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Supplementary Feeding with Beeswax Wastes to Lactating Zaraibi Goat Enhances Blood Parameters and Milk Composition

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ABSTRACT

Increasing milk production as well as its quality is necessary to address milk shortages around the world. However, the high cost of feed and its unavailability in some areas may pose a challenge to achieve this goal, so finding alternatives or nutritional supplements suitable for animal nutrition has become an urgent necessity. Here, we explore the effect of adding 3% old wax and 1% scraped wax (Kashta) as nutritional supplements on digestibility, some blood parameters, and milk composition in lactating Zaraibi goats.

Thirty Zaraibi lactating goat weighing 40±4 kg were divided into 3 groups G1: fed total mixed ration (TMR) (control), G2: TMR+ 3% of old wax and G3: TMR+1% Kashta, after two months blood samples were taken from the jugular vein and milk samples were collected to be analyzed.

The chemical composition of Kashta was higher than old wax in protein, TS, and ash while old wax exceeded Kashta concerning fat and phytochemicals. A significant increase in fat and protein digestibility and improving in antioxidant biomarkers was observed in G2 and G3 compared to G1. Superoxidase dismutase, an enzymatic antioxidant biomarker (SOD) is raised statically in G2 and G3 195.1 and 161.4, respectively. Furthermore, Glutathione (GSH) a non-enzymatic antioxidant biomarker and T_3 hormone increase statically. Moreover, G2 treatment showed a progressive increase in %fat, %protein, %ash, %SNF and conjugated linoleic acid (CLA)(µg/mL) in milk 4.927±0.024, 4.830±0.011, 0.780±0.005, 8.780±0.048 and 53.082±2.925, respectively.
Generally, adding beeswax waste to the feed of farm animals (Zaraibi goats) enhanced the digestibility of protein and ether extract, improved blood parameters and the quality of goat milk.

KEYWORDS: beeswax wastes, Zaraibi goat, old wax, goat milk, conjugated linoleic acid.

1. INTRODUCTION

Increasing animal production faces many challenges. The most prominent of these difficulties is the high prices of feed as well as its unavailability, as feed costs constitute a large portion of expenses in animal husbandry, making it crucial for sustainable animal production. A significant increase in the prices of feed raw materials has been observed worldwide, and this may be due to economic or environmental reasons, which has affected feed prices (Schreurs, 2022). To address these challenges, research has focused on alternative sources of feed such as food waste, which is viewed as an inexpensive but highly useful material that can be composted or used as animal feed (Baiano, 2014). One such material used in ruminant feed is beeswax waste, which is a natural source of bioactive compounds that can positively impact animal health (Giampieri et al., 2018).

Beeswax waste (Kashta) is the waxy covering layer that bees use to seal the honey and is removed during honey sorting, these wastes can be used in poultry feed or transformed into compost, and it approved to be used in human nutrition(Adewale et al., 2010) . While old waste wax is old wax combs that are no longer usable. Generally, beeswax wastes contain phytopigments, propolis, pheromones bee pollen and royal jelly residues. Wax wastes moreover contain shedding skins, larvae, pupae, insect parts and whole insects, which are appropriate for nourishing just like the larvae of the dark soldier fly. These insects are rich in protein, fat, and other essential supplements required by animals (Makkar et al., 2014). Old wax can absorb pheromones emitted by bees within the hive, such as brood pheromones (Le Conte et al., 1995). Old brood comb also contains propolis(Marcucci, 1995), it is an organic substance that bees have collected that includes plant secretions and resinous substances collected by bees. It also includes phenolics and flavonoid compounds, aromatic acids, esters, hydroxy acids, terpenes and caffeic acid derivatives. Owing to its complicated composition, propolis has a wide range of effects, including antibacterial, antifungal, antiviral, antiphlogistic, hepatoprotective, antioxidant, cariostatic and immunomodulatory properties (Šabanović et al. 2019). It can be concluded that bee wax wastes and their complicated composition (phenolic acids and active compounds) are dietary supplements used to feed ruminants and improve the quality and shelf life of their products (meat and milk). As mentioned previously, wax residue like other honey products contains many antioxidants, phenolic substances, and flavonoids that work to improve the digestion process and activate the beneficial bacteria present in the stomach and increase their numbers. Some scientists have found that improving the digestion process reduces the production of ammonia and methane, which may an effective strategy to reduce global warming (Ngwabie et al., 2011; Aguiar et al., 2014; Kara et al., 2014 and Marin et al., 2020). However, this point requires more detailed studies to clarify it.

Goat milk is a suitable choice for people who have a bovine milk allergy. Focusing on its nutritional value, it has a unique fatty acid profile, goat milk being much higher in butyric, caproic, caprylic, capric, lauric, myristic, palmitic and linoleic, in contrast, lower in stearic (C18:0), and oleic acid (C18:1). It contains about 20% short chain fatty acids, and 55% of medium chain fatty acids, with special concerning on having high level of conjugated linoleic acid (CLA) besides lactose-derived oligosaccharides (Tudisco et al., 2014). Only Adewale et al., (2010) studied the impact of feeding beeswax residual 1 and 3% on milk composition, they reported that beeswax residues 3% triggered high milk yield, protein, fat, phosphorus, and calcium contents. Additionally, it may benefit lambs and calves' growth, and feed efficiency as well as beef cattle's daily live weight increase, feed efficiency and carcass weight (Marcucci, 1995). To our knowledge, a very limited concern had attuned to feeding lactating goats on bee wax waste. Therefore, this research aims to know the effect of feeding lactating goats on the wax residues (old wax 3% and Kashta 1%) and also on the composition of the milk as an experiment to introduce alternative natural feed and improve the quality of the milk.

2. MATERIALS AND METHODS

2.1. Animals

Thirty multiparous female Zaraibi goats at an average of weight 40 ±4 kg and age range of 2.5±0.3 years were selected. Goats were assigned randomly in a completely randomized design in 3 groups. Body weight, Age, and parity were considered in randomization. Ethical approval (No:0100223) for all experimental protocols was accomplished by the local Experimental Animal Care Committee and approved by the Institutional Committee of the Department of Animal Production, Faculty of Agriculture, Minia University, Egypt.

2.2. Beeswax wastes

Old wax: old wax combs that were previously used by bees, whether in storing honey, pollen, propolis, royal jelly or rearing brood. After using them, they are disposed of or recycled. They contain the remains of honeybee products and shedding skins.

Scraping wax (Kashta): is the external layer of wax which the workers secreted to close the container ripping honey six-sided eyes to prevent moisture from being absorbed from the hive´s atmosphere again. During the sorting process, the beekeeper scrapes this layer. Kashta contains larvae, pupae, adult bees, or some parts of them. All beeswax residues were frozen from 24-48 hrs at -18° C, then they are ground. If Kashta included honey, it was rinsed with water before freezing.

2.3. Experimental design and animal diets

All Zarabi goats were assigned randomly to three treatments (10 goats/treatment): G1 control (without any supplementation), G2: control ration plus 3% old wax, G3: control ration plus 1% Kashta, the experiment 90 days including a 10-d metabolism trial. The experimental diet was formulated to be isonitrogenous and isocaloric. The goats were fed at a level of 1.2 kg dry matter /goat /day TMR. Clean and fresh water was provided ad libitum throughout the experimental period (February to April 2023) in the Sheep Research Unit at the Center of Agricultural Research and Experiments, Minia University, Egypt. Animals were kept at suitable temperatures and humidity in covered loose pens and attached to another place with open yards. The ration was mixed twice weekly, and beeswax waste was added and thoroughly mixed with other feed constituents for treatments (G2 and G3). Ration was formulated (Alderman & Cottrill 1996). to meet the requirements of goats for metabolizable energy and protein. Feed and chemical compositions of the basal diet are exposed in Table 1. Feed was offered daily at 06:00 and 18:00 h in two equal portions.

2.4. Measurements

2.4.1. Digestibility

At the end of the experiment, four females (initial BW = 42.72 ±2.15 kg) were haphazardly chosen from each treatment group and set in an isolated place. A digestion trial consisted of 10-d for collection period, feed and faeces were collected individual from each animal and determined according to(AOAC, 2016)**.**

Ration and faeces samples were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and Ash according to AOAC (2016). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to (Van Soest et al., 1991)**.** Hemicellulose values were estimated by difference (NDF - ADF) and cellulose values were calculated by difference (ADF - ADL) (Table 1).

Total tract digestibility of DM, OM, CP, EE, CF and NFE were determined using acid insoluble ash (AIA) as an internal marker according to (Van Keulen & Young, 1977)· The nutritive values as total digestible nutrients (TDN) and digestible crude protein (DCP) of the experimental rations were calculated (Table 3). Finally, NFE was calculated as NFE= OM-(CP+CF+EE).

2.4.2. Hematological parameters

Blood samples (10 mL from each goat) were taken from the jugular vein in heparinized and non-heparinized specialized sterile tubes. At the end of the experiment, fresh blood was analyzed immediately for physical blood characteristics. An automated hematology analyzer model (MEK-6510 J/K- Nihon Kohden Middle East, Japan) was used to measure all physical blood characteristics.

2.4.3. Biochemical tests

Non-heparinized blood samples were centrifuged at (3000 rpm for 15 minutes) to separate serum, then stored immediately at - 20 °C till assay. Total protein was determined according to (Gornall et al., 1949)**,** and Albumin (AL) was determined according to(Doumas et al., 1971)**.** While globulin was calculated by

Table 1. Composition and calculated chemical composition of basal diet fed to Lactating goats.

Feed ingredient	%	Chemical composition	%
Corn yellow	12.8	**Dry matter**	92.22
Barley Grain	32.8	**Organic matter**	93.68
Wheat bran	5	**Crude protein**	14.91
Soybean meal	14	**Ether extract**	2.12
Alfa Alfa meal	5	**Crude fiber**	15.29
Wheat straw	27.9	**Neutral Detergent Fiber**	36.79
Limestone	0.80	**Acid Detergent Fiber**	20.08
Urea	1.00	**Acid Detergent Lignin**	5.64
Ca. P. Dibasic	0.30	**Hemicellulose**	16.71
Premix	0.20	**Cellulose**	14.43
Sodium chloride	0.20	**Nitrogen free extract**	62.51
Total	**100%**	**Ash**	6.32

Data represents the means of observations from three replicates.

subtracting Albumin from total protein (mg/dl). Alanine aminotransferase (AlT) (IU/L) and aspartate aminotransferase (AST) (IU/L) were determined according to (Alan, 2006). Plasma glucose concentration was measured by the colorimetric method according to (Trinder, 1969).Lipid profile: Plasma cholesterol concentration was determined according to (Allain et al., 1974). Triglyceride was determined according to (Fossati & Prencipe, 1982). All previous tests were analyzed by following the instructions of commercial kits (Biodiagnostic, Giza, Egypt).

2.4.4. Antioxidant indexes

The concentrations of serum superoxide dismutase enzyme (SOD) were determined as described by Nishikimi et al., (1972), glutathione reduced (GSH) was determined by Beutler et al., (1963) and lipid peroxide (Malondialdehyde) MDA was estimated according to Ohkawa et al., (1979) all tests were determined by commercial colorimetric assay (Bio-diagnostic, Cairo, Egypt), according to the manufacturer's instructions.

2.4.5. Wax analysis

Total nitrogen (TN), total solids (TS), fat and ash were determined according to (AOAC, 2023). FTIR was analyzed using (Niclot, IS 10, Thermoscientific, USA) and data was analyzed by irAnalyze -RAMalze 7.1.5.0 software.

2.4.6. Antioxidant activity

The amount of total phenol content was determined by the method of (McDonald et al., 2001). Total flavonoid content was determined according to (Chang et al., 2020). The determination of total antioxidants is discussed by (Kanika et al., 2015).

2.4.7. MILK analysis

Chemical composition

Titratable acidity, pH and ash were determined according to (AOAC, 2016). Fat, Protein, TS, SNF, and Specific density were estimated by using (Ekomilk 120 Ultrasonic milk analyzer), and lactose was calculated from the equation: TS- (protein + fat +ash).

Conjugated linoleic acid determination:

CLA was estimated as follows, 1 ml of milk was centrifuged at 20,800 ×g for 1 min, 2 ml of isopropanol (Carloerba, Strada Rivoltana, Ronado) was added to the supernatant then vortex and keep it for 3 min, following add 4 ml of hexane (Chem-lab NV, zedelgem), hexane and isopropanol were HPLC grade)(Barrett et al., 2007). Measurements were obtained in triplicate in hexane layer. The standard curve was constructed for the absorbance at 233 nm (T80 UV/VIS spectrometer PG instrument Ltd) versus CLA (C18:2 c9, t11) (Sigma–Aldrich St. Louis, MO, USA) concentration (0–50 µg/ml)(Rodríguez-Alcalá et al., 2011).

2.5. Statistical Analysis

The data were analyzed using a one-way analysis of variance (ANOVA), and the SAS software (Statistical Analysis System, version 9.4, SAS Institute, 2020. Inc., Cary, NC, USA.) was used to conduct Duncan's multiple range tests for mean separation. A p-value of less than 0.05 was considered significant. The data were analyzed accordance with the following model: $Y_{ij}=\mu+G_i+E_{ij}$. Where, Y_{ij} = The studied trait; μ = The overall mean; G_i = The effect of

Table 2. Bee wax waste chemical composition and antioxidant profile:

Composition	Old wax	Kashta
Protein %	2.293±0.061	2.830±0.158
Fat%	58.44±0.667	39.88±0.350
TS%	85.22±0.594	87.70±0.262
Ash%	0.956±0.0005	0.974±0.006
TPC mg/g	944.8±42.59	501.1±33.11
TFC mg/100g	886.0±35.51	673.8±115
TAC mg	2831±91.97	1764±67.53

Data represents the mean ±S.E. of observations from three replicates. TPC: total phenol content, TFC: Total flavonoid content and TAC: total antioxidant capacity

treatments (i = G1, G2 & G3); and Eij = The experimental error. Data in Table (2) was performed at least three times. Means and standard errors were calculated.

3. RESULTS AND DISCUSSION

Typically, the cost of feeding the ruminant industry makes up 40 to 60 percent of the cost of production, with the cost of protein making up more than 15% of the overall feed cost. Numerous sources of protein can be employed in the ration, including grains, legumes, and animal waste (Astuti & Wiryawan, 2022). From an eco-friendly view, there is an expanding curiosity in utilizing economic sources that do not leave a negative effect on the environment, beeswax waste as a protein source is a smart option to achieve this goal. On the other hand, the presence of these waxy wastes and their accumulation in apiaries constitutes great harm because they spread the waxworm insect, which causes damage to the wax combs and may even lead to the destruction of bee colonies (Han et al., 2023). Therefore, using them in animal feed saves us from their accumulation in the environment. They are also inexpensive alternatives, but they have high nutritional value.

Beeswax waste extracted from the honeycomb has been taken immediately after collecting honey from cells(Adewale et al., 2010). Beeswax wastes like other bee products are very safe and now could be used in feeding sheep (Mohamed & Zanouny, 2017). Data in Table (2) represented the chemical composition and antioxidant activity of beeswax wastes used in goat feeding.

Old wax contains protein, lipids, and sugar in regard of beeswax is composed of protein, lipids, polyphenols, hydrocarbons, and flavonoids, and propolis mainly consists of polyphenols and flavonoids (Dumitru et al., 2022). Many authors emphasize polyphenols and antioxidant presence in old wax(Marcucci, 1995). Taha et al., (2010) stated that old wax comb contains higher mineral content, especially trace elements than new ones, that reflected in the ash content in beeswax waste and milk (Tables 2 and 6).

By 2050, consumption of animal products is likely to increase by 60-70%. This increase will lead to the depletion of many resources, and as the provision of feed is the most difficult requirement due to the scarcity of natural resources, ongoing climate change, and competition between food resources and feeds such as soy flour and fishmeal, this will probably limit the availability of these feeds in the future (Makkar et al., 2014).

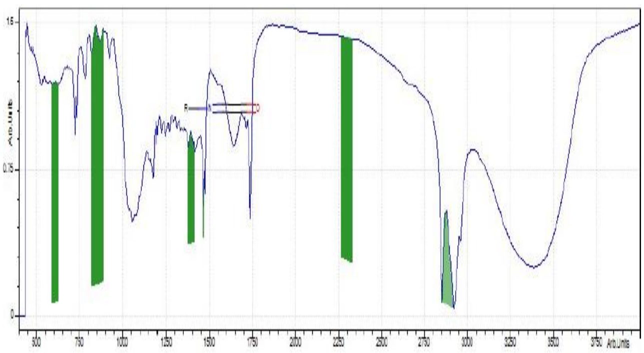
Although goats and sheep are small ruminants which can contribute to the provision of meat and dairy, their reproduction and production rates are still very low (Jayanegara et al., 2017). Therefore, it is necessary to feed animals on high-nutritional feed to increase animal production. Insect husbandry may contribute to the solution as it has recently been commonly used in animal nutrition due to its high nutritional content of protein, fat, and other essential elements (Astuti and Wiryawan, 2022).

Some insects, such as locusts and larvae of house flies and silkworms are used as alternative sources in ruminant nourishment for their nutritional value. It was found that the crude protein contents of these insects are high at 42-63% as well as fat contents (up to 36% of oil), which can be extracted and used in different applications including biodiesel production. Also, concentrations of unsaturated fatty acids were high in housefly larva meal (60-70%), whereas their concentrations in dark soldier fly larvae are least (19–37%). Kashta contain larvae, pupae, and adult insects. It is similar to feeding on insects.

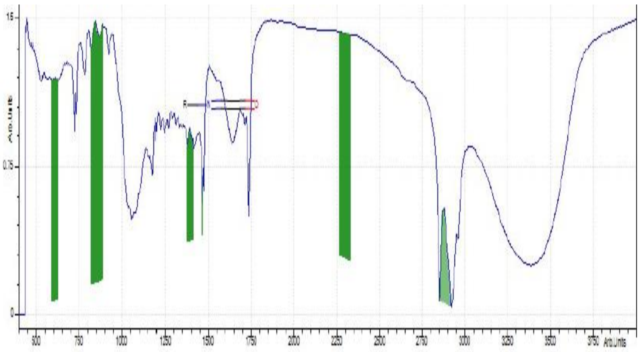
Beeswax residues represent a complicated organic combination of several different substances. A typical IR spectrum of genuine beeswax. However, only shows the most prominent ones, primarily analyte signals from hydrocarbons, esters, and free fatty acids (Fig. 1a).

Fig 1a and 1b showed the same manner in FTIR analysis that for old wax and Kashta that was CH 2 stretch alkyl (2825-3000), NCO stretch asym (2250-2295), CH 2 Bend CH2/CH3 (1445-1470), NCO stretch, sym (1360-1440), C-N Bend (830-890) and NCO Def (590-645) that emphasize results in Table (2), although the quantity of compounds have differed. For instance, Kashta has more peptides due to the presence of larvae.

In the purpose of more about beeswax waste composition, FTIR analysis was established, the signal at 2920 cm −1 is assigned to CH 2 stretch due to the combination of CH 2 stretch in waxy material (2918 cm −1) and CH 2 stretch in lipidic compounds (2926-2929 cm −1), while the weak signals at 1318 cm −1, 1650 cm −1 and 1545 cm −1 are better evidenced in the unsmoothed spectra.



(Fig. 1a)



(Fig .1b)

Fig (1a,1b) FTIR analysis for beeswax wastes.

Table (3) showed a significant increase in the digestibility of ether extract and protein in the treated groups compared with the control group. In the same direction there is improvement in nutritive values (TDN and DCP) but, this improvement is not significant. The significant improvement in digestibility coefficient of CP, and EE due to beeswax wastes supplementation could be explained by the components of beeswax wastes that enhance the activity of rumen microbes in the gastrointestinal tract (Gaafar et al., 2023). our results are following results of Adewale et al., (2010) who argued an increase in crude protein when fed lactating goat on 3% old wax. In addition, our observations follow Gaafar et al., (2023) who reported that beeswax supplementation at a rate of 4 g per day for growing Assaf lambs may enhance zootechnical performance, nutrient digestibility, and rumen fermentation. In addition, (Adewale et al., 2010) finding dry matter did not boost statically.

Table (4) presents data on blood hematological parameters (RBCs, WBCs, hemoglobin, hematocrit, and erythrocytic indices) as influenced by dietary interventions. The RBC count, Hb concentration, and Hct (%) increased ($P < 0.05$) with the 3% old wax and 1% Kashta treatments compared to the control treatment. However, the erythrocytic levels of MCV and MCHC, were not notably impacted by the therapies. WBCs, neutrophils, lymphocytes, and monocytes all showed no statistically significant differences in the same line. Hematology is a discipline that diagnoses and treats a broad range of diseases (Elwan et al., 2020). Our results showed that all hematological parameters were within the normal range, in accordance with the description of the reference ranges of normal hematological values for several goat species (Al-Bulushi et al., 2017).

Table 3. Digestibility of nutrients and nutritional values of tested diets.

Item %	Treatments			SEM	*p*-Value
	Control G1	**Old wax** G2	**Kashta** G3		
DM	63.32	63.95	65.05	0.78	0.353
OM	67.32	67.69	68.34	0.74	0.635
CP	68.35b	73.92a	74.68a	0.66	0.003
EE	64.06b	69.20a	69.38a	1.14	0.027
CF	56.16	57.56	58.00	1.59	0.711
NFE	68.96	67.45	67.72	1.22	0.663
Nutritive values (%)					
TDN	62.98	63.33	63.91	0.65	0.155
DCP	9.80	10.63	11.89	0.78	0.353

$^{a, b}$ values within a row with deferent superscripts differ significantly at $p < 0.05$. SEM = standard error of the mean.
DM: dry matter, OM: organic matter, EE: ether extract, CP: crude protein, CF: crude fiber, NFE: Nitrogen Free Extract, TDN: Total digestible nutrients and DCP: digestible crude protein.

Table 4. Effect of feeding on beeswax wastes on hematological parameters:

Item	Treatments			SEM	*p*-Value
	Control G1	**Old wax** G2	**Kashta** G3		
Hemoglobin (gm/dl)	8.43^b	8.83^a	8.73^a	0.075	0.021
RBCs[1] ($10^6/mm^3$)	5.60^b	6.27^a	6.17^a	0.098	0.016
Hematocrit (%)	34.00^b	41.33^a	38.67^a	1.277	0.018
Erythrocytic indices[2]					
MCV	60.71	65.96	62.91	2.798	0.459
MCH	15.06^a	14.10^b	14.17^b	0.156	0.018
MCHC	24.86	21.38	22.71	0.920	0.092
WBCs[3] ($10^3/mm^3$)	9.47	7.27	8.80	0.816	0.228
Neutrophiles	30.23	34.17	34.63	2.419	0.423
Lymphocytes	56.67	50.87	55.03	3.388	0.500
Monocytes	14.77	14.70	17.03	1.174	0.344

$^{a, b}$ values within a row with deferent superscripts differ significantly at $p < 0.05$. SEM = standard error of the mean.
[1]RBCs: Red blood cells. [2] Erythrocytic indices MCV: mean corpuscular volume, MCH: mean corpuscular hemoglobin, and MCHC mean corpuscular hemoglobin concentration. [3]WBCs: White blood cells.

The notably higher hemoglobin concentration and red blood cell counts of goats fed G2 and G3 indicate that these animals' diets supplemented with old wax and Kashta have improved metabolic and productive states. Hemoglobin is known to be responsible for gas exchange via cellular oxidation, which is closely linked to cellular activity (Frandson, 1986). The rise in the hematocrit% of goats given old wax and Kashta is associated with an increase in the Hb concentration of G2 and G3.

Results in Table (5) revealed a significant increase in glucose and total protein in blood samples (G2 and G3) compared with G1, that higher amounts of total protein and glucose suggest a greater metabolic rate in reaction to better protein digestibility, particularly when it comes to the amount of protein in the diet and the addition of Kashta and old wax. The same findings were observed when feeding Assaf lambs on beeswax 2 and 4 % (Gaafar et al., 2023).

Considering lipid profile, the difference in cholesterol levels for G1, G2, and G3 were 202.64, 196.56 and 197.85 mg/dl respectively, results did not differ statically. Moreover, triglycerides decreased in both G2 and G3 compared to control. According to our results, Gaafar et al., (2023) explained a good impact of beeswax on the decreased lipid profile in lamb also, Hargrove et al., (2004) Claimed that beeswax supplementation was implicated with low total cholesterol levels.

Table 5. Effect of feeding on beeswax residues on blood biochemical parameters of Zaraibi goat:

Item	Treatments			SEM	*p*-Value
	Control G1	Old wax G2	Kashta G3		
Glucose (mg/dl)	99.02[b]	105.36[a]	109.57[a]	1.16	0.0364
Total protein (g/dl)	6.90[b]	7.30[a]	7.31[a]	0.08	0.0163
Albumin(g/dl)	3.67	3.94	4.18	0.16	0.1661
Globulin(g/dl) *	3.23	3.36	3.13	0.20	0.7078
Cholesterol (mg/dl)	202.64	196.56	197.85	1.80	0.1142
Triglycerides (mg/dl)	119.59	116.49	115.88	1.65	0.3064
Liver Functions:					
ALT (U/ l)	1.31	1.35	1.38	0.08	0.5057
AST (U/ l)	29.74[b]	33.57[a]	32.49[a]	0.70	0.0211
Thyroid hormones:					
T_3	1.07b	1.27[a]	1.30[a]	0.03	0.0053
T_4	25.56[b]	30.25[a]	30.58[a]	0.82	0.0084
Antioxidant parameters:					
SOD (U/ml)	137.3[c]	195.1[a]	161.4[b]	5.07	0.001
MDA (µM/L)	4.390[a]	3.997[b]	3.533[b]	0.09	0.010
GSH (mg/ml)	0.690[b]	0.830[a]	0.903[a]	0.03	0.001

[a, b and c] values within a row with deferent superscripts differ significantly at $p < 0.05$.
SEM = standard error of the mean.
* Globulin (mg/dl) = total proteins (mg/dl) – albumin (mg/dl)

Thyroid hormones were used as a remarkable tool to judge the metabolism of the T_3 hormone raised statically in G2 and G3 to G1 control, although the T_4 increment was not significant. Regarding liver function, AST enzyme was boosted significantly, and ALT enzyme also improved by supplemented old wax and Kashta in G2 and G3, respectively compared with G1, which means fortification with old wax and Kashta are in favor of liver functions. In consideration of blood parameters, the current results showed higher glucose levels in the case of feeding on beeswax wastes. Gaafar et al., (2023) recorded an increase in glucose levels after 3 months of feeding on beeswax. However, they proved to decrease liver function enzymes. It is worthwhile to mention that the current study utilizes old wax and different experiment animals and duration.

It was shown a significant elevation in both enzymatic and non-enzymatic antioxidant biomarkers SOD and GSH, respectively with an average of (195.1 and 0.830) for G2 and (161.4 and 0.903) for G3. Consequently, MDA decreases statically in both treatments compared to the control, G3 represents more decline in MDA concentrations, (3.533, µM/L).

This improvement in antioxidant enzymes may be attributed to the high levels of TPC, TFC, and TAC found in old wax and Kashta (Table. 2), and other content of bee wax waste like propolis. Our findings are in line with Giampieri et al., (2018) who claimed that the process of recycling beeswax can serve as a rich source of phytochemicals with a high total antioxidant capacity. After applying propolis supplements, there has been evidence of a considerable reduction in cholesterol and triglycerides as well as an increase in glucose, and TAC (Hashem et al., 2013). Propolis could lift HCT, protein and globulin besides improving liver enzymes and cholesterol levels(Galal et al., 2008).

A progressive increase has been observed in fat, protein, ash, titratable acidity, SNF and TS content in milk when beeswax wastes are added to the lactating goat meal 4.927، 4.830, 0.780, 0.176, 8.806 and 13.270%, respectively. In addition, the incorporation of Kashta in goat provender maximize protein content in milk yield 5.850 %, pH degrees were decreased in G2 and G3, reflecting the high protein content and this notice is expressed as a slight boost in titratable acidity in both G2 and G3. In addition, low specific density in G2 refers

Table 6. Effect of feeding on beeswax wastes on milk composition and CLA.

Milk composition	Treatments			SEM	*p*-Value
	Control G1	**Old wax** G2	**Kashta** G3		
Fat %	3.263^{c}	4.927^{a}	4.150^{b}	0.0967	<0.0001
Protein %	3.113^{c}	4.830^{b}	5.850^{a}	0.0077	<0.0001
Lactose%	4.376	3.170	3.400	0.5292	0.1825
TS%	11.513^{c}	13.707^{b}	14.233^{a}	0.0148	<0.0001
SNF%	8.250	8.780	9.950	0.6724	0.1293
Ash%	0.746	0.780	0.776	0.0137	0.0956
pH	6.676	6.613	6.503	0.0991	0.4182
Acidity%	0.163^{b}	0.176^{a}	0.187^{a}	0.0060	0.0224
Specific density	1.024	1.022	1.026	0.0145	0.8577
CLA(µg/ml)	22.070^{b}	53.082^{a}	45.458^{a}	1.5090	<0.0001
CLA (mg/100ml)	2.207^{c}	5.308^{a}	4.545^{b}	0.0112	<0.0001
CLA (mg/g fat)	0.676^{b}	1.077^{a}	1.095^{a}	0.0580	<0.0005

a, b and c values within a row with deferent superscripts differ significantly at $p < 0.05$. SEM = standard error of the mean.
TS: total solids, SNF: solids not fat and CLA: conjugated linoleic acid.

to high fat percentage and results do not differ statically. Lactose percentage was decreased in treatments whose ash content was increased which may be to maintain the osmotic pressure still constant, generally lactose and ash did not differ statically. CLA was raised about twice or more as much in G1, it was increased significantly in G2 and G3, where CLA was 0.0676 g/100g fat.

Goat populations in Africa and Asia make up 38.7 % and 55.4 % of the world´s goats, respectively (Mazhangara et al., 2019). For decades, goat milk has been regarded as a nutraceutical due to its features like simple digestion and few level of allergenicity compared to cow milk (Clark & Mora García, 2017).

Similarly, Adewale et al., (2010) found that feeding goats on wax residues by 3% increased fat (6.2%) and protein (4.86%) as well as minerals in milk Our results were slightly lower than Adewale et al., (2010) in % fat and higher in %protein these may be due to the variation in the species of the studied goat and the chemical composition of beeswax waste.

CLA is a family of linoleic acid isomers that have health benefits more than isolated forms of linoleic acid. For instance, CLA can act as immunomodulatory, hypercholesteremic, hypertension lowering, lean body mass, fat deposition reduction and antiatherosclerosis (Rodríguez-Alcalá et al., 2011). A hilarious feature that was added by beeswax residues is increasing CLA concentrations in milk.

Martínez Marín et al., (2011) reported that CLA average was 0.754 g/100g fat, furthermore, CLA content in goat milk as a control was 2.207± 0.0685 mg/100 g, a higher CLA content informed was 11.5 mg/100 g by Cossignani et al., (2014). In contrast, a lower content CLA than our results which was 0.478 in April had been recorded by Tudisco et al., (2014), the differences may be related to the lipid extraction method, region, season and feeding. High concentrations of lactose-derived oligosaccharides and CLA in goat milk shed light on the behavior of lactic acid bacteria and bifidobacteria, especially in the case of dietary supplementation with beeswax wastes, further studies may be necessary for this area.

It can be said that old wax and Kashta can be considered effective tools for enhancing protein and fat content in milk. Protein and fat are the cornerstones of cheesemaking. Thus, when adding raw materials that increase their percentage in cheese, it leads to an increase in its prices, so our use of dairy with a high content of protein and fat in the cheese industry may avoid this problem.

4. CONCLUSION

It can be recommended to enhance the diet of lactating goats by adding beeswax wastes of 3% old wax or 1% Kashta can be adopted as alternative additives to animal nutrition because it increases the fat and protein content of both the meal and the milk produced, improves digestion and some blood properties of animals despite being low-cost substances. The results in this area are very limited but very encouraging, and require further research. This may be more feasible in large animals with high milk production but low in fat, such as Holstein cows, which provide the opportunity to use cow's milk in the manufacture of high-quality milk fat products.

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الملخص العربي

التغذية التدعيمية بمخلفات نحل العسل للماعز الزرايبي الحلابة تحسن مقاييس الدم وتركيب اللبن

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إن زيادة إنتاج الحليب وكذلك جودته أمرا ضروريا لمعالجة نقص الحليب في جميع أنحاء العالم، الا ان ارتفاع تكلفة العلف وعدم توفره في بعض المناطق قد يشكل تحديا لتحقيق هذا الهدف، لذلك أصبح إيجاد البدائل والمكملات الغذائية المناسبة لتغذية الحيوان صار ضرورة ملحه. هنا نستكشف تأثير إضافة الشمع القديم ٣% (الكشطة) ١% كمكملات غذائية على الهضم وبعض مؤشرات الدم وتركيب الحليب في الماعز الزرايبي المرضعة.

تم تقسيم ثلاثين ماعز زرايبي حلاب بوزن ٤٠ ± ٤ كجم إلى ثلاث مجموعات G1: تغذية إجمالية مختلطة (TMR) (الكنترول)، G2: TMR + 3% من الشمع القديم وG3: TMR + 1% كشطة، بعد شهرين من جمع عينات الدم واللبن لتحليلها.

اظهر التركيب الكيميائي للكشطة أنها أعلى من الشمع القديم في البروتين، TS، والرماد بينما تجاوز الشمع القديم الكشطة من حيث الدهون والمواد الكيميائية النباتية. وقد لوحظت زيادة معنوية في معامل هضم الدهون والبروتينات والمؤشرات الحيوية المضادة للأكسدة في G2 وG3 مقارنة بـ G1. كما ازداد انزيم سوبراكسيديزديسميوتيز وهو علامة حيوية مضادة للأكسدة إنزيمية (SOD) بشكل ملحوظ في G2 وG٣ ١٩٥,١و ١٦١,٤. علي التوالي علاوة على ذلك، فإن الجلوتاثيون (GSH) وهو مؤشر حيوي مضاد للأكسدة غير إنزيمي وهرمون T_3 ارتفعوا بصورة معنوية. علاوة على ذلك، أظهرت G2 زيادة تدريجية في %للدهن، البروتين، الرماد، SNF وحمض اللينوليك المقترن (CLA) (ميكروجرام/مل) في اللبن ٤,٩٢٧ ± ٠,٠٢٤، ٤,٨٣٠ ± ٠,٠١١، ٠,٧٨٠ ± ٠,٠٠٥، ٨,٧٨٠ ± ٠,٠٤٨ و٥٣,٠٨٢ ± ٢,٩٢٥ على التوالي.

وبشكل عام، أدت إضافة مخلفات شمع النحل إلى علف حيوانات المزرعة (الماعز الزرايبي) إلى تحسين هضم كلا من البروتين ومستخلص الأثير، وكذلك تحسين مؤشرات الدم وجودة الحليب للماعز.

الكلمات المفتاحية: مخلفات شمع النحل، الماعز الزرايبي، الشمع القديم، لبن الماعز، حمض اللينوليك المقترن.