Journal of Animal & Plant Sciences, 35(2): 2025, Page: 584-591
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2025.2.0049

COSMETICS INDUSTRY AS A PROMISING OPPORTUNITY FOR DONKEY BREEDING: CONSUMER ACCEPTABILITY OF A COSMETIC CREAM BASED ON MILK FROM THE MARTINA FRANCA BREED

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ABSTRACT

Donkey milk is a valuable product due to its uses that range from feeding newborns and heart and hypercholesterolemic patients to making dairy products, cosmetics, active biomolecules, and soaps. Although the use of donkey milk for cosmetic applications has a long history, there is little knowledge about its perceived quality in cosmetics. Therefore, in this study, we investigated the perception of untrained consumers regarding the sensory aspects of a donkey milk-based face cream. The consumer test was carried out by 110 randomly recruited women who evaluated two formulations of the cosmetic with or without donkey milk. On the 7th and 15th day of use, the following sensory aspects were evaluated: appearance, fragrance, effectiveness, and overall satisfaction. ANOVA test demonstrated the effect of cosmetics and skin type on judgement. In both periods, the donkey milk-added cream reached a good rating in most of the parameters. Consumers with dry skin appreciated this product more than consumers with normal and oily skin and gave significantly higher ratings for moisturization and smoothness of the skin in both periods.

Keywords: biodiversity; donkey milk; cosmetics; consumer acceptance

Published first online March 29, 2025 Published final April 28, 2025

INTRODUCTION

In the marginal areas of central and southern Italy, farmers are rediscovering donkey rearing as a profitable and alternative source of income. The donkey is a non-selective grazer equid, therefore, in these areas, it feeds on many invasive plants normally avoided by other herbivores, with positive effects on plant biodiversity (Karatosidi *et al.*, 2013; Freschi *et al.*, 2017; Colonna *et al.*, 2020). Donkey milk is known for its unique nutritional profile, it is a nutrient source of fat, sugar (carbs.), protein, vitamins, minerals, and enzymes (Singh *et al.*, 2024) and can be effectively used in neonatal nutrition (Aspri *et al.* 2017) as well as in cardiac and hypercholesterolemic patients (Baloš *et al.* 2023). Recently, two promising opportunities for the valorization of donkey milk have been discussed: innovative cheese production and use in cosmetic preparations (Niro *et al*, 2017; Cosentino *et al.*, 2022). In cheese making, the lysozyme contained in donkey milk is a good alternative to egg-derived lysozyme, which can cause allergy symptoms in some consumers.

The lysozyme content in donkey milk is high, ranging from 1.0 to 3.7 mg/mL depending on the lactation stage and production season (Niro *et al*, 2017). In addition, recent studies (Ozturkoglu-Budak *et al.*, 2021; Cosentino *et al.* 2022; Paolino *et al.*, 2022) have shown that the addition of donkey milk in the production of cow and goat cheeses improves their appearance (texture and uniformity) and sweetness. In the cosmetics sector, the industry needs to constantly develop new products and improve its existing ones to stay ahead in a highly competitive market by obtaining information on consumer preferences (Cortez-Pereira *et al.*, 2009; Parente *et al.*, 2010; Cosentino *et al.*, 2013a; Jung *et al.*, 2013; Barrenar *et al.*, 2015). The use of anti-age cosmetics has become increasingly popular among consumers interested in natural skin care products (Jung *et al.*, 2013). In fact, the cosmetics trade mainly focuses on products with natural ingredients without added preservatives, prompting many companies to increase the use of natural ingredients in existing or new products (Kim *et al.*, 2009; Hanss and Böhm, 2012; Sasounian *et al.*, 2024). When evaluating a new cosmetic product, its effectiveness in improving the skin's moisturizing function as a barrier against water loss is the main factor assessed (Kim *et al.*, 2014; Fonseca *et al.*, 2024). With a sufficient amount of water in the *stratum corneum*, the skin retains its barrier function, becomes soft

and flexible and looks smooth and healthy. Nevertheless, its elasticity decreases due to ageing, sun exposure, and dehydration. The facial area of the skin is easily exposed to many external factors such as environmental stress and UV radiation with relevant consequents (Tagami, 2008; Ryu *et al.*, 2014). Due to their natural origin, milk components fulfil the requirements of the cosmetics sector in many areas. The proteins and other components contained in milk have a high absorption capacity and a strong water-binding capacity, thus promoting high hydration of the skin and preventing the degradation of epidermal cells (Temuujin *et al.*, 2006; Gilbert *et al.*, 2012; Cristiano *et al.*, 2022). In addition, milk proteins with a glycosylated component could be widely used in any products developed to mitigate skin ageing. For example, lactoferrin, which is known to have a high iron chelating property, could prevent the formation of free radicals in the skin after prolonged sun exposure (Cotte, 1991; Herrouin *et al.*, 2001; Girardet *et al.*, 2004, Superti, 2020; Zhou *et al.*, 2024). Thanks to these properties, there are several products on the cosmetics market that are made from milk of different species. Products made from cow's milk (face and body creams, cleansing milks, and tonics) are the best known among consumers. On the other hand, cosmetics made from the milk of other species such as camel (Ahmed *et al.*, 2014; Kula, 2016), sheep (Kazimierska *et al.*, 2021), goat (Ribeiro and Ribeiro, 2010), mare (Temuujin *et al.*, 2006), and donkey (Medhammar *et al.*, 2012; Cosentino *et al.*, 2013b) are little known and rarely used. Regarding donkey milk, despite the historically recognized beautifying effects of donkey milk (Orsingher *et al.*, 2011; Cristiano and Guagni, 2022), few studies have been conducted on its perceived quality in cosmetics. The aim of the present study was to assess the perception of untrained consumers regarding the sensory aspects of a face cream with added donkey milk.

MATERIALS AND METHODS

Milk collection and analysis: The bulk milk used for the face cream was collected from 8 pluriparous Martina Franca donkeys. After collection, the milk was pasteurized, cooled to 4 °C, and transported to the cosmetics laboratory. Milk composition resulted: protein (13.5 g/L), fat (2.9 g/L), lactose (59.8 g/L), dry matter (80.6 g/L) (Milkoscan FT 6000, Foss Electric, Hillerød, Denmark). Titratable acidity (2.00 °SH) (Soxhlet-Henkel direct method), pH (7.20) (MeterLab pHM 240; Radiometer Analytical SAS, Lyon, France), and ash content (4.5 g/L) were also measured (AOAC, 1990).

Face cream formulation: A face cream formulation was prepared in a cosmetic laboratory by a phase inversion technique at moderate temperature to obtain an emulsion with thin and stable microdroplets. The physical and chemical stability of the creams was tested and confirmed. According to the International Nomenclature of Cosmetic Ingredients (UE Regulation, 2009) the components of the control cream, were: Aqua, *Prunus amygdalus dulcis* Oil, *Vitis vinifera Seed* Oil, *Butyrospermum parkii* Butter, *Olea europaea* Oil, Carbomer, Phenoxyethanol, Ethylhexylglycerin, Triethanolamine. The treated cream was prepared by adding 30% pasteurized donkey milk -by weight- to the control cream. The creams were filled into white 25 mL containers.

Acceptance test: Acceptance was assessed by 110 women, aged 30-50 years, regular users of cosmetic creams, and all belong to the Mediterranean ethnic group. Voluntary recruitment of consumers took place at the University of Basilicata (Potenza, Italy) and in various supermarkets; after reading all the information, they gave their informed consent. All subjects had to be free from skin diseases or other physical disorders with skin manifestations, pregnancy, and breastfeeding. The skin type of the recruited women was determined by sebumetry (Sebumeter CM 815, Courage+Khazaka, Cologne, Germany) and they were divided according to skin type into dry (35), normal (39), and oily (36) groups. The duration of the study was six weeks. The subjects tested the control cream (CC) and the experimental cream (EC) at home for 15 days, with a waiting period of 15 days between the two treatments. At the beginning of the experiment, all participants were randomly assigned one of the two creams and each one received instructions on cosmetic application. Each tester received a leaflet describing 11 attributes relating to the following sensory aspects: Appearance, Fragrance, Effectiveness, and Overall Satisfaction (Table 1).

Before the test, a short training session was conducted to familiarize consumers with the descriptors. The instructions for the test were: self-apply the face cream once a day in the evening with clean hands and rub it until the product is absorbed. Before applying the cream, the face skin had to be completely clean and well cared for. The bibliography lists several attributes to describe a face cream, among we have selected the most representative ones. All attributes were measured using a categorical hedonic scale from 1 to 10. After 7 and 15 days of use, consumers had to rate the attributes listed in the questionnaire for each face cream. At the end of each treatment, consumers returned the cream containers and questionnaires (7 and 15 days). Each container was then weighed to determine the amount of product consumed and to rule out unreliable ratings.

Table 1. Sensory aspects and their definition

Sensory aspects	Attributes	Definition	References
Appearance	Thickness	Viscosity of the cream when picking up from the container	Parente *et al.*, 2010
	Spreadability	Ease of moving product over the skin. A product that spread easily will cover a large area of the skin	Lee *et al.*, 2005
	Total appearance	Overall satisfaction of the considered attributes	This trial
Fragrance	Impact	Efficacy of a perfume during the first moments of application the cream on skin.	Cortez-Pereira *et al.*, 2009
	Volume	Effectiveness over distance, sometime after application.	Cortez-Pereira *et al.*, 2009
	Total fragrance	Overall satisfaction of the considered attributes	This trial
Effectiveness	Smoothness	Degree to which the product makes the skin smooth	Parente *et al.*, 2010
	Moisturization	Degree of hydration of skin after applying the product	Parente *et al.*, 2010
	Adhesiveness	Degree to which the product adheres to skin.	Lee *et al.*, 2005
	Total effectiveness	Overall satisfaction of the considered attributes	This trial
Overall satisfaction		Overall satisfaction of the considered sensory aspects	This trial

Data analysis: The data were analyzed using a 2 × 3 factorial ANOVA, with two factors: cosmetic type (treated vs. control) and skin type (dry, normal, oily). The interaction effect between cosmetic type and skin type was not significant. Mean differences were considered statistically significant at $P \leq 0.05$. All analyses were performed using SAS software (2004).

RESULTS

The ANOVA showed the effect of the cream and skin type on consumers ratings. After 7 days of treatment, the perception of smoothness (6.70 vs. 5.70, $P \leq 0.05$) and moisturization (8.20 vs. 7.25, $P \leq 0.01$) was significantly higher for dry skin with the treated cream (Table 2).

Table 2. Sensorial aspects of face creams at 7 days (Mean ± SE)[1]

Sensorial aspects	Attributes	Skin Type					
		Dry		Normal		Oily	
		Cream Type					
		Treated	Control	Treated	Control	Treated	Control
Appearance	Spreadability	7.05 ± 0.30	7.05 ± 0.36	7.70 ± 0.35	8.00 ± 0.25	7.56 ± 0.31	7.24 ± 0.42
	Thickness	7.70 ± 0.40	7.50 ± 0.57	7.40 ± 0.50	7.41 ± 0.37	7.10 ± 0.44	8.18 ± 0.50
	Total appearance	6.50 ± 0.35	7.00 ± 0.36	8.07 ± 0.42	7.89 ± 0.30	7.55 ± 0.37	8.40 ± 0.50
Fragrance	Impact	8.00 ± 0.33	7.00 ± 0.42	6.90 ± 0.40	7.74 ± 0.29	7.56 ± 0.35	8.20 ± 0.47
	Volume	7.40 ± 0.36	7.00 ± 0.47	7.22 ± 0.43	6.67 ± 0.31	6.80 ± 0.38	7.22 ± 0.41
	Total fragrance	7.00 ± 0.38	6.50 ± 0.44	7.43 ± 0.46	7.30 ± 0.33	7.11 ± 0.40	8.20 ± 0.50
Effectiveness	Smoothness	6.70 **a** ± 0.36	5.70 **b** ± 0.40	6.86 ± 0.43	6.07 ± 0.31	5.44 ± 0.38	5.80 ± 0.51
	Moisturization	8.20 **A**± 0.30	7.25 **B** ± 0.38	8.07 ± 0.36	7.41 ± 0.26	8.00 ± 0.32	8.00 ± 0.43
	Adhesiveness	7.10 ± 0.46	6.60 ± 0.73	7.90 ± 0.45	7.00 ± 0.40	5.78 ± 0.49	6.40 ± 0.55
	Total effectiveness	7.00 ± 0.33	7.00 ± 0.52	8.00 ± 0.40	7.41 ± 0.28	7.22 ± 0.35	7.00 ± 0.36
Overall cream satisfaction		7.60 ± 0.30	6.75 ± 0.48	8.00 ± 0.35	7.40 ± 0.26	6.44A±0.32	8.00B± 0.42

[1] a, b = $P \leq 0.05$; A, B = $P \leq 0.01$.

No significant difference was found between the creams in consumers with normal and oily skin. When all consumers were considered, the higher ratings for the attributes of skin smoothness and moisturization were confirmed for the treated face cream (7.07 vs 5.64 and 8.50 vs 7.40, respectively; $P \leq 0.01$) (Figure 1).

After 15 days of treatment, the subjects with dry skin rated the treated cream better in terms of spreadability (+1.04, $P \leq 0.05$), total appearance (+1.1, $P \leq 0.05$), smoothness (+1.05, $P \leq 0.01$), moisturization (+1.25, $P \leq 0.01$), total effectiveness (+0.43, $P \leq 0.05$), and overall cream satisfaction (+1.6, $P \leq 0.01$) (Table 3).

The other consumers expressed a good acceptance of the two tested creams after 15 days, thus improving their judgement given after 7 days. Considering the judgement of all consumers, the treated face cream

confirmed the highest level ($P \leq 0.01$) of smoothness (6.61 *vs* 5.66) and moisturization (8.10 *vs* 7.20) compared to the control cream (Table 3 and Figure 2).

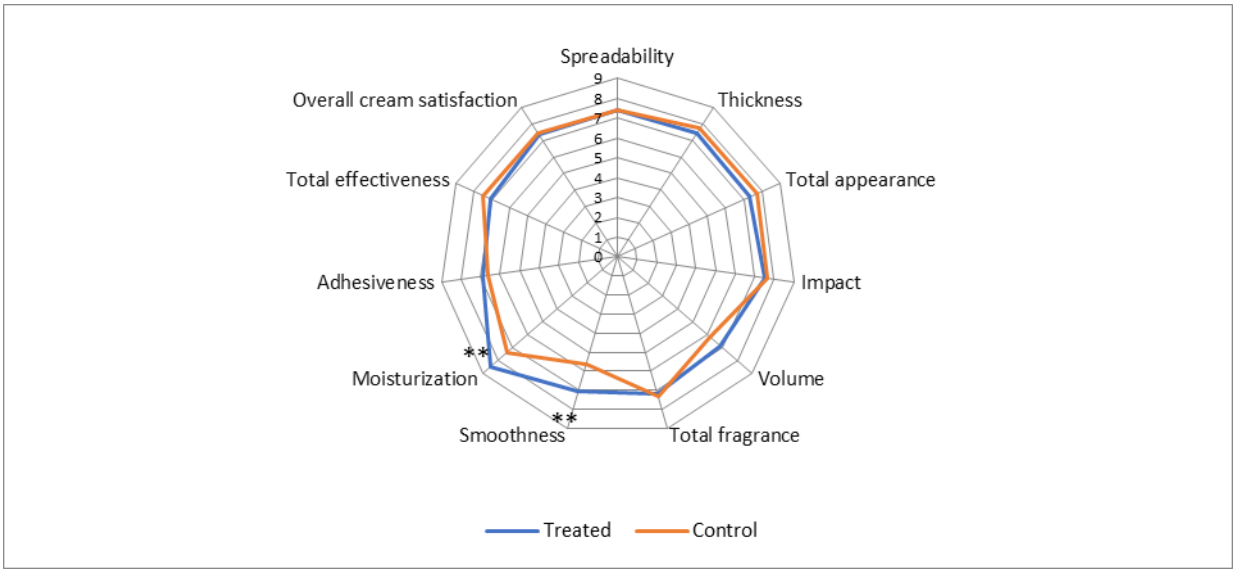

Figure 1. Overall sensorial aspects of face creams at 7 days; ** $P \leq 0.01$.

Table 3. Sensorial aspects of face creams at 15 days (Mean ± SE)[1].

Sensorial Aspects	Attributes	Skin type					
		Dry		Normal		Oily	
		Treated	Control	Treated	Control	Treated	Control
Appearance	Spreadability	7.45 a ± 0.28	6.41 b ± 0.41	7.47 ± 0.33	8.17± 0.27	7.57±0.34	6.85± 0.32
	Thickness	6.30 ±0.40	7.180 ± 0.45	7.85 ± 0.45	8.17±0.66	7.40±0.46	7.40±0.43
	Total appearance	7.70 a± 0.32	6.60 b ± 0.45	7.27 ± 0.37	7.39±0.30	7.43± 0.38	8.13±0.35
Fragrance	Impact	7.80 ± 0.34	6.80 ± 0.48	7.53 ± 0.39	8.39±0.31	7.14 ±0.40	7.38±0.38
	Volume	7.80 ±0.33	7.00 ± 0.46	6.80 ± 0.38	7.52± 0.30	7.71±0.39	7.86±0.36
	Total fragrance	7.60±0.34	7.00 ± 0.48	7.00 ± 0.39	7.90±0.32	6.57 ±0.41	7.38±0.38
Effectiveness	Smoothness	6.20 **A**± 0.31	5.15 **B** ± 0.44	6.60 ± 0.36	6.39± 0.29	6.00 ±0.38	6.38 ±0.35
	Moisturization	8.40 **A** ± 0.38	7.15 **B** ± 0.40	7.60 ± 0.33	7.70±0.27	8.29±0.34	7.75± 0.32
	Adhesiveness	7.60 ±0.36	7.40 ± 0.50	7.10 ± 0.41	7.10±0.33	6.55±0.42	6.25±0.40
	Total effectiveness	8.23 a ±0.31	7.80 b ± 0.45	7.00 ± 0.37	7.83±0.30	7.15±0.38	7.00±0.36
Overall cream satisfaction		8.20 **A** ±0.30	6.60 **B** ± 0.43	7.53 ± 0.35	7.74 ±0.29	7.14±0.37	7.25 ±0.34

[1] a, b = $P \leq 0.05$; A, B= $P \leq 0.01$.

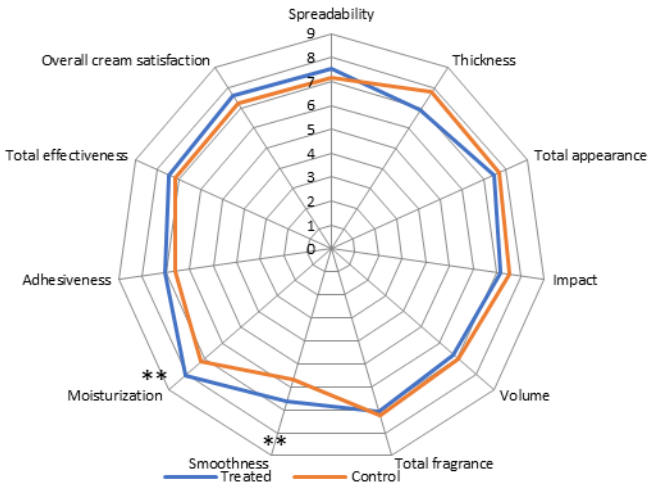

Figure 2. Overall sensorial aspects of face creams at 15 days; ** P ≤ 0.01.

DISCUSSION

The current study highlights the efficacy of a face cream enriched with donkey milk, particularly in improving skin smoothness and moisturization. The results confirmed a significant improvement in sensory perceptions, especially for consumers with dry skin. After just 7 days of treatment, the treated cream showed a significant increase in perceived smoothness and moisturization, suggesting that the addition of donkey milk provides an effective hydrating boost. The persistence of these benefits after 15 days, especially in attributes such as spreadability, total appearance, and overall satisfaction, underscores the longer-term efficacy of the cream for individuals with dry skin. Interestingly, while the treated cream had a pronounced impact on those with dry skin, no significant differences were noted for individuals with normal or oily skin. This suggests that donkey milk's hydrating components, such as proteins, vitamins, and lactose, may particularly benefit individuals with a higher predisposition to dry skin, as these compounds help restore and retain moisture more effectively (Cosentino *et al.*, 2016; Temuujin *et al.*, 2006). Donkey milk has long been recognized for its beneficial cosmetic properties, such as wrinkle reduction, improved skin elasticity, and the restoration of the skin's natural defenses (Orsingher, 2011; Adduci *et al.*, 2019). The results of this study support these findings, demonstrating that the cream with donkey milk not only improves the skin's appearance but also contributes to deep hydration and enhanced smoothness, even within the short period of this study. Moreover, the balanced nutrient profile of donkey milk, including essential fatty acids, lysozyme, and β-lactoglobulin, likely plays a critical role in enhancing the moisturizing and soothing effects of the cream (Blasi *et al.*, 2008; Cosentino *et al.*, 2013a; Labella *et al.*, 2016). These components are known to relieve irritation and restructure skin affected by aging or inflammation (Blasi *et al.*, 2008; Nazzaro *et al.*, 2010; Simos *et al.*, 2011; Vincenzetti *et al.*, 2012) which could explain the enhanced user satisfaction after 15 days of use. Notably, while the primary benefits were observed in individuals with dry skin, the broader acceptance of the cream by all consumer groups after 15 days indicates that the donkey milk-enriched formulation holds appeal across different skin types. This supports previous research suggesting that donkey milk's components offer hydration and nourishment suitable for all skin types by balancing moisture levels (Cristiano and Guagni, 2022). According to Orsingher (2011), the pool of substances contained in donkey milk provides deep hydration with visible results after just a few days and not only restore the normal physiological balance of the skin, but also stimulate and reactivate the most vital part of the skin, the papillary dermis, rich in blood vessels and fibroblasts, which are responsible for the production of collagen and elastic and glucosaminoglycans, molecules that form the intercellular substance of skin tissue (Luebberding *et al.*, 2013; Kim *et al.*, 2014).

These findings are particularly relevant from a commercial perspective. While sensory attributes such as fragrance and appearance are critical for consumer acceptance, the functional benefits of the cream, particularly in improving hydration and smoothness, play a decisive role in overall satisfaction. The data indicate that incorporating donkey milk not only enhances the cosmetic efficacy of the cream but also maintains its market appeal through favorable sensory characteristics. Future research could explore the long-term effects of the cream across different skin types to further understand the potential differences in response. Additionally, investigating the synergistic effects of donkey milk with other common cosmetic ingredients might offer insights into even more effective skincare formulations.

Conclusions: Thanks to its proprieties, donkey milk could be increasingly used to produce innovative cosmetics in

the future. However, to fully harness the potential of donkey milk in cosmetic products, further research is needed to explore the effects of varying concentrations of donkey milk in face creams. Testing different concentrations could help optimize the formulation for different skin types, maximizing the balance between hydration, texture, and consumer satisfaction. By refining the concentration, manufacturers could develop targeted treatments for specific skin needs, expanding the scope of donkey milk-based skincare products like, as example, body and aftershave lotions, shampoos, hair conditioners, and cleansing milks. In conclusion, donkey milk-enriched formulations present a promising option for consumers seeking both functional efficacy and sensory satisfaction in skincare products. Future studies on optimal concentrations and long-term effects will be crucial in advancing the use of donkey milk in cosmetics and enhancing its benefits across a wider range of skin types. Moreover, the cosmetics industry and food production aimed at high-value markets could open up new prospects for donkey farming and help to stop the phenomenon of depopulation in rural areas by attracting young skilled entrepreneurs to these areas (Lestingi *et al.*, 2019). Finally, it should be emphasized that the existence of these enterprises is an essential resource for the countries and territories where they operate or have operated. In several cases, they represent a wealth that goes beyond the economic survival of those engaged in their activities, in a logic of integration between new models and lifestyles and the recovery of ancient products and knowledge.

Author Contributions: Conceptualization: C.C. and P.F.; methodology: C.C.; software, S.T.; validation, C.C., V.V. and P.F.; formal analysis, R.P.; investigation, C.C.; resources, C.C.; data curation, S.T..; writing—original draft preparation, R.P. and S.T.; writing—review and editing, P.F. and S.T.; visualization, P.F.; supervision, P.F.; project administration, C.C.; funding acquisition, C.C.

Funding: This research was funded by Basilicata Region - Measure 16.1 Rural Development Programme 2014-20 - Project: INNOPROLATTE, grant number C56C18000170002".

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: We thank the Basilicata Region - Measure 16.1 Rural Development Program 2014-20 - Project: INNOPROLATTE [Cod. C56C18000170002].

Conflicts of Interest: The authors declare no conflict of interest.

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