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The effect of the inclusion of detoxified *Argania spinosa* press cake into the diet of Alpine goats on the polyphenol compounds and antioxidant properties of the cheese

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Abstract. Goat milk and dairy products, including cheese, are an excellent source of antioxidants known to resist oxidative stress. This research aimed to introduce detoxified Argane press cake (DAPC) in the diet of Alpine goats and to evaluate the effect on antioxidant activity and polyphenol compounds in the cheese. The results showed that the cheese fermented with autochthonous starter obtained from goats fed detoxified Argane press cake showed the highest total phenolic content and DPPH (1,1-diphenyl-2-picrylhydrazyl) scavenging assays (160.8 \pm 5.0 μ g GAE/g of cheese dry matter [DM] and 44.76 \pm 4.1%, respectively) compared to the control cheese obtained from goats fed Argane press cake non-detoxified (100.75 \pm 5.1 μ g GAE/g DM and 38 \pm 4.0%, respectively).The collected data revealed that including detoxified Argane press cake in the goat diet offers a good method for raising the amounts of polyphenol compounds and antioxidant activity in goat cheese. Therefore, goat products could be considered as a functional food with benefits for human health.

Keywords. Argane – Goat's cheese – Antioxidant – Polyphenol.

Effet de l'inclusion du tourteaud' Argania spinosa détoxifié dans le régime alimentaire des chèvres alpines sur les composés phénoliques et les propriétés antioxydantes du fromage

Résumé. Le lait de chèvre et ses produits laitiers, y compris le fromage, constituent une excellente source d'antioxydants reconnus pour leur résistance au stress oxydatif. L'objectif de cette étude est d'introduire dans le régime alimentaire quotidien des chèvres alpines le tourteau d'Argane détoxifié (DAPC) et d'évaluer son effet sur l'activité antioxydante et les composés phénoliques du fromage. Les résultats ont montré que le fromage fermenté avec une levure autochtone obtenue à partir du lait de chèvres nourries avec le regime encluant du tourteau d'Argane détoxifié est caractérisée par la teneur la plus élevée en polyphénols ainsi qu'il exhibe un pouvoir antioxydant intéressant (160.8 ± 5,0 µg GAE / g MS et 44.76 ± 4,1%, respectivement) par rapport au fromage témoin fermenté avec une levure autochtone issu du lait des chèvres nourries avec le regime temoin incluant du tourteau d'Argane non détoxifié (100.75 ± 5,1 µg GAE / g de MS et 38 ± 4,0%, respectivement). Les données collectées ont révélé que l'inclusion du tourteau d'Argane détoxifié dans le régime alimentaire des chèvres améliore la qualité du fromage. Par conséquent, les produits à base de lait de chèvre pourraient être considérés comme un aliment nutritionnel présentant des avantages pour la santé humaine.

Most-clés. Argane – Fromage de chévre – Antioxidant – Polyphenol.

I – Introduction

Goat's milk and derivatives are considered healthy food, owing to its composition and recognized benefits for humans (Lakram *et al.*, 2019a). Furthermore, goat's milk and cheese exhibit a high antioxidant capacity which reflects greater oxidative stability and improve health protection for the consumer against exposure to the oxidative stress, which is known as characteristic of several acute and chronic diseases (Lakram *et al.*, 2019a). The antioxidant activity of goat's milk and cheese can be due to a large variety of functional components, such as phenols, flavonoids, carotenoids, and vitamins (E and C), or even proteins. Additionally, results of two studies using the same antioxidant test show that dairy products have an antioxidant capacity of the same order of magnitude as cereals, legumes and fruit juice (Wu *et al.*, 2004,Cloetens *et al.*, 2013).

Goat farming in Morocco is considered an important socioeconomic sector. The Moroccan goat population estimated at around 5.3 million heads (Lakram *et al.*, 2019b). However, ruminants in Morocco's arid and semiarid areas suffer from lack of forage and water availability due to low precipitation (Mercha *et al.*, 2019). For these reasons, it is necessary to contribute to the development of native forage resources adapted to local climate and soil conditions as an alternative resource. Among such native resources, Argane press cake (APC), a by-product of oil extraction from Argane seeds. Unlike other forages, APC has high levels of crude protein (48.4%), crude fiber (17.6%), and fat (18.9%). It is therefore a major source of protein and energy to fill the gap in food rations in the Moroccan live-stock (Lakram *et al.*, 2019c). On the other hand, it contains antinutritional factors such as saponins (4%), which give it a bitter taste. The astringent and irritating flavor of saponins reduces feed intake. In order to improve its quality and make it more appetizing by livestock, detoxification of the APC is carried out at the National Institute of Agronomic Research (INRA) in Rabat (Morocco). The objective of the present study was to investigate the effect of the inclusion of detoxified Argane press cake into the diets of the Alpine goat on antioxidant activity and polyphenol compounds in the cheese.

II – Materials and methods

The study was conducted on a farm in the region of Meskala (Essaouira, in the region of Marrakech Safi). A follow-up was conducted over a period of six weeks on two groups of eighteen goats. The first group of goats consumed a diet including detoxified Argane press cake (DAPC), while the second group consumed a diet with non-detoxified Argane press cake (APC), a fifteen day adaptation period was respected. The ingredients and chemical composition are shown in Table 1.

	Diet 1	Diet 2
Ingredients (g/100g of fresh matter)		
Argane press cake detoxified	20%	0
Argane press cake no detoxified	0%	20%
Corn silage	16%	16%
Lucerne	17%	17%
Wheat bran	15%	15%
Ground carob	16%	16%
Barley	14%	14%
Concentrate	0	0
Minerals and vitamins	2%	2%
Chemical composition		
Dry matter (%)	89.59	88.12
Crude protein (%)	17.95	18.05
Ash (%)	7.58	8.23
Crude fiber (%)	18.15	15.27
Ether extract (%)	1.78	4.53

Table 1. Ingredients and che	mical composition	of the	diets
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The experiment used the response surface methodology to optimize the various detoxification factors (volumes of water, boiling temperature and time) for better saponin reduction from APC. The optimum conditions for detoxifying APC are to boil APC in distilled water at 80 °C for 25 minutes and then to dry it at 40 °C in a hot air oven.

For making cheese, autochthonous starter cultures consisting of a mixture of *Lactococcus lactis* and *Streptococcus thermophilus* were used.

The two groups of bio-cheese were made from goats feed DAPC or APC as described by Jamaly *et al.*, (2011).

The total phenolic content (TPC) was determined according to Lakram *et al.*, (2019a). The antioxidant activity was determined by measuring the free radical scavenging cheese extract using DPPH inhibition assay as described by Lakram *et al.*, (2019a).

Results are expressed as means ± standard deviation (SD). Significant differences between means were tested by ANOVA followed by Tukey's studentized range test at P<0.05.

III – Results and discussion

DPPH inhibition of cheese from milk from goats fed DAPC was higher than that from milk obtained from goats fed APC diet over the storage period (14 days in 4°C) as shown in Fig. 1. On day 14, highest DPPH inhibition was shown by DPAC cheese, $44.76\pm4.1\%$, while cheese made with milk from goats fed APC showed $38\pm4.0\%$.

The percentage of DPPH radical scavenging activity is affected by several factors such as goat feeding, pasteurization and the type of bacterial culture involved in the maturation (Meira *et al.*, 2012).



Fig. 1. Changes in antioxidant activity (scavenging % of DPPH) ofgoat's cheese during refrigerated (4°C) storage in days (14 days). APCD: cheese made with milk from goat fed Argane press cake detoxified; APC: cheese made with milk from goat fed Argane press cake non-detoxified. Values are presented as mean ± SD (n = 3).

The total phenolic contents (TPC) estimated by the Folin–Ciocalteu reagent method of the different cheeses analyzed are presented in Fig. 2, the phenolic content followed the same tendency; the highest levels in cheeses made with milk came from goats fed DAPC, averaging 160.8 \pm 5.0 µg GAE/g of cheese DM, compared to that made with milk obtained from goats fed APC (100.75 \pm 5.1µg GAE/g of cheese DM). These values are close to those found by Delgadillo Puga *et al.*, (2009).



Fig. 2. Changes in total phenolic content (TPC; μg GAE/g of cheese DM) of goat's cheese during refrigerated (4°C) storage in days (14 days). APCD: cheese made with milk from goat fed Argane press cake detoxified; APC: cheese made with milk from goat fed Argane press cake nondetoxified. Values are presented as mean ± SD (n = 3).

Liu *et al.*, (2018), when comparing two feeding systems, showed that TPC concentrations were affected by the animals' feed; this finding is in accordance with our results

IV – Conclusion

Although during the last decade's goat cheese has been the subject of many studies throughout the world, very few investigations have focused on the quality of cheese produced in Morocco. The use of a diet based on the argane tree sub products in replacement of a traditional one in goat's diets affect the cheese antioxidant activity and polyphenolic compounds significantly. The diet appears to be a promising alternative for dry season feeding systems and, thereby, to improve the livelihood of farmers in dry area.

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