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Physicochemical characteristics of ewe's milk following partial substitution of concentrate with Date by–products and *Saccharomyces cerevisiae*

Características fisicoquímicas de la leche de oveja tras la sustitución parcial del concentrado con subproductos de dátiles y *Saccharomyces cerevisiae*

Tarek Boussaada[1]*, Salha Amira Benatallah[2], Boukaous Leyla[2], Kaouthar Lakhdari[1], Abdelhamid Djekoun[2], Nedjoua Lakhdara[3]

[1]Scientific and Technical Research Centre for Arid Areas (CRSTRA). Biskra 07000, Algeria.
[2]Pharmaceutical Sciences Research Center (CRSP). Constantine 25000, Algeria.
[3]Université des Frères Mentouri Constantine 1, Institut des Sciences Vétérinaires El – Khroub, Laboratoire de Recherche Gestion Santé et Productions Animales (GSPA). Constantine 25000, Algeria.
Corresponding author: boussaadatarek@gmail.com

ABSTRACT

Sustainable feeding strategies are needed to improve the quantity and quality of sheep milk. This study evaluated the impact of partially substituting conventional concentrate with date by–products, with or without the addition of *Saccharomyces cerevisiae*, on the physicochemical composition of milk produced by Ouled Djellal ewes. 30 ewes were randomly divided into 5 groups. All ewes received wheat straw (1 kg·ewe^{-1}) as roughage (66.66%). In addition to wheat straw, the control group received 33% concentrate (33CON), and the 4 experimental groups received different levels of date by–products and concentrate: 8.33% date by–products + 25% concentrate (8.33 date by–products), 25% date by–products + 8.33% concentrate (25 date by–products), 16.6% date by–products + 16.6% concentrate (16.6 date by–products), and 16.6% date by–products + 16.6% concentrate with *Saccharomyces cerevisiae* (16.6 date by–products sc). The milk samples were analyzed to determine their fat, protein, lactose, total solids, and non-fat solids content. Milk fat content (P<0.01) and total solids (P=0.025) were significantly higher in the experimental groups than in the control group, particularly in the 25 date by–products and 16.6 date by–products sc rations. Protein and non-fat solids content increased numerically without reaching statistical significance, while lactose levels remained relatively stable in all treatments. Partial substitution of concentrate with date by–products improved milk quality, indicating that date by–products can be a sustainable feed resource for dairy ewes, thereby adding value to their milk products.

Key words: Dietary Supplements; milk composition; *Saccharomyces cerevisiae*; date by product; milk ewes

RESUMEN

Se necesitan estrategias de alimentación sostenibles para mejorar la cantidad y la calidad de la leche de oveja. Este estudio evaluó el impacto de la sustitución parcial del concentrado convencional por subproductos de dátiles, con o sin la adición de *Saccharomyces cerevisiae*, en la composición fisicoquímica de la leche producida por ovejas Ouled Djellal. 30 ovejas fueron divididas aleatoriamente en 5 grupos. Todas las ovejas recibieron paja de trigo (1 kg·oveja$^{\$1-1}$) como forraje (66,66 %). Además de la paja de trigo, el grupo de control recibió un 33 % de concentrado (33CON), y los 4 grupos experimentales recibieron diferentes cantidades de subproductos de dátiles y concentrado: 8,33 % subproductos de dátiles + 25 % C (8,33 subproductos de dátiles), 25 % subproductos de dátiles + 8,33 % C (25 subproductos de dátiles), 16,6 % subproductos de dátiles + 16,6 % C (16,6 subproductos de dátiles), y 16,6 % subproductos de dátiles + 16,6 % C con *Saccharomyces cerevisiae* (16,6 subproductos de dátiles sc). Las muestras de leche fueron analizadas para determinar su contenido de grasa, proteína, lactosa, sólidos totales y sólidos no grasos. El contenido de grasa de la leche (P<0,01) y los sólidos totales (P=0,025) fueron significativamente más altos en los grupos experimentales que en el grupo de control, particularmente en las raciones de 25 subproductos de dátiles y 16,6 subproductos de dátiles sc. El contenido de proteínas y sólidos no grasos aumentó numéricamente sin alcanzar significancia estadística, mientras que los niveles de lactosa se mantuvieron relativamente estables en todos los tratamientos. La sustitución parcial del concentrado por subproductos de dátiles mejoró la calidad de la leche, lo que indica que los subproductos de dátiles pueden ser un recurso alimenticio sostenible para las ovejas lactantes, añadiendo así valor a sus productos lácteos.

Palabras clave: Suplementos dietéticos; composición de la leche; *Saccharomyces cerevisiae*; subproductos de dátiles; leche de oveja

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INTRODUCTION

In Algeria, sheep (*Ovis aries*) farming is a strategic component of food security, It plays a vital role in animal production systems [1]. However, climate change has exacerbated nutritional challenges, leading to chronic or seasonal undernutrition and, consequently, suboptimal productivity in sheep [2].

Addressing this issue requires rethinking traditional feeding practices, particularly through the use of locally available agro–industrial by–products as alternative feed resources. Such by–products can reduce livestock dependence on human–edible cereals and lower feed costs and waste management expenses [3].

Among these, date palm by–products represent a promising energy-rich resource for ruminant feeding [4, 5]. Their high energy content makes them especially suitable for lactating ewes, which experience a significant energy deficit during early lactation [3, 6]. However, due to their low crude protein content, supplementation with additional protein sources is necessary to achieve a balanced diet [7].

Recent studies have also demonstrated the beneficial effects of *Saccharomyces cerevisiae* as a dietary additive. When administered in adequate amounts, this yeast can enhance rumen microbial activity, improve nutrient utilization, and support the overall health and productivity of ruminants [8, 9].

The formulation of balanced diets for ewes at the end of gestation is essential to ensure maternal health and optimize milk quality. Conventional diets often rely on ingredients such as maize and soybean, valued for their energy and protein content [10].

However, in regions where these feedstuffs are not locally produced, reliance on imports can be costly and unsustainable. The use of abundant, low–cost agro–industrial by–products thus represents a sustainable alternative, contributing to feed cost reduction and adding value to local dairy and meat products [11].

Several international studies have investigated the incorporation of date residues in ruminant diets to improve milk production and composition [12, 13, 14, 15]. However, limited research has focused on the partial replacement of concentrate with date by–products (DBP) in ewes of the Algerian breed of Ouled Djellal and its specific effect on milk quality. Most previous work has emphasized growth performance and metabolic responses [5, 16].

This study aims to promote optimal lactation by encouraging the production of milk rich in essential nutrients for lambs. It does this by evaluating the impact of partially replacing concentrate with DBP and *S. cerevisiae* on the chemical composition of milk from Ouled Djellal ewes, thereby encouraging the use of locally available resources for sustainable sheep production.

MATERIALS AND METHODS

Experimental design, animal management, and feeding strategy

The experiment was carried out at El Baraouia farm (14 km SE of Constantine, 2 km NW of El–Khroub) in a semi-intensive housing system ensuring welfare standards, natural light, and ventilation. Thirty healthy Ouled Djellal ewes (2–4 years, 62.92 ± 5.10 kg), both multiparous and primiparous, were selected at the last month of gestation and monitored until two months postpartum.

Animals were dewormed with fenbendazole (5 mg·kg^{-1}, *per os*), and ivermectin 1% (1 mL·50^{-1} kg body weight, injectable solution for subcutaneous administration), supplemented with a multivitamin preparation containing Vit. A, Vit. D_3, Vit. E, Vit. B_1, Vit. B_2, Vit. B_6, Vit. PP, d–panthenol, and Vit. B_{12}, administered as a 3–5 mL subcutaneous or intramuscular injection, and randomly assigned to five groups (six ewes each). Feed was offered once daily, with water *ad libitum*. A 15–day (d) adaptation period preceded the trial, with gradual introduction of DBP and yeast. Representative feed samples (100 g) were collected for analysis. The composition of the control and experimental diets, including the concentrate, DBP, and *S. cerevisiae*, are presented in TABLE I.

Analytical methods for the determination of chemical composition in forage samples

In this study, the chemical composition of feeds offered to ewes was analyzed using standard forage protocols [17]. Samples were ground, stored in airtight containers, and analyzed at the Scientific Research Center for Biotechnology and the accredited laboratory "Catalyse Lab," with each test performed in triplicate. The chemical composition of the three feed ingredients is presented in TABLE II.

TABLE I
The food rations offered to the ewes in the experimental groups and the control group, in percentage and grams

Groups	Rations	Concentrate		Date by-product		Wheat straw		*Saccharomyces cerevisiae* (g/ewes)
		%	g	%	g	%	G	
Experimental	8.33 DBP	25	375	8.33	125	66.66	1000	0
	25 DBP	8.33	125	25	375	66.66	1000	0
	16.66 DBPsc	16.66	250	16.66	250	66.66	1000	2
	16.66 DBP	16.66	250	16.66	250	66.66	1000	0
Control	33.33 CON	33.33	500	0	0	66.66	1000	0

Ration 8.33 DBP: Wheat straw + concentrate and date by product (66.66%: 25%: 8.,33%). Ration 25 DBP: Wheat straw + concentrate and date by product (66.66%: 8.33%: 25%). Ration 16.6 DBPsc: Wheat straw + concentrate + date by product + *Saccharomyce cerevisiae* (66.66%: 16.66%: 16.66%: 2 g *S. cerevisiae* /ewes). Ration 16 DBP: Wheat straw + concentrate and date by product (66.66%: 16.66%: 16.66%). Ration 33.3 CON: Wheat straw + concentrate (66.66%: 33.33%)

TABLE II
Chemical composition of the three feeds (wheat straw, concentrate, date by–products)

Chemical composition (% DM)	Concentrate	Date by–product (Date waste)	Wheat straw
Dry matter (DM)	90.86	91.34	87.69
Ether extract (EE)	2.95	1.48	2.37
Organic matter (OM)	97.29	95.87	93.62
Mineral matter (MM)	2.7	4.12	6.37
Crude proteins (CP)	10	4.28	5.68
Neutral Detergent Fiber (NDF)	33.8	32.5	68
Acid Detergent Fiber (ADF)	28.7	28.1	37.9
Acid Detergent Lignine (ADL)	11.7	6.69	5
Crude fibre (CF)	8.8	6.66	23.98
Cellulose	17	21.41	32.9
Hemicellulose	5.1	4.4	30.1

Milk sampling and physicochemical analysis in lactating Ouled Djellal ewes

Milk sampling and analysis were conducted during the first week of lactation on Ouled Djellal ewes from the five and the milk produced is intended exclusively for breastfeeding lambs. Following the removal of foremilk, individual 20 mL samples were collected aseptically each morning at 7:00 a.m. into sterile dry tubes and stored at 4°C. After homogenization, samples were analyzed using the Milkoscan™ Minor infrared spectrophotometer (FOSS Electric, Hillerød, Denmark) at the Constantine Biotechnology Research Center. This device enabled simultaneous quantification of key physicochemical parameters, including fat content, protein, lactose, total solids, and non–fat solids.

Statistical analysis

Data entry and statistical analyses were performed using XLSTAT 2018.1.1. These tools were used to calculate means, standard deviations, and standard errors for quantitative variables, as well as to compare percentages and means. A descriptive analysis was first conducted, followed by a one-way analysis of variance (One-Way ANOVA). When significant differences were detected, the Newman–Keuls post–hoc test at a 5% significance level was applied to identify homogeneous groups. Differences were considered statistically significant at $P<0.05$.

RESULTS AND DISCUSSION

Influence of rations on milk quality in Ouled Djellal ewes

The variations in the chemical parameters of milk are presented in TABLE III.

Milk Fat composition

According to the results of milk fat content in TABLE III. A highly significant difference ($P=0.0002$) was observed between the milk produced by ewes receiving the five different dietary treatments: 8.33 DBP, 25 DBP, 16.6 DBPsc, 16.6 DBP, and 33.3 CON. The highest values were recorded in the rations supplemented with DBP and DBP with *S. cerevisiae*, particularly in the 25 DBP (10.34%) and 16.6 DBPsc (10.22%) groups, compared to the other treatments and the control group 33.3CON (4.38%).

TABLE III
Variations in the chemical parameters of milk according to the incorporation of date by–products and *Saccharomyces cerevisiae* in the ration at the beginning of lactation

Chemical parameters (%)	8.33DBP	25 DBP	16.6 DBP sc	16 DBP	33CON	*P*
Milk fat (MF)	7.52 ± 0.78^{b}	10.34 ± 0.70^{a}	10.22 ± 0.78^{a}	7.52 ± 0.78^{b}	4.38 ± 0.78^{c}	0.0002
Crude proteins (CP)	14.55 ± 2.52^{a}	13.96 ± 2.52^{a}	13.48 ± 2.52^{a}	14.49 ± 2.52^{a}	5.90 ± 2.52^{a}	0.118
Lactose	3.11 ± 0.51^{a}	3.23 ± 0.46^{a}	3.57 ± 0.51^{a}	3.33 ± 0.51^{a}	3.84 ± 0.51^{a}	0.856
Total solids (TS)	25.26 ± 2.62^{a}	26.62 ± 2.34^{a}	26.19 ± 2.62^{a}	25.63 ± 2.62^{a}	14.77 ± 2.62^{b}	0.025
Not-fat solids (NFS)%	16.66 ± 1.71^{a}	16.31 ± 1.53^{a}	15.86 ± 1.71^{a}	16.84 ± 1.71^{a}	10.35 ± 1.71^{a}	0.075

^{abc} :Different lowercase letters (a. b. c) in the same row indicate a significant difference ($P<0.05$). Ration 8.33 DBP: Wheat straw + concentrate and date by product (66.66%: 25%: 8.33%). Ration 25 DBP: Wheat straw + concentrate and date by product (66.66%: 8.33%: 25%). Ration 16.6 DBPsc: Wheat straw + concentrate + date by product + *Saccharomyces cerevisiae* (66.66%: 16.66%: 16.66%: 2 g *S. cerevisiae* / ewes). Ration 16 DBP: Wheat straw + concentrate and date by product (66.66%: 16.66%: 16.66%). Ration 33.3 CON: Wheat straw + concentrate (66.66%: 33.33%)

The milk fat content observed in this study exceeded the values reported by Abaidia *et al.* [18], who also supplemented Ouled Djellal ewes with DBP but did not find a significant effect on milk fat (5.08 g·L^{-1}). However, Iqbal *et al.* [13] reported increased milk fat in Damani ewes with varying levels of date supplementation (3.8 at 10%, 4.07 at 20%, and 4.84 at 30%).

In contrast, Al–Dobaib *et al.* [15] found no impact of date supplementation on milk fat content in goats. Other studies reported fat content values of 8.66% [19] and 6.83% [20] in Ouled Djellal sheep without date supplementation. Similarly, Valenti *et al.* [21] observed 8.29% fat after supplementing ewes with pomegranate pulp.

According to Zebeli *et al.* [22] milk fat concentration is closely linked to diet composition and ruminal metabolism, serving as an indicator of rumen health and fiber adequacy in dairy animals. Kholif and Olafadehan [12] attributed the increase in fat content to the fact that, during the in vitro digestibility of date scraps, the degradation of fibers produces volatile fatty acids (VFA), mainly acetic acid. This acid is the main precursor of fatty acid synthesis in the mammary gland, thus promoting the increase of milk fat. Another study by Urrutia *et al.* [23] shows that the intake of acetate in the diet significantly increases the concentration and fat yield of milk, confirming its key role in this process.

The findings also demonstrate that *S. cerevisiae* supplementation improved milk fat concentration. This agrees with Zaleska *et al.* [24], who reported a significant increase in milk fat at d 28 and 70 of lactation in ewes receiving *S. cerevisiae*. Similarly, Giger–Reverdin *et al.* [25] observed higher milk fat content in dairy goats following yeast supplementation. According to Dobicki *et al.* [26], yeast improves ruminal microbiota, enhances fiber degradation, and stimulates milk production by improving nutrient utilization and energy balance.

Furthermore, You *et al.* [27] showed that *S. cerevisiae* can produce fatty acids, and through genetic modifications such as overexpression of acetyl–CoA carboxylase, thioesterase, and malic enzyme they achieved a 4.7–fold increase in fatty acid production compared to wild–type strains, suggesting potential benefits in animal nutrition. In another study on dairy ewes (Chios), Mavrommatis *et al.* [28] tested the addition of 2 g of live yeast (ActiSaf) per animal, from pre–partum to post–partum. The results show a trend towards increased milk production, an improvement in the fatty acid composition of milk, and better use of energy. Conversely, Arambel and Kent [29] found that stimulation of cellulolytic bacteria did not affect milk yield or composition, likely due to the already adequate ADF content in the ration, which may have masked any additional effects on fat synthesis.

Milk protein content

As summarized in TABLE III, a non–significant increase was observed between groups. The control group (33CON) exhibited the lowest protein content (5.90%), whereas higher values were recorded in the groups supplemented with date by–products, either alone or in combination with *S. cerevisiae*: 8.33 DBP (14.55%), 25 DBP (13.96%), 16.6 DBPsc (13.48%), and 16.6 DBP (14.49%).

These values exceed those reported by Abaidia *et al.* [18], who, using the same breed, found no significant effect between the control batch and the batch supplemented with date by–products (4.60% vs 4.88%). Iqbal *et al.* [13] observed a gradual increase in milk protein content in Damani ewes as dietary date waste levels increased (3.58, 3.63, 3.69% for 10, 20 and 30% supplementation, respectively).

Similarly, Al-Dobaib *et al.* [15] reported a significant rise in milk protein concentration in goats fed date by–products compared to control groups (3.05 vs 2.85%). Other studies on Ouled Djellal ewes receiving 500 g·d^{-1} of concentrate reported protein values of 0.84% [19].

However, supplementation with *S. cerevisiae* in the present study did not significantly influence protein levels, consistent with the findings of Zaleska *et al.* [24] in Polish ewes and Milewski *et al.* [30] in Kamieniec ewes. Dann *et al.* [31] also reported no increase in milk protein content in dairy cows after yeast supplementation at 60 g·d^{-1}.

In accordance with Al–Musawi *et al.* [32], The increase in protein content in the experimental groups is possibly explained by the addition of DBP, rich in easily fermentable carbohydrates. These carbohydrates increase the activity of rumen microorganisms. This results in increased production of ammonia (NH3–N) and VFA, promoting the growth of bacteria from the rumen, resulting in better ruminal fermentation. According to Khattab and Anele [33] Increased synthesis of microbial proteins augmented linearly as rejection dates increased in the ration (0 g:94.4 mg–93 g: 103 mg–187 g: 108 mg–280 g–121mg).

Several studies have shown that milk protein levels, particularly casein, are influenced by the diet and nutritional status of the ewes. For example, Couteils [34], emphasizes the strong correlation between total protein content and caseins, while Coulon *et al.* [35] found that insufficient energy intake in ewes can lead to reduced casein synthesis and overall milk protein. Milewski *et al.* [30] noted shifts in casein fractions, with reduced β–casein and increased ϰ–casein following *S. cerevisiae* supplementation, suggesting potential improvements in milk quality and cheese yield. Additionally, Sevi *et al.* [36] reported that as lactation progresses and ambient temperatures rise, milk volume tends to decrease while fat and protein concentrations increase, driven by reduced energy reserves and greater metabolic demands for thermoregulation.

Lactose Content

TABLE III present the variations in milk lactose content as influenced by the different diets. Statistical analysis revealed no significant differences among the five groups, with lactose values remaining relatively close across treatments: 8.33 DBP (3.11%), 25 DBP (3.23%), 16.6 DBPsc (3.57%), 16.6 DBP (3.33%), and 33CON (3.84%).

These findings align with those of Iqbal *et al.* [13], who also reported no significant impact of DBP supplementation on lactose content. According to Grieve *et al.* [37], milk lactose composition appears largely unaffected by the energy content of the diet. Similarly, Yabrir [20] described lactose as the most stable and constant milk component compared to others. Kozloski [38] noted that higher concentrate levels in ruminant diets increase ruminal propionic acid production, enhancing glucose availabilitythe main precursor for lactose synthesis.

However, the present study did not reflect this effect, which agrees with findings by Kalantzopoulos [39], who emphasized that lactose is the principal osmotically active component of milk, generally remaining constant throughout lactation in healthy animals. Fernandes *et al*. [40] observed no change in milk lactose content in Santa Inês sheep supplemented with concentrate during pre and postnatal periods. Campos *et al*. [41] reported higher lactose levels in ewes receiving greater concentrate supplementation (0.4 vs. 0.8% of body weight), indicating that both pre – and postnatal nutrition directly affect milk quality and yield. Fredeen [42] further emphasized that lactose levels correlate more strongly with overall milk production than with diet composition alone, indicating that an increase in lactose is generally associated with a higher milk yield.

In the present study, supplementation with *S. cerevisiae* did not significantly affect milk lactose levels. This aligns with previous findings, which reported no increase in milk lactose in ewes with a dose of 3 $g \cdot kg^{-1}$ of feed$\cdot d^{-1}$ [24] 1g/head/d [43] and goats with a dose of 0.2 $g \cdot head^{-1} \cdot d^{-1}$ [25, 44] receiving yeast supplements. In contrast, Christodoulou *et al*. [45] observed a significant rise in lactose in Chios and Lacaune ewes during the fifth week of live yeast (1 $g \cdot d^{-1}$) supplementation.

Abd El–Ghani [46] found a non-significant increase in lactose levels with the increase in doses of *S. cerevisiae* between the supplemented batches at 3 $g \cdot d^{-1}$ and 6 $g \cdot d^{-1}$ (4.52 vs 4.65%). Jiménez–Sobrino *et al*. [47] noted a negative correlation between lactose content and both milk fat and protein concentrations in ewes. In the present study, lactose values remained within physiological norms, in line with those reported by Chachoua *et al*. [19] (2.98 $g \cdot L^{-1}$) and Rouissi *et al*. [48] (3.89%), and lower than those documented by Yabrir [20] (4.76%) and Sevi *et al*. [36] (5.21–4.70%).

Total solids

TABLE III illustrates the total solids (TS) content of milk collected from ewes subjected to different dietary treatments. A statistically significant increase (P=0.025) in TS was observed in the milk of ewes fed rations supplemented with date by–products, with or without *S. cerevisiae*. The highest TS values were recorded in the following groups: 25 DBP (26.62%), 16.6 DBPsc (26.19%), 16.6 DBP (25.63%), and 8.33 DBP (25.26%), while the control group (33CON), which received 500 g of concentrate, showed a markedly lower value (14.77%). Al–Musawi *et al* [32] found that the energy and nutrients available from dates in the sheep diet can affect digestion and nutrient absorption and the efficiency of rumen microbes, by increasing the production of VFA and ammonia, essential for the synthesis of milk fats and proteins, thus contributing to the increase in TS. Contrary to our results, Abaidia *et al*. [18] did not observe a significant effect of DBP supplementation on TS in milk from Ouled Djellal ewes.

However, Campos *et al*. [41] reported higher TS levels (15.61%) in Santa Inês ewes supplemented with concentrated feed at 0,8% of body weight, suggesting that energy–dense diets may contribute to increased TS content. The elevated TS levels observed in the present study is likely influenced by the partial substitution of concentrate with DBP. The control diet (33CON), was insufficient to maintain high TS content, indicating the potential nutritive value of DBP in enhancing milk quality.

Similarly, Salama *et al*. [49] and Baiomy [50] found no significant effect of *S. cerevisiae* supplementation on TS in dairy goats (0.9 $g \cdot d^{-1}$: 13.2%) and Ossimi ewes (3 $g \cdot d^{-1}$: 18.8%–6 $g \cdot d^{-1}$: 19.5%), respectively. Conversely, Abd El–Ghani [46] reported an increase in total solids with increasing yeast doses in goat diets (3 g: 12.40%–6 g: 12.57%), highlighting the dose-dependent response of TS to yeast supplementation.

According to Yabrir [20], coagulation time (CT) in milk is more closely related to TS and fat content than to physical properties such as pH or density. Higher TS and fat levels improve gel firmness and reduce CT, which suggests that the dietary treatments in our study could enhance the technological properties of ewe milk for cheese-making and other value–added products. Ochoa–Cordero *et al*. [51] reported a negative correlation between milk yield and TS content, known as the dilution effect, which may also contribute to variations observed across diets.

Overall, the TS values of the control group and experimental groups obtained in our study exceed those previously reported on Ouled Djellal ewes, citing the results of Abaidia *et al.* [18], which were fed only from steppe pastures (19.6 $g \cdot L^{-1}$); Chachoua *et al.* [19], where the ewes were fed with 500 $g \cdot day^{-1}$ of concentrate (11.8 $g \cdot L^{-1}$); and Yabrir [20], where the ewes were fed with natural pasture, silage, and barley (16.65%), highlighting the positive impact of the tested rations on milk production.

Non–fat solids

The results related to the not-fat-solids content (NFS), presented in TABLE III, show a non-significant increase associated with the inclusion of DBP in the diets. The lowest NFS value was recorded in the control group (33CON: 10.35%), while the groups receiving date-supplemented rations exhibited higher and relatively similar values, ranging from 15.86 to 16.84%.

The NFS content in the control group aligns with physiological norms reported by Yabrir [20] (10.64%) and Selmi *et al*. [52] (10.92%). In contrast, NFS values observed in the groups supplemented with date by product were higher than these references but lower than those reported by Abaidia *et al*. [18] (17.83% $g \cdot L^{-1}$) in ewes of the same breed fed DBP at a rate of 400 $g \cdot animal^{-1}$/day. These findings are consistent with those of Iqbal *et al*. [13], who demonstrated a proportional increase in NFS with increasing levels of date inclusion: at 10, 20, and 30%, NFS values were 8.40, 9.22, and 9.76%, although the absolute values were lower in their study.

Conversely, Sharifi *et al*. [53] found no significant effect on NFS in Saanen goats with low-quality date supplementation at different percentage: 12, 16, 18%, with values of: 8.07, 8.16, 8.06%. Campos *et al.* [41] reported a significant increase in NFS in ewes receiving high-concentrate diets (0.4 and 0.8% of live weight), with values of 11.37 and 11.57%, compared to the control group 11.19%.

According to Saleh *et al*. [54] The high soluble sugar and fiber content of discarded data can enhance the activity of fibrolytic bacteria, leading to increased acetic acid production and reduced propionic acid levels, which improves the efficiency of nutrient conversion into fat and milk solids.

Supplementation with *S. cerevisiae* did not significantly influence NFS. However, a slight decrease that is not significant was observed when comparing the yeast-supplemented ration (16.6 DBPsc: 15.86%) to the equivalent non-yeast ration (16.6 DBP: 16.84%). This observation aligns with findings by Baiomy [50] and Masek *et al*. [43], who reported no significant impact on SNF in ewes supplemented with 3–6 $g \cdot d^{-1}$ and 1g of yeast.

Similarly, Abd El–Ghani [46] observed no significant difference in SNF in dairy goats even with increasing yeast supplementation (3 $g \cdot d^{-1}$: 8.33%; 6 $g \cdot d^{-1}$: 8.26%). According to Hachana *et al*. [55], NFS plays a direct role in the binding capacity between milk fat and water, and a high-protein diet does not induce an increase in NFS; only an increase in energy intake can increase NFS, which corroborates the trends observed in the present study.

CONCLUSION

The statistical evaluation of milk quality in ewes fed experimental diets revealed a significant increase in milk fat content and total solids in animals receiving rations supplemented with date by–products and/or *S. cerevisiae*, compared to the control group. The 25 DBP and 16.66 DBPsc groups exhibited the highest fat concentrations, while all date-supplemented rations yielded higher total solids. In contrast, protein content, lactose and NFS, differences were not statistically significant.

These findings indicate that partial substitution of concentrate with DBP, with or without *S. cerevisiae*, can enhance the compositional quality of ewe's milk, particularly in terms of solids and milk fat, offering potential benefits for dairy product valorization.

This work has demonstrated that DBP (date waste), a sustainable local resource treated as waste, can be used as an acceptable partial substitute in the diet of ewes in late gestation and lactation, replacing expensive imported concentrate and helping to reduce the high cost of imported feed paid by the state.

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Conflict of interest

The authors declare no conflict of interests.

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