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RESEARCH ARTICLE
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The effect of replacing yellow corn with potato starch with or without enzymes mixture in laying hens' feed on egg quality characteristics.

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ABSTRACT

Potato starch obtained as waste from potato gypsum production was used and introduced into the feed of laying hens as a substitute for yellow corn in an experiment conducted in the poultry field of the Animal Production Department / College of Agriculture / University of Kirkuk. It lasted for 90 days, divided into 6 production periods, starting from 2/1/2024 until 15/4/2024, to know its effect on some qualitative characteristics of the produced eggs. A flock of 112 laying hens of the Lohmann Brown breed, 50 weeks old, was us.ed. They were randomly distributed into 7 treatments with 4 replicates per treatment. Each replicate contained 4 hens. The treatments were: T1: contained a standard feed of 100% yellow corn. T2: 25% potato starch as a substitute for yellow corn. T3: 50% potato starch as a substitute for yellow corn. T4: 75% potato starch as a substitute for yellow corn. T5: 25% potato starch as a substitute for yellow corn + enzyme mixture. T6: 50% potato starch as a substitute for yellow corn + enzyme mixture T7: 75% potato starch as a substitute for yellow corn + enzyme mixture, the results of the statistical analysis showed no significant effect ($P \leq 0.05$) between the experimental treatments and the control treatments in both the relative weight of the yolk and white, while the significant superiority of the partial starch replacement treatments with the addition of enzymes T6, T7 was achieved for the yolk index and Unit Haugh compared to the other experimental treatments and the control treatments.

***Keywords*:** Potato Starch, laying hens, egg quality, mix enzymes.

Introduction

Given that global production of table eggs has increased by up to 24.4% over the past decade, reaching approximately one million tons in 2018, and is expected to rise further due to the increasing demand for animal protein [3] . It is one of the best sources of animal protein, due to its high-quality protein content, in addition to its low economic cost[4][5] . Hence, there is a need for increased attention to poultry nutrition, as it is the main factor on which the production process depends, as it accounting for about 60-65% of the total costs of egg production projects [6][7] the availability of feed resources and rising prices have been significant constraints on production, contributing to increased production cost [8] . This has prompted nutrition experts to seek solutions to the economic problems associated with the poultry industry, which relies heavily on energy and protein sources such as corn and soybeans. Corn contains 70-75% starch, which is the main source of energy in poultry feed [9]. Among the alternative solutions researchers have turned to is the use of unconventional feed materials particularly those produced as by-products of the food industry such as vegetables and fruits, which can reduces the economic cost and mitigate environmental pollution, that they yield the same production [10]. Feed additives such as enzymes, amino acids, and natural and synthetic antioxidants can also be utilized to enhance the nutritional value of these materials, maximizing benefits for the birds consuming them[11] [12] Potato starch is one of the most important by-products representing the main storage compound in potatoes, comprising about 10-25% of their content and around 80% of their dry weight [13]. Due to its unique properties and high quality, it is used in various food and industrial applications . potato starch differ from other types of starch, as it is considered a pure starch with a lower contain of fat and protein [14]. Therefore, this study aimed to investigate the effect of partial replacement of potato starch with or without an enzyme mixture on the quality traits of eggs from Lohmann Brown laying hens.

Materials and methods

A total of 112 Lohmann Brown laying hens were used to conduct an experiment aimed at investigating the effect of partial substitution of potato starch Alternative to yellow corn, with or without enzymes, on the qualitative characteristics of the produced eggs. The experiment was carried out at the poultry farm affiliated with the Department of Animal Production, College of Agriculture, University of Kirkuk. The experimental period lasted for 12 weeks, starting from January 2, 2024, until April 15, 2024. This period was divided into production phases, each lasting two weeks. During this time, the birds were distributed into iron cages across seven treatments, with each treatment including four replicates. Each replicate consisted of four hens. The housing facility was equipped with a lighting system providing 16 hours of light per day, and the birds were fed at a rate of 15 grams/per//bird per day. The enzyme mixture used consists of : β- XYLANASE, CELLULASE, β-GLUCANASE, α-AMYLASE and PECTINASE it was added at a rate of 200 gm/ton according the recommendations producing company . Nutritional requirements were estimated according to the production guide for the Lohmann breed, taking into account the age of the birds and the production stage, as shown in the table (1) . At the end of each phase, eggs were collected 24 hours prior to conducting qualitative assessments. The experimental treatments were as follows: T1: Contained 100% yellow corn,T2: Partial substitution of potato starch at 25% replacing yellow corn, T3 : Partial substitution of potato starch at 50% replacing yellow corn, T4 : Partial substitution of potato starch at 75% replacing yellow corn, T5 : Partial substitution of potato starch at 25% + enzyme mixture, replacing yellow corn, T6 : Partial substitution of potato starch at 50% + enzyme mixture, replacing yellow corn, T7: Partial substitution of potato starch at 75% + enzyme mixture, replacing yellow corn. The Percentage weight of the yolk, yolk index, and Percentage weight of the white and Haugh unit were measured using the following equations:

$$Percentage\ of\ Yolk\ weight = \frac{yolk\ weight\ (gm)}{egg\ weight\ (gm)} \times 100$$

$$yolk\ index = \frac{yolk\ height(mm)}{yolk\ diameter(mm)} \times 100$$

$$Albumen\ Weight\ percentage = \frac{albumen\ weight(gm)}{egg\ weight\ (gm)} \times 100$$

Haugh unit = 100Log (H+7.57-1.7W 0.37)

H= albumen height(mm) W=egg weight (gm)

Statistical analysis

In accordance with the SAS program, statistical analysis was carried out using a completely randomized design (CRD) to examine the impact of the investigated parameters on the various features. [15] The following mathematical model is based on the significant differences between the means according to several levels at a significance level (0.05): use the mathematical model shown below [16]:

Yij = μ + Ti + eij

Yij = an observation

μ = overall mean effect

ti = true effect of the (Ti) treatment

eij = error term of the (Yj) unit receiving (i) treatment

i = a particular treatment

j = a particular replicate

Table (1) Feed components and their calculated chemical composition included in feeding laying hens.

Components of the feed	T1 control	T2 25% starch	T3 50% starch	T4 75% starch	25 T5% starch with enzyme mixture	50 T5% starch with enzyme mixture	75 T5% starch with enzyme mixture
Crushed yellow corn	33	24.75	16.5	8.25	24.75	16.5	8.25
Crushed wheat	30.38	27.45	30.3	21.33	27.45	30.83	21.33
Potato starch	zero	8.25	16.5	24.75	8.25	16.5	24.75
Soybeans	22	24.1	21.18	28.5	24.1	21.18	28.5

Protein center	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sunflower oil	1.4	2.7	2.7	4.5	2.7	2.7	4.5
Lysine	0.08	0.06	0.08	0.01	0.06	0.08	0.01
Methionine	0.17	0.19	0.18	0.01	0.19	0.18	0.21
limestone	10.02	10	10	9.95	10	10	9.95
DICAL	zero	zero	zero	0.06	zero	zero	zero

Wafi protein complex, contains 11% crude protein, 819.53 kal/kg, 3% crud fat, 2.5% lysine, 5.06% methionine+cysteine, 20.07% calcium, 10.46% phosphorus. The chemical composition of feed materials based on what was stated in the US National Research Council [17].

Results and Discussion

The yolk weight ratio represents the difference between the yolk weight and the total egg weight. Table (2) shows that the partial replacement of potato starch—with or without enzymes—as an alternative energy source to corn in the yolk weight ratio did not result in any significant differences compared to the experimental treatments and the control treatment during the first (50-51), second (52-53), third (54-55), fourth (56-57), fifth (58-59), and sixth (60-61) production periods. Thus, it yielded positive results compared to the control treatment.

Table (3) indicates that the results of the yolk index of the produced eggs were significantly affected The partial replacement treatments with enzyme supplementation showed a significant superiority ($P \leq 0.05$) in the first production period, with treatment T7 recording the highest value at 49.74%, compared to the control treatment, which recorded the lowest value at 43.19%.

In the second and third periods, no significant differences were observed between the experimental treatments and the control treatment. However, in the fourth period, the partial replacement treatments—with or without enzymes—showed significant superiority ($P \leq 0.05$), with treatment T7 recording the highest value at 51.28%, compared to the control treatment, which recorded the lowest value at 46.01%.

In the fifth period (T6, T7) significantly outperformed ($P \leq 0.05$) the other experimental treatments and the control treatment, recording the highest values at 50.83% and 53.11%, respectively. Meanwhile, the control treatment (T1) and the partial potato starch replacement treatment without enzymes (T2) recorded the lowest values at 45.03% and 47.83%, respectively, with no significant difference between them.

In the sixth period, the partial replacement treatments with enzyme supplementation (T6, T7) again recorded the highest values at 51.44% and 52.53%, respectively. The control treatment (T1) and the partial replacement treatments without enzymes (T2) recorded the lowest values at 45.68% and 45.77%, respectively, with no significant difference between them.

These results were reflected in the overall experiment average, where a significant superiority ($P \leq 0.05$) was observed for (T6, T7), which recorded the highest values at 49.82% and 50.84%, respectively, compared to the control treatment (T1) and the partial replacement treatment without enzymes (T2), which recorded 46.53% and 45.11%, respectively, with no significant difference between them

Table (2) Effect of experimental treatments on the relative weight of the yolk (%) (mean ± standard error)

Perid T	1	2	3	4	5	6	Average of egg mass
T1	26.60±0.2	27.48±0.4	26.46±0.3	26.84±0.6	26.44±0.8	27.12±0.5	26.82±0.2 ab
T2	25.29±1.6	26.83±0.8	26.04±0.7	25.55± 1.1	25.41±0.5	26.34±0.8	25.88±0.5 b
T3	26.46±0.7	26.48±0.9	26.33± 0.5	26.37±0.5	26.85±0.8	26.44±0.3	26.37±0.2 ab
T4	27.10±0.4	26.78±0.5	25.95±0.5	26.50±0.9	26.67±1.5	25.01±0.6	26.33±0.2 ab
T5	26.15±1.3	27.02±1.1	26.70±1.0	27.01±0.4	26.19±0.6	27.72±0.7	26.80±0.2 ab
T6	26.68±0.7	26.06±1.5	27.33±1.1	27.50±0.7	27.59±0.4	26.47±1.1	26.93±0.3 a

T7	27.46±0.5	27.16±1.0	26.93±0.5	26.29±0.4	26.30±0.7	25.44±0.8	26.64±0.2 ab
Moral level	N.S	N.S	N.S	N.S	N.S	N.S	0.05

Table (3) The effect of experimental treatments on the yolk index (%) (mean ± standard error)

Perid T	1	2	3	4	5	6	Average of egg mass
T1	43.19±1.3 b	44.89±2.4	45.89±1.4	46.01±0.3 b	45.03±0.6 b	45.68±0.9 b	45.11±0.2 b
T2	45.48±0.7 ab	45.01±2.5	46.62±1.7	48.48± 0.4 ab	47.83±2.2 b	45.77±0.9 b	46.53±1.2 b
T3	46.59±1.2 ab	45.98±0.6	46.88± 0.8	48.86±0.7 ab	49.90±0.8ab	47.59±0.9 ab	47.63±2.0 ab
T4	47.58±0.8 ab	46.98±2.3	48.03±1.2	49.12±0.8 ab	50.07±2.1ab	48.73±2.2 ab	48.41±0.7 ab
T5	47.91±1.4 ab	47.14±3.1	48.10±1.8	50.61±0.8 ab	50.54±1.4 ab	50.45±1.8ab	49.12±0.8 ab
T6	48.77±0.9 ab	48.35±1.0	48.64±1.1	50.91±0.9 ab	50.83±0.5 a	51.44±1.6 a	49.82±1.9 a
T7	49.74±0.9 a	48.53±0.8	49.89±1.9	51.28±0.8 a	53.11±0.6 a	52.53±1.7 a	50.84±1.8 a
Moral level	0.05	N.S	N.S	0.05	0.05	0.05	0.05

From Table (4), it is noted that there were no significant differences at the significance level (P≤0.05) in the percentage of egg weight between the experimental treatments and the control treatment during all production periods, which include the first period (50-51), the second period (52-53), the third period (54-55), the fourth period (56-57), the fifth period (58-59), and the sixth period (60-61), and this was reflected in the general average of the percentage of egg weight. It is noted from Table (5) that the results of the unit for the produced eggs were significantly affected (P≤0.05) by the treatments of partial replacement of starch with and without enzymes as a substitute for yellow corn during the production periods of the experiment, except for the first and fourth production periods in which no significant differences were observed. In the second period, the treatments of partial replacement with or without enzymes T2, T3, T4, T6, T7 were significantly superior (P≤0.05), as these treatments recorded 91.75, 92.09, 90.87, 89.79, 89.87% respectively, while the treatment of partial replacement of starch with the addition of enzymes T5 and the control treatment T1 recorded the lowest values, reaching 84.34, 85.19% respectively.

Table (4) The effect of experimental treatments on the relative weight of layers (%) (mean ± standard error)

Perid	T	1	2	3	4	5	6	Average of egg mass
T1		62.67±0.4	60.76±0.5	61.99±1.0	62.38±1.2	61.37±1.9	61.31±1.1	61.74±0.5
T2		63.92±2.4	61.83±0.6	62.47±0.5	62.84±1.1	62.58±1.0	62.36±2.4	62.66±0.9
T3		62.59±0.6	62.18±1.3	62.14±0.6	61.39±1.1	61.02±0.8	61.01±0.6	61.72±0.2
T4		62.70±0.4	61.79±0.8	62.31±1.2	61.51±1.2	61.66±2.6	62.30±0.6	62.04±0.4
T5		63.92±1.6	61.36±1.8	63.03±0.9	61.67±0.9	68.53±0.7	61.07±1.1	62.14±0.1
T6		63.15±1.2	62.02±1.3	61.99±0.8	60.79±0.2	61.81±1.2	61.97±1.8	61.95±0.3
T7		62.26±1.8	61.10±0.7	61.84±2.1	62.30±1.3	62.68±3.1	63.77±0.9	62.32±1.3
Moral level		N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (5) The effect of experimental treatments in Haugh unit (mean ± standard error) of laying hens.

Perid T	1	2	3	4	5	6	Average of egg mass
T1	80.75±1.3 a	85.19±2.6 bc	84.07±0.5 b	86.94±2.1	89.08±0.5 c	89.71±0.3 c	85.96±0.7 c
T2	83.68±2.3 a	91.75±1.3ab	89.12±1.6 a	92.45±1.3	90.85±0.4 bc	93.13±0.5 b	90.16±0.2 ab
T3	82.04±0.1 a	92.09±0.9 a	93.05±1.8 a	92.56±1.3	91.73± 0.7 b	94.39±0.5 bc	90.98±0.4 a
T4	80.64±2.0 a	90.78±0.8abc	89.03±1.5 a	86.79±1.5	90.70±0.9 bc	95.00±0.5 bc	88.82±0.1 b
T5	79.87±2.7 a	84.34±3.5 c	89.40±1.0 a	89.32±4.4	92.55±0.9 b	96.12±1.0 ab	88.60±0.4 b
T6	80.68±2.5 a	89.79±1.1abc	90.01±2.6 a	89.79±3.0	95.03±0.1 a	95.67±0.7 ab	90.16±0.5 ab
T7	79.18±1.6 a	89.81±2.3abc	91.91±0.7 a	92.81±0.5	95.40±0.2 a	97.29±0.6 a	91.07±0.3 a
Moral level	N.S	0.05	0.05	N.S	0.05	0.05	0.05

From the results of egg quality characteristics, the studied traits were not affected during the production periods for the partial starch replacement treatments (second, third, and fourth) compared to the control treatment. This reflects the positive effect of potato starch and its high nutritional value as a direct source of glucose for metabolic energy generation [18] . Starch granules contain high amounts of phosphate, which makes them highly phosphorylated compared to starches obtained from other forage crops [19] .800 ppm of associated phosphate [20]. The significant superiority in some qualitative traits observed in treatments T5, T6, and T7 can be attributed to the role of the enzymes comprising the enzyme mixture used in our current study and their ability to improve the availability of nutrients in feedstuffs such as corn, wheat, and soybeans [21][22]. The action of enzymes may focus on anti-nutritional factors such as complex sugars (fiber), phytate, and anti-protein digestive enzymes, which negatively affect egg quality traits [23] . Our study revealed that the components of the enzyme mixture had a positive effect on some qualitative traits, including yolk index and Haugh unit .

Studies have demonstrated the role of phytase on metabolizable energy, protein digestibility, and amino acid metabolism. Its effect on phytate, which is widely present in grains and legumes such as wheat and corn [24][25] . in addition to the role of protease and xylanase enzymes in influencing the anti-factors present in both soybean meal and polysaccharides (fibers) in wheat, thus obtaining an abundance of nutrients that were released by digestive enzymes, which is positively reflected on the components of the egg and its qualitative characteristics [26][27] .

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تأثير استبدال الذرة بنشأ البطاطا مع أو بدون مكملات انزيمية في علائق الدجاج البياض على صفات جودة البيض.

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الخلاصة

تم استخدام نشأ البطاطا الذي تم الحصول عليه كمخلفات لصناعة جبس البطاطا و ادخاله في عليقة الدجاج البياض بديلا عن الذرة الصفراء في تجربة اجريت في حقل الطيور الداجنة التابع لقسم الانتاج الحيواني / كلية الزراعة / جامعة كركوك و استمرت لمدة 90 يوما مقسمة الى 6 فترات انتاجية ابتداءً من 1/2 /2024 لغاية 2024/4/15 لمعرفة تأثيره على بعض الصفات النوعية للبيض المنتج و استخدم فيها قطيع مكون من 112 دجاجة بياضة سلالة لوهمان البني بعمر 50 اسبوع وزعت عشوائياً الى 7 معاملات بواقع 4 مكررات للمعاملة يحتوي المكرر على 4 دجاجات و كانت المعاملات *T1*: احتوت على عليقة قياسية 100% ذرة صفراء *T2: 25%* نشأ البطاطا بديلا عن الذرة الصفراء *T3: 50%* نشأ البطاطا بديلا عن الذرة الصفراء *T4: 75%* نشأ البطاطا بديلا عن الذرة الصفراء *T5*: % نشأ البطاطا بديلا عن الذرة الصفراء+ خليط الانزيمات *T6*: % نشأ البطاطا بديلا عن الذرة الصفراء+ خليط الانزيمات *T7: 75%* نشأ البطاطا بديلا عن الذرة الصفراء+ خليط الانزيمات ، اظهرت نتائج التحليل الاحصائي عدم حصول تأثير معنوي ($P\leq0.05$) بين معاملات التجربة ومعاملات السيطرة في كل من الوزن النسبي للصفار والبياض بينما حصل التفوق المعنوي لمعاملات الاستبدال الجزئي للنشأ مع اضافة الانزيمات *T7* , *T6* بالنسبة لدليل الصفار ووحدة هو مقارنة بمعاملات التجربة الاخرى ومعاملات السيطرة وهذا التفوق ناتج عن استخدام خليط الانزيمات الذي أثر على المواد العلفية الداخلة بتكوين العليقة وادى الى تحسينها وزيادة جاهزية العناصر الغذائية.

الكلمات المفتاحية: نشأ البطاطا ، دجاج بياض ، نوعية البيض ، خليط الانزيمات.