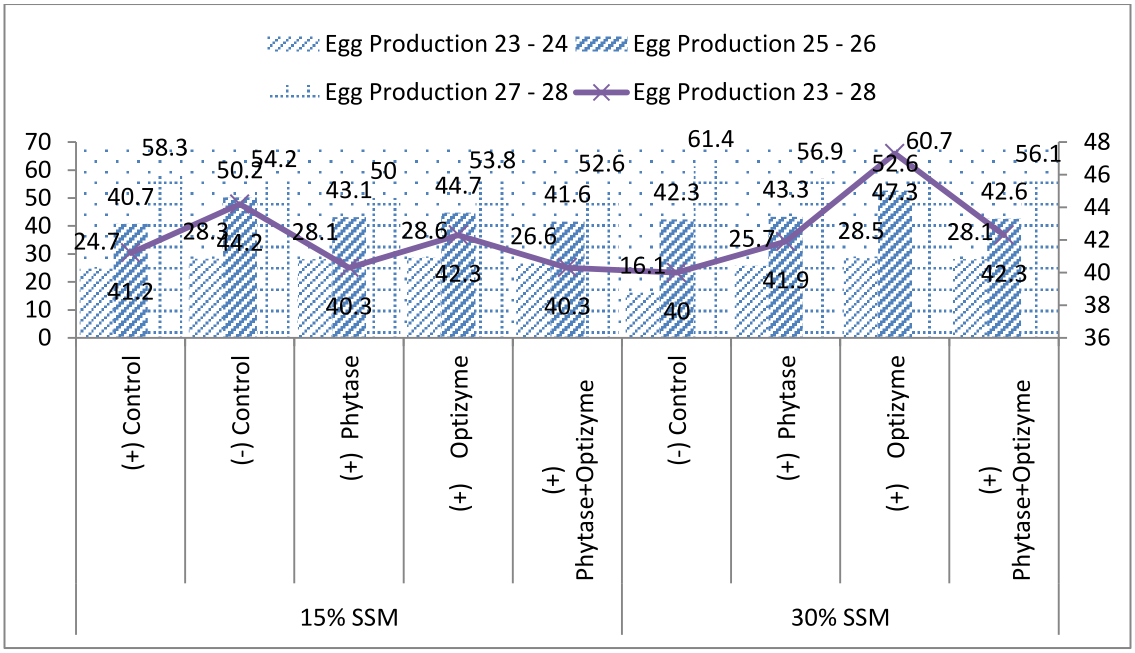

Figure 3: shows the relationship between the level of SM and enzymes on laying rate.

Evidently, there was a significant effect of the interrelation among SM and enzyme supplementation on laying rate during 25-26 and 23-28 week of age, also the impact approached significant ($P<0.08$) during 23-24 week of age. However, the effect of the interrelation was not significant only during only 27-28 week of age. For the whole part of early laying period, results indicated that inclusion of 15% SM in pullet's diets during 12-21 week of age increased laying rate by 7.3 and 10.5% compared to the unsupplemented control and 30% SM basal diet. The outcomes showed that when compared to the negative control, pullets given 30% SM diets had a laying rate that was 18.3% higher thanks to enzymes, and particularly multienzymes. This group logged the highest rate of laying among the experimental group throughout the experimental period and had also a better laying rate by 14.8% than the positive control. Also, Abd El-Hack *et al*. (2018) discovered that the inclusion of enzymes enhanced the rate of egg production, with the extent of the improvement varying based on the diet's composition. The improvement due to multienzymes and phytase on performance of laying hens was also reported by Abd El-Hack *et al.* (2024).

Egg weight

There was a significant increase in egg weight when feeding a diet containing 15% sesame meal (SM) during the 23-24 week of age ($P<0.07$) and 25-26 week of age ($P<0.005$) compared to the control group. Additionally, pullets fed a diet with 30% SM showed a significant increase in egg weight during the 25-26 week of age compared to the control diet, although the differences from those fed 15% SM were not significant. Egg weight values during the 27-28 and 23-28 week of age were not significantly affected by the level of SM. In accordance with the present results, Sulaiman *et al.* (2017) found that egg weight was not significantly affected by dietary inclusion of sesame meal for hens over 50 weeks of age, whilst significantly decreased egg weight of 20 week old hens. Also, Diarra and Usman (2008) concluded that dietary sesame meal up to 50% for laying hens did not significantly affect egg weight. It could be concluded that SM level up to 30% in pullets diets did not significantly affect egg weight during early part of laying period, indicating that sesame meal (SM) could be utilized as an energy source in isocaloric isonitrogenous pullets' diets during 12-22 week of age without adverse effect on egg weight.

Table 7: Shows the impact of different dietary levels of SM and the inclusion of phytase, Optizyme, or a combination of both on the egg weight of White Leghorn hens between 23-28 weeks of age.

Treatments	Egg weight (g)			
	23-24	25-26	27-28	23-28
Effect of SM levels				
0.0	31.7	38.2[b]	41.6	37.1
15	34.5	39.9[a]	41.4	38.6
30	31.9	40.2[a]	41.4	37.9
SEM	0.92	0.31	0.19	0.33
P value	0.07	0.005	0.09	0.21
Effect of additives				
Unsupplemented control	31.2	39.6	41.6	37.5
Phytase	34.3	39.6	41.2	38.4
Optizyme	33.7	40.1	41.4	38.4
Phytase + Optizyme	33.9	40.2	41.4	38.5
SEM	1.06	0.36	0.18	0.38
P value	0.061	0.094	0.07	0.055
Sesame meal × treatment				
P value	0.09	0.23	0.08	0.07

[a-c] Means within a column not sharing similar superscripts are significantly different (P<0.05).

The results of the study on the effect of enzymes on egg weight during the early laying period (23-28 weeks of age) are summarized in Table 6. The data show that the addition of enzymes did not have a significant impact on egg weight at different time points within this period. However, there was a slight increase in egg weight of approximately 2.5-3.0 grams (8.0-9.9%) with enzyme supplementation at 23-24 weeks of age and about 1 gram (2.4%) for the entire early laying period. Previous studies have shown mixed results regarding the effect of enzymes on egg weight. Jia *et al.* (2008) reported a significant increase in egg weights with enzyme supplementation at 50% production. Alinejad *et al.* (2023) found that enzymes, particularly phytase, increased egg weight in Japanese quail hens. In contrast, Mehmet *et al.* (2005) did not observe a significant impact on egg weight with a mixture of multienzymes in laying hens. In addition, there was no synergistic effect on egg weight when Optizyme and phytase were combined, indicating that the two compounds had no cumulative effect.

Table 7 presents the findings of how the interaction of SM level and enzymes affects egg weight. Evidently, during the entire early laying period as well as during any examined time, there was no discernible interaction between SM and enzyme supplementation and egg weight. The data for the entire trial period showed that adding 30% SM to the meals of pullets aged 12 to 21 weeks did not have an impact on egg weight when compared to the positive control.

For the whole part of early laying period, results showed that pullets fed enzyme supplemented 15% or 30% sesame meal produced heavier egg weight than those of their respective the positive control. These data confirm the positive effect of enzymes on nutrient availabilities reported by (Kanani *et al*, 2018, Rezaeipour *et al.*, 2016 and Al Harthi and El Deek 2009).

Egg mass

The results in Table 8 indicated that the inclusion level of sesame meal (SM) had a significant effect on egg mass during the early part of the laying period. Egg mass values at 23-24 and 23-28 weeks of age were not significantly different based on the dietary SM level. However, there was a noticeable decrease in egg mass at 27-28 weeks of age when the diet contained 15% SM compared to the control group or the group with 30% SM. Overall, egg mass was not significantly impacted by the level of SM throughout the early laying period (23-28 weeks of age), and egg mass remained similar across all experimental groups. These results are in agreement with those reported by Um and Paik (1999) who found that hens fed diet containing 30% SM had similar egg mass to that of the control. Besides, Hens fed SM at 12.6% or 4.7 to 18.8% of dietary CP and control hens fed SBM showed no differences in egg mass, (Mamputu and Buhr 1995).

The results for the impact of enzymes on egg mass during the early part of the laying period (23-28 weeks of age) are presented in Table 7. There was no significant effect of enzymes on egg mass during weeks 23-24 and 27-28. However, multienzymes did show a significant improvement in egg mass during weeks 25-26 compared to the other groups. Additionally, multienzymes led to a 10.6% and 8.5% increase in egg mass during weeks 23-28 compared to phytase alone or with multienzymes, respectively. These findings suggest that multienzymes enhance nutrient availability for egg formation. These results are in agreement with the results by Kanani *et al.* (2020).

Table 8: shows the impact of different dietary levels of SM and the inclusion of phytase, Optizyme, or a combination of both on the egg mass of White Leghorn hens between 23-28 days of age.

Treatments	Egg mass (g)			
	23-24	25-26	27-28	23-28
Effect of SM levels				
0.0	8.68	16.1	24.3^{a}	16.3
15	9.9	17.9	21.8^{b}	16.5
30	8.75	18.2	24.4^{a}	17.1
SEM	0.59	0.53	0.66	0.35
P value	0.191	0.08	0.009	0.076
Effect of treatments				
Unsupplemented control	8.2	17.8^{b}	24.2	16.7^{ab}
Phytase	9.3	17.1^{b}	22.1	16.1^{b}
Optizyme	10.2	19.5^{a}	23.7	17.8^{a}
Phytase + Optizyme	9.7	16.9^{b}	22.5	16.4^{b}
SEM	0.68	0.61	0.76	0.40
P value	0.151	0.01	0.088	0.03
Sesame meal × treatment				
P value	0.08	0.01	0.159	0.05

$^{a-c}$ Means within a column not sharing similar superscripts are significantly different (P<0.05).

The results in Figure 4 show the effect of the interaction between SM level and enzyme supplementation on egg mass. There was a significant impact of this interaction on egg mass during weeks 25-26 and 23-28, with a near-significant effect during week 23-24 (P<0.08). However, the interaction did not have a significant effect on egg mass during week 27-28. Overall, during the early laying period, adding 15% SM to pullets' diets from weeks 12-21 increased egg mass by 8.0% and 8.6% compared to the unsupplemented control and the 30% SM basal diet, respectively. Alencar *et al* (2022) also found similar results, reporting that including 12% to 24% of sunflower meal in the diets of brown-egg laying pullets did not have any lasting impact on their productive performance at the start of the laying phase.

Pullets that were fed a diet containing 30% SM with multienzymes exhibited a 15.4% increase in egg mass compared to the negative control group. They surpassed the positive control group by 14.7% and had the highest egg mass among all the experimental groups. This enhancement in egg mass as a result of multienzymes was consistent with findings from previous studies. Al-Kanaan (2022) demonstrated a significant correlation between enzyme supplementation and the highest level of barley inclusion on egg production in broiler breeder hens. Similarly, Wang *et al*. (2022) observed that the addition of enzymes improved laying rate, with the response being influenced by the composition of the diet.

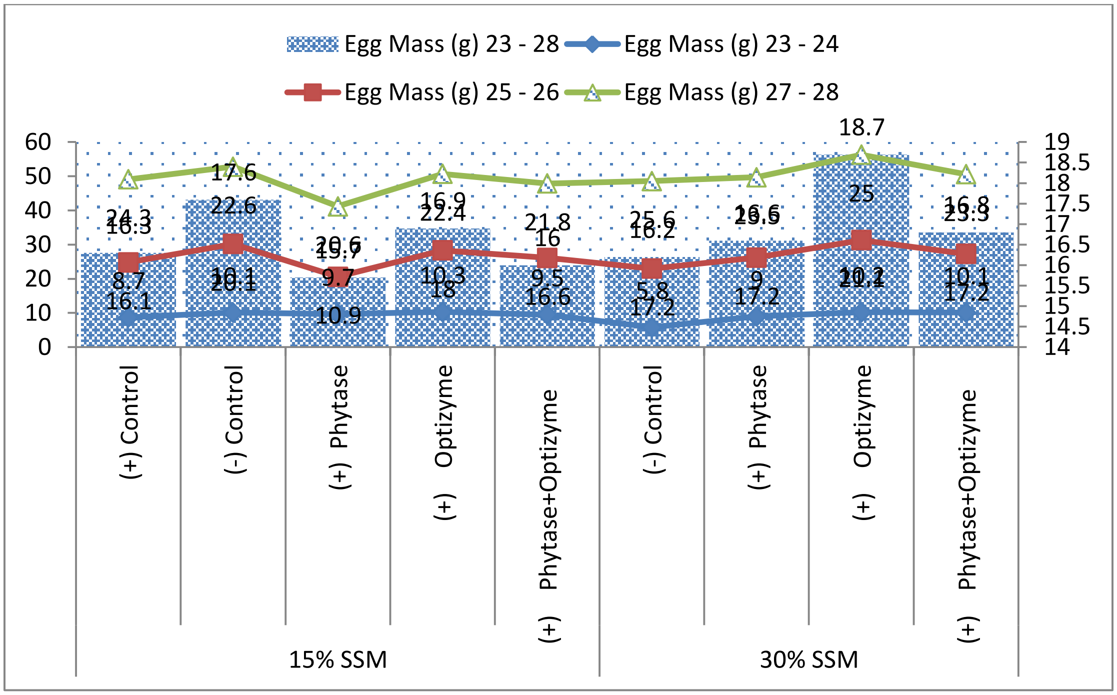

Figure 4: Effect of the interrelation among Sesame Meal level and enzymes on egg mass

CONCLUSSION

Supplementing Optizyme at 15% and 30% in the SM diet can be provided to pullets during the rearing phase (12-21 weeks of age) and the initial laying period (21-28 weeks of age) without negatively impacting their performance. This enzyme blend enhances the utilization of NSP in SM, which is a valuable protein source. By substituting soybean meal with SM and optimizing its utilization through the enzymes, chickens can benefit from improved nutrition.

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