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تقييم مسحوق مخلف نوى البلح كبديل للذرة الصفراء في أعلاف الدجاج

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Valuation date seed waste meal as partial supplementation with corn yellow in pullet diets

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الملخص:
الهدف من هذه الدراسة هو تحديد القيمة الغذائية لمخلفات نوى التمور، وتقييم الأحماض الدهنية والأحماض الأمينية لهذه المادة، ودراسة مدى سهولة هضم الأحماض الأمينية (تجربه 1). في التجربة الثانية، تم فحص الأمعاء الدقيقة للدجاجات التي تناولت مسحوق مخلف نوى البلح كأهم مصدر للطاقة من الناحية النسيجية. التجربة 3 درست تأثير مستويات مختلفة (0%، 7.5%، و15%) من مسحوق مخلف نوى البلح في أعلاف الدجاج على الهضم.
أظهرت النتائج أن مسحوق نوى البلح : يحتوي على 96,33% من المادة الجافة، و7,2% من البروتين الخام، و8,9% من المستخلص الكحولي للدهن، و3.61% من الرماد الخام، و10.61% من الألياف الخام، مع 42.79% من الكربوهيدرات الذائبة، و20.83% من الالياف المتعادلة، و21.96% من الهيميسيلولوز. يحتوى مخلف نوى البلح على 69.62% من المستخلص الخالي من النيتروجين.
الأحماض الدهنية الرئيسية في مخلف نوى البلح كانت حمض الأوليك (33,2%)، حمض اللينوليك (29,1%)، حمض البالمتيك (12,34%)، وحمض اللوريك (11,2%). تراوحت الأحماض الدهنية المشبعة، والأحماض الدهنية الأحادية غير المشبعة، والأحماض الدهنية المتعددة غير المشبعة بين 27-44,3%، و41,45-49,2%، و14-21,8%، على التوالي.
كانت الأحماض الأمينية الكبريتية الكلية في مخلف نوى البلح ،05% ميثيونين، 0,13% سيستين، 0,32% ليسين، 0,73% أرجينين، 0,19% ثريونين، و0,07% تريبتوفان.
أدى إضافة انزيم الفيتيز إلى التخفيف من الأثر السلبي لمخلف نوى البلح على قابلية هضم الأحماض الأمينية.
أظهرت الفحوص النسيجية للقطاعات التشريحية لأمعاء الدجاجات التي تناولت مخلف نوى البلح آثارًا سلبية على التركيب التشريحي للأمعاء، لا سيما في منطقة الاثني عشر والأمعاء الوسطى، مع تأثير أقل على القولون. أدى اضافة مكملات الأحماض الأمينية إلى انخفاض الطاقة القابلة للتمثيل الواضح مقارنةً مع إضافات غذائية أخرى وصفات القطاعات الهستولوجية لهذى الاجزاء من الامعاء.
معاملات الهضم للعناصر الغذائية اوضحت ان انزيم الفيتيز حسّن بتحسين تخزين الرماد في المعاملات التي تحتوي على 7,5% و15% من مخلف نوى البلح. بينما تأثيرات اضافة الإنزيمات المتعددة، والأحماض الأمينية، والعلف المكعب في أعلاف الدجاجات التي تحتوى على مخلف نوى البلح ادت الى حدوث انخفاض ملحوظ في معامل هضم الرماد مع زيادة مستوى مخلف نوى البلح بقيمه توازى 18,9% مقابل 8و4% لانزيم الفيتيز.
الكلمات المفتاحية: وجبة مخلفات نوى التمر، الصيصان، الفحص النسيجي، الهضم.

Abstract:
The study's objectives were to determine the date seed waste meal's (DSWM) nutritional value, examine the fatty acid and amino acid profiles of the material, and gauge how easily amino acids could be digested (Experimental 1). In Experiment 2, the small intestines of chicks given DSWM as their main source of energy were examined histopathologically. Experimental 3 investigated the impact of different levels (0%, 7.5%, and 15%) of DSWM in poultry diets on digestibility.

Results revealed that DSWM contains 96.33% dry matter, 7.2% crude protein, 8.9% ether extract, 3.61% crude ash, and 10.61% crude fiber, with 42.79% neutral detergent fiber, 20.83% acid detergent fiber, and 21.96% hemicellulose. DSWM also contains 69.62% nitrogen-free extract. The main fatty acids in DSWM were oleic acid (33.2%), linoleic acid (29.1%), palmitic acid (12.34%), and lauric acid (11.2%). Saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids ranged from 27.0-44.3%, 41.45-49.2%, and 14.0-21.8%, respectively. Total sulfur amino acids in DSWM were 0.05% methionine, 0.13% cystine, 0.32% lysine, 0.73% arginine, 0.19% threonine, and 0.07% tryptophan.

Phytase supplementation mitigated the negative impact of DSWM on amino acid digestibility. Histopathological examination revealed adverse effects of DSWM on the intestinal structure, particularly in the ileum and jejunum, with less impact on the colon. Amino acid supplementation decreased apparent metabolizable energy compared to other dietary additives and crumble treatments.

Phytase consistently improved ash retention in diets with 7.5% and 15% DSWM. The effects of multienzymes, amino acids, and crumble varied based on the DSWM level, with crumble showing a decreasing effect as DSWM level increased (18.9% vs. 8.4%).

Keywords: Date seed waste meal-chicks-histopathology-digestibility

1. INTRODUCTION

Dates (*Phoenix dactylifera L.*) are highly popular in Middle Eastern countries, with over 70% of the world's production coming from this region. According to the FAO, global date production reached a peak of 4,492,000 metric tons in 2022. Iran is the largest producer at 775,000 MT, followed by Egypt (695,000 MT), Saudi Arabia (697,000 MT), Pakistan (565,000 MT), Algeria (375,000 MT), and the UAE (290,000 MT). Other significant producers include Libya, Morocco, Sudan, Tunisia, China, Oman, Yemen, Qatar, Bahrain, the USA, and Jordan (FAO, 2022). Approximately 20% of the dates produced are inedible and unsuitable for human consumption due to poor quality. The average weight of date seed waste meal is around 10% of the total date weight. Currently, there is limited utilization of this waste in Egypt. It is possible, from an economic and environmental perspective, to consider date waste as a partial replacement for imported yellow corn as an energy source in poultry feeds.

But thus far, there have been no encouraging outcomes from the inclusion of DSWM in poultry diets. Its high fibre content, which lowers digestion and nutrient availability, could be the cause of this. Furthermore, it's possible that the reduced amounts of vital amino acids—like lysine, methionine, leucine, and isoleucine—will not be enough to meet the needs for chick growth, (Sadeghi et al 2015 and Onwudike, 1986).

Also, to keep with the advances made in feed-enzymes industry and the recent knowledge in amino acid nutrition, diets containing the date seed waste meal were supplemented with phytase, and/or multienzymes or amino acids. Using this method, it was possible to increase the nutritional value of diets with varying amounts of DSWM. Also, the impact of crumble treatment was investigated, (AI-Harthi, 2006 and Cerrate et al 2009).

2.MATERIALS AND METHODS

The study was conducted at the Poultry Research Station of the Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, from January to April 2024.

Date Seed Waste Meal assessment:

The date seed meal was processed to fit the needs of the diet formulation after being obtained from a private enterprise in the El-Wadi El-Gaded Governorate, Egypt. The date seed waste meal's approximate analysis was conducted using the A.O.A.C. (2012) methodology.

Fatty acids resolves:

The DSWM fatty acid profile was determined as follows:

Separation and abstraction of fatty acids:

The fatty acids were prepared according to the method of Brockerhoff (1965) as follows:

Overnight at room temperature, alcoholic potassium hydroxide (20% w/v) was used to saponify the lipid samples. Following a quantitative transfer of the contents into a little separating funnel, the unsaponified components were eliminated. Using 20% v/v HCl, the aqueous layer was made acidic, and petroleum ether was used three times to extract the freed fatty acids. Acid methyl orange was used to show that the combined petroleum ether extracts had been successively washed with distilled water until the washings were no longer acidic. After filtering and drying the petroleum ether extract over anhydrous sodium sulphate, the solvent was removed with a water bath. The fatty acids were methylated by adding small portions of a diazomethane solution (Vogel, 1975). After a few minutes at ambient temperature, the mixture was placed over a warm water bath to allow the solvent to evaporate. After dissolving the methyl esters of fatty acids in chloroform, aliquots of this solution were subjected to Gas-Liquid Chromatography analysis (GLC).

Separation of fatty acid methyl esters by (GLC):

1. The methyl esters of fatty acids were derived from standard acids, and various samples were analyzed using the method outlined by Radwan (1978) with a Unicam GLC Model: Shimadzu – 4CM (PFE) equipped with a PID detector and a glass column measuring 2.5 m in length and 3 mm in inner diameter.
2. The analysis was conducted under the following conditions:

Column: DEGS on 80/100 Chromo Q	Column Temp. : 180º C isothermal
Detector Temp. : 270º C	N2 flow rate : 20ml / min
H2 flow rate : 75 ml / min	Airflow rate : 0.5 ml / min
Sensitivity : 16 X 10	Shart speed : 2.5 mm / min.

Bioassay for amino acids digestibility:

To find out how the addition of 750 U/kg of microbial Ronozyme phytase® to the date seed waste meal diet affected the true and apparent amino acid availabilities, a force-feeding assay based on the Sibbald (1979) method and reported by McNab (1990 and 1994) was utilised. Six male Bahieg birds, aged six months, were included in the trial; each treatment had six male birds kept in separate cages. The birds were force-fed 33 g of DSWM in mash form via the oesophagus using a metal funnel with an internal diameter of 5.5 mm after they had fasted for 36 hours. The feed was pushed into the crop using a metal rod and delivered through a tube, either with or without microbial phytase (Ronozyme®). As a control group, a different group was maintained fasting.

After being fed, the males were put back in their cages, and each cage had a plastic dish under it to catch waste. The excreta were quantitatively collected exactly 36 hours after feeding, freed of feathers and scattered feed, weighed, and dried in an oven at 65 to 70°C until they had around 10% moisture content.

The determination of amino acid values in DSWM and excreta from the fed group, as well as those from the fasted control group, was conducted at BASF AG, Germany.

Availability of the apparent amino acids and true amino acids were computed for each amino acid using the following equations:

% apparent amino acid availabilities = total amount of amino acid consumed - total amount of amino acid voided in excreta×100/ total amount of amino acid consumed

% true amino acids availabilities=total amount of amino acid consumed - (total amount of amino acid voided in excreta - amount of amino acid voided by fasted control males over a 36-hour period following a 36-hour fast)×100/ total amount of amino acid consumed

Impact of DSWM on histopathology of the small intestinal segments

We looked into DSWM's effects on the small intestine's histology in additional detail because of its documented detrimental effect on the digestion of amino acids. Two groups of ten chicks each were created from twenty-six-day-old chicks. A control group was given a diet consisting of 32.3% soybean meal, 64% yellow corn, and additional additives. The identical diet was given to the second group, but finely milled DSWM was used in place of yellow maize. Following a 28-day feeding period, five chicks from each group were put to death after body weight gain was determined. Hepatocellular, jejunal, and ileal samples were obtained for histological examination. Following a 48-hour fixation in 10% neutral buffered formalin, the specimens were rinsed with tap water and subjected to the standard paraffin embedding procedure. Under a light microscope, tissue sections were stained with haematoxylin and eosin and checked for histological alterations.

Digestibility Experimental:

1. This experiment aimed to investigate the impact of incorporating varying levels of date seed waste meal at 0%, 7.5%, and 15% with or without amino acid supplementation (increasing methionine, lysine, arginine, threonine, and tryptophan by 10% above the negative control), phytase, optizyme, or by enhancing date seed waste meal utilization through crumble of the diet. The National Research Council (1994), states that the basal ration was designed to satisfy the nutritional needs of chicks. Ad libitum food and unrestricted access to clean water were given to the chicks via stainless steel nipples secured in every cage,. Table 1 displays the ingredients.
2. 55 adult male chickens (5 per treatment) kept in separate metabolism cages to enable total excreta separation and collection were utilised in a digestibility experiment. To help the chickens become used to their cages, five days were allotted to each nutritional treatment. Data on feed consumption were recorded throughout a 5-day period while excreta were quantitatively collected. After being dried for 24 hours at 65°C in a forced-air oven, the excreta were weighed, finely crushed and kept in glass bottles for analysis after allowing the air to acclimatise. We conducted the nutrient analysis in compliance with the A.O.A.C. (2012) criteria.

Table1. Composition (Kg) of the diets (Experimental 3).

Iingredients	Date Seed Waste Meal (Kg)		
	0	75	150
Yellow corn	555	459	360
Soybean meal (44%)	379	385.5	392.5
DSWM	0.0	75	150
Soybean oil	15.8	30	47
Molasses	20	20	20
Dicalcium phosphate	18	18.2	18.1
NaCl	3	3	3
Limestone	5	5	5
Vit+Min Mix. [1]	3	3	3
Dl-methionine	1.2	1.3	1.4

[1]Vit+Min mixture provides per kilogram of diet: vitamin A, 12000 IU; vitamin E, 20 IU; menadione , 1.3 mg; Vit. D_3, 2500 ICU; riboflavin, 5.5 mg; Ca pantothenate, 12 mg; nicotinic acid, 50 mg; choline chloride, 600 mg; vitamin B_{12}, 10 μg; vitamin B_6, 3 mg; thiamine, 3 mg; folic acid, 1.0 mg; d-biotin, 50 μg. Trace mineral (milligrams per kilogram of diet): Mn, 80; Zn, 60; Fe, 35; Cu, 8; Se, 0.60.

The technique described by Jakobsen et al. (1960) to distinguish between urine and faecal nitrogen was used to calculate the faecal nitrogen. In a 300 ml beaker, 2 g of dried excreta and 70 ml of distilled water were combined. Subsequently, 6 ml of potassium permanganate (prepared by dissolving 3.16 g potassium permanganate in 97 ml distilled water) and 20 ml of sodium borate (made by dissolving 50 g boric acid and 100 g sodium hydroxide in 385 ml distilled water) were added. After agitating the mixture for an hour at 50º C in a water bath, it was left to settle for an additional hour at room temperature. Following a one-hour rest at room temperature, 30 ml of a 10% trichloroacetic acid solution was added and agitated with a glass rod. After that, the mixture was dried in an oven at 90º C after being filtered through 15 cm of ashless filter paper and cleaned four times with 25–30 ml of 2% trichloroacetic acid each time. The Kjeldahl method was used to calculate the nitrogen content. Gross energy was calculated at the Animal Production Research Institute in Giza using an adiabatic bomb calorimeter, and digestibility was evaluated by monitoring feed intake and faecal output.

The following equations were used for computing the values of metabolizable energy:

AME (Kcal/g) = (Energy intake - Energy output) / feed intake

Thus AME = [(feed intake × gross energy of feed) - (feaces x gross energy of feaces)] / feed intake.

Statistical analysis

Data of each trial were analyzed using one-way ANOVA of GLM procedure of SAS® (SAS 1996) using the following model:

$$Y_{ik}=\mu+D_i+e_{ik}$$

where Y is a single observation, μ is the general mean, D is the effect of the diet, and e is the error.

3. RESULTS AND DISCUSSION

Chemical analyses, fatty acids and amino acid profile of date seed waste meal:

Chemical analyses of date seed waste meal are presented in Table 2. The results show that DSWM contains significant amounts of nutrients, such as 7.22% crude protein (CP), 8.91% ether extract (EE), and 10.61% crude fiber (CF), with 42.79% neutral detergent fiber (NDF) and 20.83% acid detergent fiber (ADF), indicating a hemicellulose content of 21.96%. It also contains 3.61% crude ash and 69.62% nitrogen-free extract (NFE). These values are reliable with those reported by El-Deek et al. (2008), who found similar ranges of nutrients in date seed waste meal produced in Egypt.

In contrast, Hossain et al. (2014) reported lower levels of CP, ash, and EE in date pits (stone), while El-Kelawy and. El-Shafey (2017) found different values for CP, EE, CF, and NFE in DSWM. The non-starch fraction of DSWM contains various sugars, including mannose, glucose, allose, galactose, arabinose, xylose, rhamnose, and fructose. These findings are significant as they challenge the previous belief that the NFE in DSWM is mainly starch, leading to misconceptions about its similarity to grains.

Attia et al. (2021) also reported variations in the chemical composition of date pits, which could be due to factors such as fruit variety, maturation stage, and agronomic conditions. These differences highlight the importance of considering these factors when analyzing the nutrient contented of date seed waste meal. The fatty acid shape of DSWM indicates that it is a rich source of oleic acid (33%), linoleic acid (29%), palmitic acid (12.3%), and lauric acid (11%). The total saturated fatty acids in DSWM amount to 34.61%, while the total unsaturated fatty acids make up 65%, with monounsaturated fatty acids accounting for 33.8% and polyunsaturated fatty acids for 31.6%. These findings imply that a rich source of important fatty acids can be found in date seed meal. Hamza et al. (2016) found that the main unsaturated fatty acid in two varieties of date pits, Deglet Nour and Allig, was oleic acid (41.3-47.7%), Lauric acid (5.81–17.8%), linoleic acid (12.2-21.0%), palmitic acid (10.9–15.0%), and linolenic acid (0.81–1.68%) were the primary saturated fatty acids. The study found that the percentages of saturated, monounsaturated, and polyunsaturated fatty acids were, respectively, 27.0-44.3%, 41.45-49.2%, and 14.0-21.8%.

Table 2: date seed waste meal assessment

Nutrients		%	
DM,%		96.33	
CP,%		7.29	
EE,%		8.92	
CF,%		10.41	
ADF,%		21.83	
NDF,%		42.39	
ash,%		4.61	
NFE,%		68.62	
Fatty Acids		Sign	Taster%
Capric		C10:0	0.985
Lauric		C12:0	11.139
Myristic		C14:0	6.640
Palmtic		C16:0	12.350
Palmitolituc		C16:1	0.670
Stearic		C18:0	2.800
Oleaic		C18:1	33.15
Linoleaic		C18:2	29.05
Linolenic		C18:3	2.54
Arachidic		C20:0	0.659
Total saturated FA		%	34.61
Total unsaturated FA		%	65.405
Mon unsaturated FA		%	65.404
Poly unsaturated FA		%	65.303
Shape and digestibility of amino acids			
Amino acid	Total	Digestibility(—)	Digestibility(+)
Methionine,%	0.064	-95.661	-46.851
Cystine,%	0.141	-41.080	-19.090
Lysine,%	0.319	-9.206	20.682
Arginine,%	0.725	37.091	37.651
Threonine,%	0.188	-46.051	-21.780
Tryptophan,%	0.066	-34.182	-38.190

(—)=Without phytase (+) = with phytase

The essential amino acid composition of date seed waste meal includes 0. 0.064% methionine, 0.141% cystine, 0.319% lysine, 0.725% arginine, 0.188% threonine, and 0.066% tryptophan. This indicates that DSWM is deficient in essential amino acids, particularly methionine, lysine, and threonine. However, it can be used in chicken diets when a rich protein source is provided. These results are in line with what Alagawany et al. (2020) has reported.

Identical to the findings of Alkhoori et al. (2022), who discovered that date pits (Zahdi strain) contained 0.17% methionine, 0.31% lysine, 0.30% arginine, and 0.36% threonine, the amino acid profile of the date seed waste meal sample used in this investigation is identical. Vandepopuliere et al. (1995) observed that date pits contained 0.09% methionine, 0.10% cystine, 0.27% lysine, 0.18% threonine, and 0.06% arginine. Hossain, et al. (2014) found that DSWM contained 0.19% lysine, 0.20% methionine, and 0.12% cystine. Also, DSWM produced in the UAE contained 0.27% lysine, 0.09% methionine, 0.10% cystine, 0.18% threonine, 0.05% tryptophan, and 0.59% arginine.

Amino acid digestibility of date seed waste meal was negatively affected by phytase enzyme supplementation, as shown in Table 1. The only exception was arginine, possibly due to the higher crude fiber content and quality of date seed waste meal (DSWM).–The high crude fiber content may have a detrimental effect on the intestinal mucosa, leading to increased amino acid excretion. In this regard, Soltan (2009) indicated that fibre of PKM had a detrimental effect on growth of chicks which was alleviated with advance of age. While, Tabook et al (2006) reported that Substitution of maize by 10 and 15% date fibre significantly depressed AME. The histopathology revision in this work indicated that DSWM caused damage to the intestines, particularly in the duodenum and jejunum. These findings are consistent with previous studies by Nwokolo et al. (1976), Onwudike (1986), and Radwan et al. (2007), which stated that diets high in crude fiber negatively impacted amino acid availability. Nwokolo et al. (1976) also observed that palm kernel meal had the lowest amino acid availability among protein concentrates, attributing this to protein-sugar interactions in feedstuffs with low protein levels. Similarly, El-kelawy et al. (2023) found that DSWM had lower crude protein digestibility compared to yellow corn (48.12% vs. 86.63%), potentially leading to reduced amino acid availability for chicks. It is worth noting that the addition of phytase decreased the negative impact of DSWM on amino acid digestibility. This may be attributed to the role of phytase in enhancing the digestibility of amino acids and crude fiber (Attia et al., 2001 and Attia, 2003).

In conclusion, while creating diets for poultry, it is important to consider the substantial levels of minerals, amino acids, and fatty acids found in DSWM.

Histopathological study of the intestines of chicks fed a diet based on date seed waste meal:

It is essential to note that, when compared to chicks fed the control diet, there was a non-significant 25% decrease in body weight gain in those fed the date seed waste meal diet (Table 3). These results was paralleled with Ghasem et al (2014) Who suggested that date pits and olive pulps can be used, singly or in combination, at the level of 20% in the laying hens diets without negatively affecting their productivity and health.

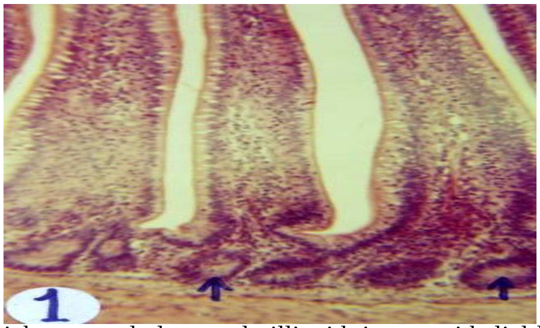
Table 3: Effect of replacement of DSWM instead of corn yellow on body weight (g) and body weight gain during 8 weeks – 12 weeks (Experimental 2)

	Control diet		DSWM	
	Body weight	Body weight gain	Body weight	Body weight gain
1	529	848	532	766
2	570	780	560	769
3	554	829	547	755
4	565	842	551	758
5	559	768	543	764
6	552	800	565	681
7	540	828	531	754
8	555	843	524	677
9	568	865	546	755
10	570	817	559	780
SEM	26.5	22.3	19.2	38.0
P value	0.0576	0.0823	0.0629	0.080

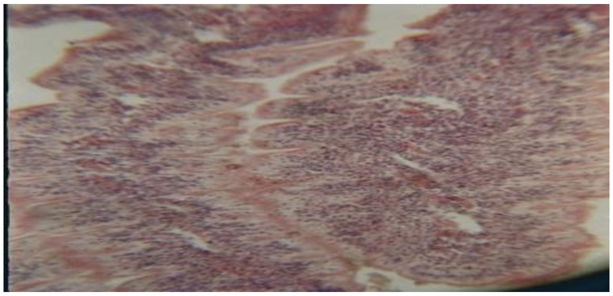
Histopathological examination of the intestinal mucosa of chickens fed on date seed waste meal in this study revealed several pathological alterations, particularly in the duodenum jejunum and Ileum. In the duodenum, compared to the control group (Slide A), alterations included shortened and thickened villi with congested vasculature and increased lymphocytic cellular reaction (Slide B). Some areas showed elongated microvilli with epithelial vacuolations and microvesicular formations (Slide C and Slide D). The normal intestinal crypts in the control duodenum (Slide E) were disrupted by large areas of lymphocytic reactions (Slide F). The normal tips of the intestinal villi in the jejunum of control chicks (Slide G) were altered in chickens fed on date seed waste meal. The elongated villi showed dilated blood and lacteal vessels, and the epithelium exhibited vacuolar degeneration (Slide H). The microvilli appeared elongated and showed extensive lymphocytic cellular reactions in some areas, along with epithelial vacuolations and microvesicular formations (Slide I). The deep intestinal crypts of the jejunum were also observed to be separated by an excess of lymphocytic reactions (Slide J). The lesions in the duodenum and jejunum are typically caused by hyperactive, degenerative, and inflammatory reactions triggered by the consumption of date seed waste meal, particularly its high fiber content. These findings are in consistent with the results of Sklan *et al*. (2003) regarding the effects of high dietary crude fiber intake.

The changes in epithelial vacuolations observed in the study are primarily linked to autophagic vacuolar formations, indicating intracellular digestion through lysosomal autophagy and suggesting under nutrition in affected birds (Yamauchi, 2002). These autophagic vacuoles serve as a useful indicator of the intestinal nutritional status (Yamauchi and Tarachai, 2000). In this experiment, the increased presence of epithelial vacuolations and micro vesicle formations in the duodenum and jejunum, the most active absorptive segments of the intestine, suggests a lower nutritional condition in chicks fed with date stones.

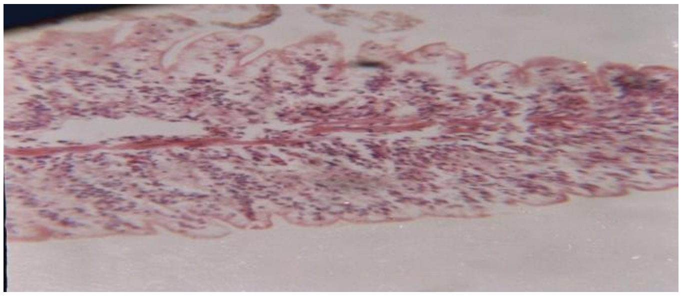
In the microscopic examination of the ileum of chicks fed a date seed waste meal diet, compared to the normal histological parameters in control chicks (Slide K), some less reactive alterations were observed. The main and most common of these alterations was the shortening and lowering of the height of the ileal villi (Slide L) compared to normal. The lacteal arteries' dilatation and congestion caused the shorter villi to become slightly thicker, but the epithelium remained active and had an abundance of goblet cells (Slides M and N), with very few or no vacuolations or microvesicular forms. The ileum of date stone-fed chicks showed less degenerative and inflammatory reactions in the ileum, which suggests that the ileum is affected by nutritional conditions. This may be because the ileum normally has an inactive absorptive function, which makes it less reactive to nutritional conditions (Yamauchi et al., 1996). The excess goblet cell formation also indicates the active secretory function of mucus in these cases.



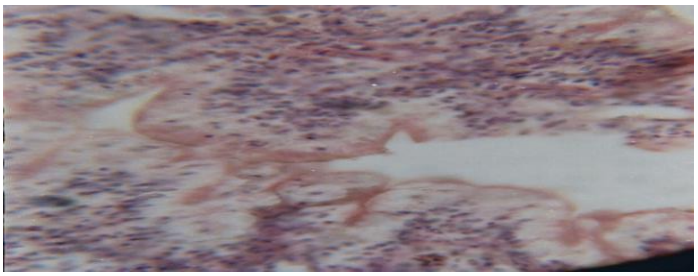
Slide A: Duodenum of control chicks: normal elongated villi with intact epithelial lining and crypts (arrows). (H&E stain, 1600x magnification).



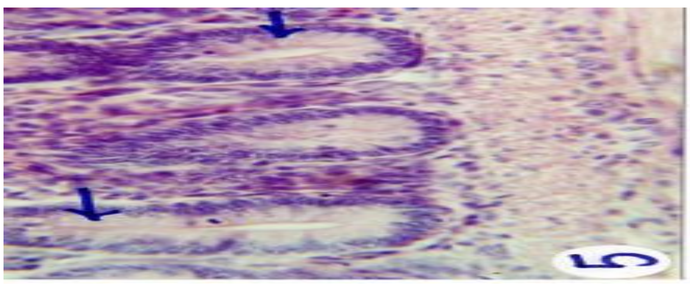
Slide B: Duodenum of DSWM fed chicks: Thickened villi with congestion and lymphocytic cellular reactions. (H& E 1600 x).



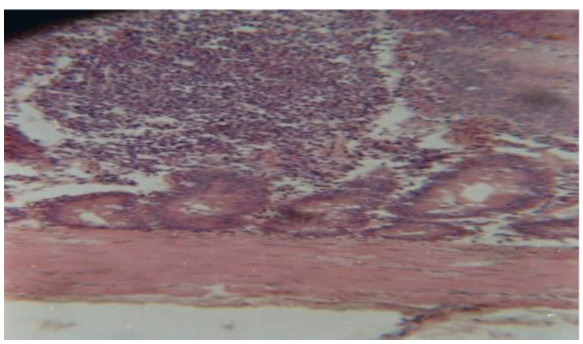
Slide C: Duodenum of DSWM chick fed: One thickened villus showing epithelial microvesiculation of the microvilli (H&E, 2500x magnification).



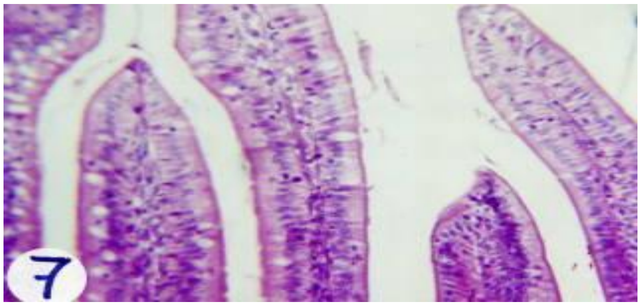
Slide D: Duodenum of DSWM chicks fed: This image shows a higher magnification to highlight the excess of epithelial microvesiculation on the microvilli. (H&E 4000x).



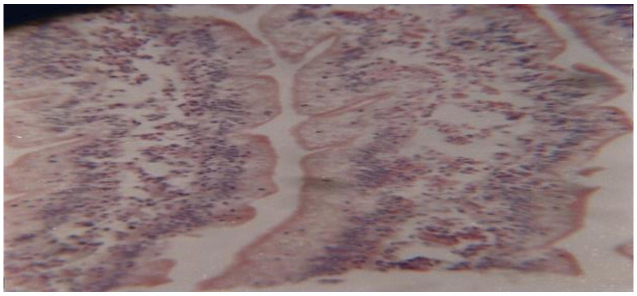
Slide E: Duodenum of a control chick: Normal epithelium of the intestinal crypts (arrows). (H&E, 400x magnification).



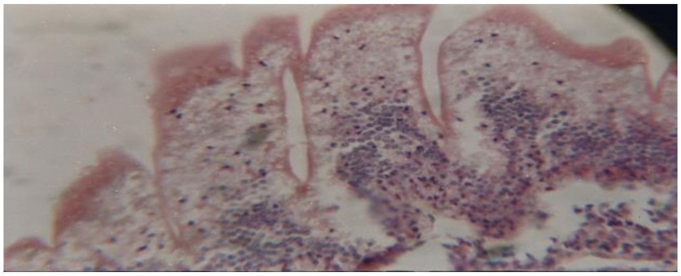
Slide F: Duodenum of treated bird: A large focus of lymphocytic cellular reaction is observed within the duodenal mucosa. (H&E 2500x).



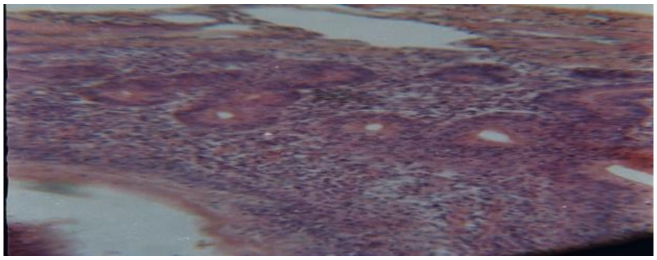
Slide G: Jejunum of control chick: The tips of the jejunal villi are of normal width and contain a few goblet cells. (H&E 2500x magnification).



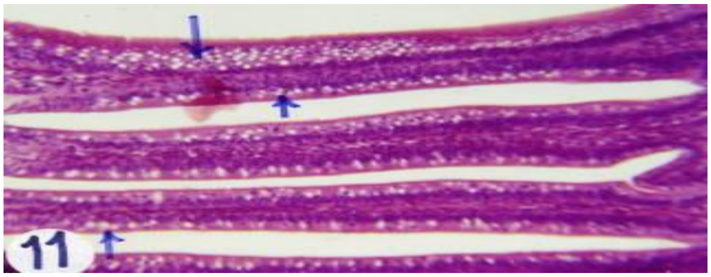
Slide H: Jejunum of DSWM chicks fed: Enlarged villi with congested and dilated lacteal vessels along with epithelial vacuolations. (H&E, 2500x magnification).



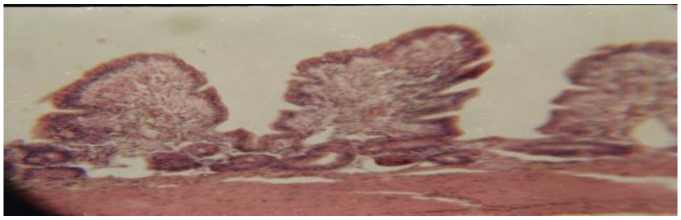
Slide I: Jejunum of DSWM chicks fed: Elongated microvilli with numerous lymphocytic cellular reactions and extensive epithelial microvesiculation. (H&E, 400x magnification).



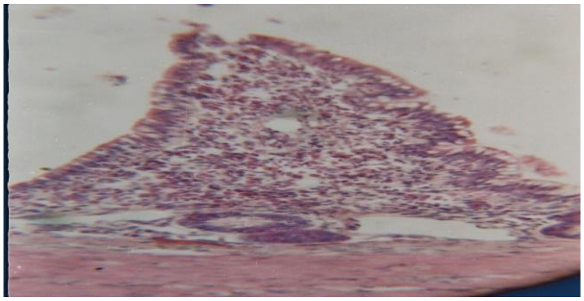
Slide J: Jejunum of treated bird: The intestinal glands are widely separated due to an excess of lymphocytic reactions. (H&E, 2500x).



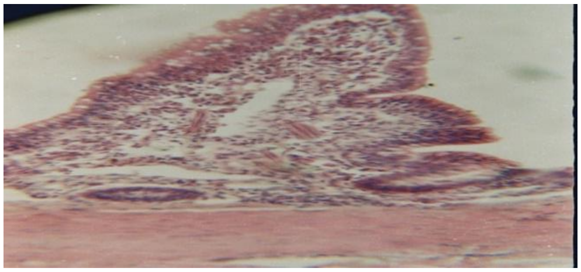
Slide K: Ileum of control chick: typical lengthy villi with typical goblet cell production excess. (H and E. * 1600x).



Slide L: Date seed waste meal fed to chicks causes the villi to thicken and shorten. (H and E. * 1600x).



Slide M: Ileum of treated bird: One of the short and thickened villi with congestion and activation in the goblet cell formations. (H and E. * 2500x).



Slide N: Ileum of date seed waste meal chicks fed: One villus with expanded and dilated lacteal vessels (asterisks) and excess of goblet cell formations. (H and E. * 2500x).

Nutrient Digestibility

The impact of including 0%, 7.5%, and 15% levels of date seed waste meal (DSWM), along with treatments such as phytase, multienzymes, amino acid supplementation, or crumble, on nutrient digestibility was examined. Table 4 results demonstrate that neither the control group nor the treatments had any discernible effects on the digestibility of organic matter, ether extract, crude fibre, crude protein, or nitrogen-free extract. However, there was a notable effect on the apparent digestibility of crude ash and apparent metabolizable energy values.

Within the un-supplemented groups, the inclusion of 7.5% or 15% DSWM did not affect the apparent digestibility of crude ash. However, when phytase and multienzymes were added to a diet with 7.5% DSWM, there was an improvement in the retention of crude ash compared to their controls. Similarly, the inclusion of phytase, multienzymes, amino acid supplementation, and crumble in a diet with 15% DSWM led to improved retention of crude ash associated to the negative controller.

The effect of phytase on ash preservation was consistent across diets with different levels of DSWM, while the impact of multienzymes, amino acids, and crumble varied based on the DSWM level. The positive effect of these treatments on mineral liberation and availability for bone mineralization and essential body functions was evident, aligning with previous studies, (Dersjant et al 2022).

Results also showed that including 7.5% date seed waste meal treated with phytase, multienzymes, amino acid supplementation, or crumble improved apparent metabolizable energy by 1.0%. However, increasing the DSWM level to 15% resulted in a decrease in apparent metabolizable energy by 1.5% compared to the control group, likely down to the upper crude fiber comfortable in the diet.

Table 4. Effect of nutritional stages of date seed waste meal treated through enzymes, amino acids and crumble management on digestibility coefficients of nutrients and apparent metabolizable energy of sixteen week-old Bahieg chickens (Experiment 3).

Items	Digestibility of nutrients,%						AME, Kcal/g feed
	CP	EE	CF	NFE	OM	Ash	
DSWM treatment							
(+) Control	85.1	80.1	31.1	78.8	76.6	56.3[c]	3.158[b]
Date seed waste meal 7.5%							
(-) control	86.3	91.3	28.4	78.8	77.6	55.5[c]	3.190[a]
+ Phytase	85.4	92.4	28.1	79.7	77.9	63.4[b]	3.206[a]
+ Optizyme	85.1	91.0	28.0	79.9	78.2	58.0[c]	3.193[a]
+ Amino acids	85.3	91.0	31.5	79.8	77.9	57.5[c]	3.191[a]
+ Crumble	86.2	91.6	30.2	80.8	79.0	67.1[a]	3.214[a]
Date seed waste meal 15%							
(-) control	84.6	90.4	33.1	78.3	77.1	56.1[c]	3.112[c]
+ Phytase	85.1	91.7	29.2	78.4	76.9	63.7[b]	3.116[c]
+ Optizyme	86.0	91.7	29.9	79.9	78.4	60.6[bc]	3.113[c]
+ Amino acids	85.6	90.5	28.9	79.3	77.5	62.4[b]	3.078[d]
+ Crumble	85.5	89.8	29.0	80.3	76.7	60.8[bc]	3.114[c]
SEM	0.52	0.66	1.51	0.96	0.49	2.10	0.0049
P value	0.09	0.12	0.08	0.19	0.22	0.02	0.008

[a-c] Means within a column not sharing similar superscripts are significantly different (P<0.05), NS (P>0.05).AME= apparent metabolizable energy

It should be noted that the including of phytase and crumble treatment improved the apparent metabolizable energy of diets containing 7.5% DSWM. Nonetheless, no noteworthy distinctions were noted among the cohorts fed diets supplemented with 15% date seed waste meal. Amino acid supplementation slightly decreased the apparent metabolizable energy value of the group fed 7.5% DSWM compared to the control by 1.1%. The beneficial effects of phytase on perceived metabolisable energy align with findings from earlier research conducted by Ravindran et al. (2001), Rutherfurd et al. (2012), and Pieniazek et al. (2017).

There was negligible change in the digestibility of crude protein, crude fiber, nitrogen-free extract and organic matter due to the inclusion of phytase, multienzymes, and amino acids in each group fed date seed waste meal diets. Nonetheless, the crumble treatment resulted in a minor improvement in the digestibility of organic matter, crude fibre, and nitrogen-free extract in the diet containing 7.5% date seed waste meal. Additionally, there was an unexplained improvement in crude fiber digestibility with increasing amino acid concentration in the 7.5% DSWM diet.

Previous research (Cozannet et al., 2023, Cozannet et al., 2021, and Amerah et al., 2014) have supported the notion that phytase's role in degrading phytic acid accounts for its positive influence on the apparent digestibility of crude ash and apparent metabolisable energy.

In summary, phytase improved the digestibility of crude ash in diets containing 7.5% and 15% DSWM, while it only improved the apparent metabolizable energy of the 7.5% DSWM diet. Crumble treatment improved the apparent retention of crude ash in diets containing 7.5% and 15% DSWM, as well as the apparent metabolizable energy of the 7.5% DSWM diet. Multienzymes and amino acid supplementation improved the apparent retention of crude ash in the 15% DSWM diet.

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