Running title: Objective and perceived quality in milk labels

Title: Fat quality, sensory properties and consumers preference towards different commercial labels for bovine milk from retail market

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Abstract

In the modern large-scale retail trade, voluntary quality schemes play a fundamental role to communicate specific quality attributes of processes and products, from farms to the market. However, consumers are not always able to recognise such an added value for milk certifications. In this paper, we evaluated the differences in the lipid quality and sensory properties of four different commercial labels for retail milk by means of gas-chromatographic analysis of fatty acids (FAs) and sensory assessment performed by a trained sensory panel. Meanwhile, we tested the effects of the four selected milk labels and information on consumers perception by means of an online experimental survey. Our results emphasised a different FAs composition of retail milk labelled under voluntary certifications. Polyunsaturated FAs of the n-3 and n-6 series (along with their ratios), branched chain FAs, *trans* isomers of C18:1 and conjugated isomers of linoleic acid were found at different concentrations in different milk labels, with the TSG *Haymilk* (HM) displaying the most favourable profile followed by the mountain product (MP) and then by High-Quality fresh milk (HQ) and Extended Shelf-Life milk (ESL) with no voluntary quality marks. Being strictly related to the farm production system, milk FAs revealed as natural markers of production system for certified milk. Quite no difference was found for the sensory properties, excepting for the over- all aroma intensity, which was lower in MP. At the same time, we evidenced that the added value given by the distinct quality of fat for HM and MP is still not recognised by consumers, which perceived these milk labels as healthy, as tasty, as natural and as nutrient as HQ. This result highlighted that there is still room for producers aligned with the voluntary certifications HQ and MP to promote their products on the market and to raise consumer awareness about their quality attributes.

Keywords: Haymilk, label claims, mountain milk, retail milk.

Introduction

In 2022, Italian dairy farms produced approximately 13 million tons of milk, with 2.5 million tons ear- marked for direct consumption as drinking milk, accounting for 19.4% of the total (data from CLAL.it). Over the past two decades, there has been a decline in the amount of milk purchased by Italian consumers, mainly affecting the fresh milk market (Merlino et al., 2021; TaSiN & Ministero della Salute, 2022). This trend persisted in 2023, with 4.3% reduction in sales volumes for fresh milk compared to 2022 (ISMEA, 2023). At the same time, a growing segment of consumers is increasingly inclined towards local, green, sustainable and organic milk options (Carfora et al., 2019; Palmieri et al., 2021). Consequently, drinking milk can significantly benefit from the strategic implementation of voluntary certifications and the careful selection of appropriate sales channels, thereby boosting sales and justifying a premium price in the market.

Presently, consumers may interact with a multitude of milk brands and labels and, in the absence of information, they form their own expectations that may align or misalign with the actual quality of different commercial designation of milk. At the retail, the primary method for conveying information to consumers and addressing the asymmetry of quality information is through front-of-package labelling. This acts as a crucial link between consumers and producers, allowing to make choices based on their personal lowland, fresh grass- or hay-based vs. maize-based) (Capuano et al., 2014; Coppa et al., 2019; Cifuni et al., 2022) and different labels on milk packaging at the retail level (Werteker et al., 2017; Laguna-Paredes et al., 2018; Tabacco et al., 2021). Particularly, milk from uplands has been evidenced to contain higher amounts of some beneficial FAs (n-3 FAs, CLAs) (Coppa et al., 2019; Cifuni et al., 2022) and, at retail level, milk certified as Mountain Product (MP) was evidenced to provide a better profile than that of noncertified milk (Tabacco et al., 2021). Even if mountain agri-food products are highly esteemed due to their origin (local product, traditional farming and processing practices, use of high-quality raw mate- rials, healthier environment; Marescotti et al., 2021), it has been reported that a significant portion of consumers is still unaware of the existence or the meaning of the MP brand (Mazzocchi & Sali, 2022). At the same time, some authors evidenced that the Traditional Speciality Guaranteed (TSG) *Haymilk* has a distinct lipid composition, represented by higher amounts of n-3 FAs, CLAs and *trans* isomers of C18:1 (Laguna-Paredes et al., 2018) when compared to non- certified retail milk. Regarding *Haymilk*, consumers perceive it as healthier and more natural than conventional milk (Palmieri et al., 2021).

In recent years, both the academia and the industry have witnessed a growing emphasis on the role and significance of quality certifications in the agri-food sector. Numerous studies have delved into the significance of quality seals. Particularly noteworthy is the recent surge in published papers focusing on the MP label within the dairy sector (Staffolani et al., 2022; Stiletto & Trestini, 2022; Zanchini et al., 2023). The studies largely concur that consumers are willing to pay a premium for foods labelled as MPs. However, despite its significance, this label remains poorly recognised and underutilised. This underscores the importance of investing in farmer training, promoting label awareness and encouraging consumer support for MP-labelled items to bridge information gaps and enhance local quality production. Amidst this burgeoning interest, there remains a notable gap in the literature, particularly concerning quality certifications, including the MP and the TSG *Haymilk* label in the drinking milk sector. This is particularly important in Italy where this sector has confronted significant challenges in terms of sales and marketing, necessitating a deeper understanding and support from the scientific community. Despite the industry's pivotal role in the nation's economy and cultural heritage, the scarcity of research focused on quality seals for drinking milk presents a critical void in current scholarly discourse.

For these reasons, this paper seeks to address this gap by exploring the dynamics of quality certifications within the context of the Italian drinking milk sector. By examining the efficacy and implications of quality seals in this specific domain, we aimed to provide valuable insights and contribute to the ongoing dialogue surrounding quality assurance in the agri-food industry.

Given these antecedents, the objective of the present research was twofold. Firstly, we aimed to analyse the lipid composition and sensory properties of different milk label at retail, including milk certified as MP and milk certified as TSG *Haymilk*. Secondly, we explored consumers' perception of these milks in term of expectations. The hypotheses of the study were as follows:

> H1. There is an objective difference among milk labelled with the voluntary quality labels TSG *Haymilk* and MP and milk with no voluntary quality labels, in terms of nutritional and organoleptic features;
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> H2. Consumers have different expectations towards different milk labels, in terms of the perception of healthiness, tastiness, naturalness and content in valuable nutrients, which can either match or mis- match their objective characteristics (measured in H1). Additionally, to assess the impact of information on consumers' perception of commercial milks, we formulated a third hypothesis:
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> H3. There is a difference between consumers' perception towards the same commercial milk type when they are given information about the meaning of the specific label.

Materials and methods

Milk samples

All milk samples were sourced from various retailer stores located in the lowland of Lombardia, Northern Italy. To ensure a representative selection, milk samples encompassing various brands were collected based on market availability during the sampling season. Only refrigerated full-fat milk samples with shelf-life of a maximum of 21 days were included. Four distinct types of retail milk were examined in this study. Two specific quality labels were chosen, specifically TSG certified *Haymilk* (HM) and milk labelled as MP. To test our hypothesis, two commercial milks with no additional quality labels were incorporated in the sample. Specifically, since MP milk samples collected in this study were also identified as High-quality fresh milk, we collected High-quality fresh milk samples, with no additional voluntary quality labels (HQ), as a control. At the same time, since HM samples collected in this study were identified as extended shelf-life milk, we collected ESL milk samples with no additional voluntary quality labels (ESL), as a control. The technical description of the four milk labels considered in this study is available as Appendix S1. One sample for each type of milk (HM, MP, HQ, ESL) was collected weekly (5 samples per month for each label) during March, May, July and September 2022, totaling 80 samples. This approach aimed to capture variability within the sampling season. One-litre milk packages were collected and transported under refrigerated conditions to the university laboratories. Subsequently, approximately 60 mL of each milk type was transferred to sterile plastic tubes (4 x 15 mL each) and stored at —20 °C until analysis. The price per litre was recorded at each sampling point for every milk type. The characteristics of the collected milk types are summarised in Table 1.

FAs analysis

Total lipids were extracted from 5 mL of each milk sample by means of a liquid–liquid extraction protocol based on the method of (Folch et al., 1957), using a mixture of Chloroform and Methanol (2:1, v/v). After extraction and total lipid quantification, 30 mg of total lipids were recovered in 1 mL of hexane containing 10 (Z)-nonadecenoic acid as internal standard (IS) at a concentration of 500 µg mL^{-1} and submitted to methyl-*trans*-esterification in cold alkaline environment (sodium methoxide in methanol 1 M), following the method of (Christie, 2003). Fatty acid methyl esters (FAMEs) prepared in this way were analysed by gas-chromatography coupled to flame ionisation detection (GC-FID), using a TRACETM 1300 chromatograph equipped with an autosampler. Data were acquired using the software Chromeleon™ by Thermo Fisher Scientific (Waltham, MA, USA). The chromatographic conditions were set as described in our previous research (Lopez et al., 2022). Peaks were identified by comparing the retention times against analytical standards analysed under the same conditions. Prior to quantification, peaks areas were corrected using the theoretical FID correction factors for FAMEs following the ISO 12966- guidelines (International Organization for Standardization (ISO), 2015). Individual FAs were quantified according to the method developed by Cruz-Hernandez et al. (2013) and expressed ad mg FA/100 mL milk.

Sensory analysis

Sensory profile was conducted by internal panellists from University of Milan staff with reference to the guidelines (ISO, 2012) stating the selection, training and monitoring of assessors and expert sensory assessors. A trained sensory panel was selected, consisting of 10 members (5 males and 5 females; aged 23–60 years; healthy subjects, non-smokers, lactose tolerant), familiar with descriptive analysis procedures (ISO, 2010). Sensory panellists were trained to enhance their competence to perceive, identify and describe the sensory attributes of milk. All samples were evaluated in three independent replicates to develop a common vocabulary, to improve the panel's ability to properly use the scale and to define the proper attribute descriptors. A total of 17 sensory attributes were identified at the end of training, which are reported, with their definition, in Table 2. The definitions are in line with those reported by Schiano et al. (2017) for trained panel sensory attributes for milk. All assessments were performed in a sensory laboratory (ISO, 2007) at room temperature (22– 24 °C) and under bright and soft LED lighting. The sensory profile was assessed according to ISO 13299 (2016) and the panel evaluated the samples in three independent replicates. During training and sampling, water was provided for panellists to clean their palate between sample tastings. The samples of approximately 30 mL were served at a serving temperature of 17 °C. One glass of milk for each type of retail milk was served to panel- lists in blind, with a three-digit random number and was presented to each evaluator following a randomised order. Panel member first scored the appearance and aroma and then scored the texture, flavour and taste. The intensity of each attribute was evaluated using a nine-point scale to assess the intensity of sensory attributes (1, absence of sensation; 9 extremely intense).

Survey on consumers' perception of milk

An online experimental survey was created to investigate the impact of labelling and information on consumers' perception of drinking milk with different commercial labels. Each respondent was randomly assigned to one out of the four types of milk considered in the analysis (MP, HQ, HM and ESL) and was asked to evaluate the product before and after the reading of a short description of the characteristic of the assigned milk. This resulted in a 4 between (*Label* treatment) x 2 within (*Information* treatment) subjects experimental design. This design was chosen drawing on the literature on effect of labelling on consumers'

perception of food (Demartini et al., 2022) where the between setting design is widely adopted. Furthermore, the repeated measure framework enabled us to control for varying levels of consumer knowledge regarding different milk types and examine whether providing information could attenuate the halo effect and alter perceptions. Although alternative experimental designs were considered, such as choice experiments (Richetin et al., 2022; Boccia et al., 2024) we selected this approach due to its cost-effectiveness in data collection. The survey was distributed online, spanning from December 2022 to August 2023, utilising social media channels. A total of 335 participants formed the final convenience sample, with an average age of 40.44 (SD = 13.92), comprising 241 women, 92 men (2 Other or Don't want to disclose). Data collection was conducted through the Qualtrics XM online survey platform and participants did not receive any compensation for their participation. The survey commenced with the presentation of an informed consent sheet outlining the details of data collection and analysis. Next, consumers were excluded from the survey if they did not buy or consume milk during the 6 months preceding the survey and if they were under 18 years old. Upon passing the screening questions, participants were randomly assigned to one of the four treatment groups.

The questionnaire is presented in Appendix S2 and consisted of closed-ended questions organised into five sections. The first section aimed at analyse consumers attitudes towards drinking milk given different labels and the provision of information about the product characteristics. To measure attitudes, consumers evaluated the drinking milk using 4 items, presented in a random order, on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The items used for the evaluation were 'It is healthy', 'It is tasty', 'It brings valuable nutrients for the diet' and 'It is natural' (Demartini et al., 2022).

The second section aimed at recording consumers perception towards the same type of drinking milk evaluated in section 1 after reading a short paragraph resuming the main features of the specific quality mark and label, considering the geographical origin of milk and raw materials used in farms, the production system employed, the thermal treatment applied to raw milk and its shelf-life. Evaluated parameters and Likert scale were the same than in section 1, with the objective of comparing the evaluations given within the same treatment before and after reading the information.

The third section aimed to measure consumers' attitudes towards food by means of the Food Values scale (Lusk & Briggeman, 2009), which is used to infer the importance that people attach to different characteristics of food in purchasing decisions. The fourth section aimed at detecting consumption habits (consumption frequency and modality) and objective knowledge about the four types of milk included in the study. For sake of brevity these results will not be discussed in the present research.

Finally, the fifth section collected the socio- demographic characteristics of the sample, including gender, age, region of residence, education level and income.

Statistical analysis

Statistics analysis on FAs data and consumers perception data was performed using the software Statistics for Data Analysis 27.0.1 by IMB (Armonk, NY, USA) and JMP Pro17 by SAS (Cary, NC, USA). The significance level (a) chosen was 0.05. FAs data were analysed by ANOVA with *milk label*, *month of sampling* and their interaction as effects. Results were expressed according to Fisher's least significant difference (LSD) test and Tukey's HSD *post-hoc* test. Data on consumers perception of milk collected by the survey were analysed by a mixed ANOVA to test both the *Label* and *Information* treatments effect. When information had a significant effect ($P < 0.05$), Wilcoxon test for paired samples was performed on the same parameter (healthy, tasty, source of valuable nutrients and natural) measured before and after information within the same milk label. When milk label had a significant effect ($P < 0.05$), Wilcoxon test for independent samples was performed on each parameter (healthy, tasty, source of valuable nutrients and natural) measured between different milk labels, considering before and after information as separated groups. Sensory data of retail milk were analysed by ANOVA, with *sample*, *replicates*, *judges* and their interactions as effects (ISO, 2010), using the statistical software Statgraphics Centurion (Ver. XVIII, StatPoint Technologies, Warrenton, VA, USA). The significance of these effects was tested with F-tests. Post-hoc pairwise contrasts were evaluated by Duncan's test.

Results

FAs composition

Results from the FAs analysis of retail milk samples are presented in Table 3 and Fig. 1. Some significant differences were detected in FAs profile of different milk labels. Detailed data with results for the multi factorial ANOVA, splitting means for each milk label in each sampling month, are presented in Appendix S3.

Interesting results were observed for many cis and *trans* isomers of 18:1. On average, vaccenic acid (VA, *trans*-11, 18:1 n-7) was more abundant in HM than in all the other milk labels (Table 1). Nevertheless, HQ (in M2) and MP (in M2 and M3) showed similar amounts of vaccenic acid to those found in HM (Fig. 1). Contemporary, HM displayed the highest values of total PUFAs, while HQ and ESL exhibited the lowest values and MP intermediate values (Table 3). The most abundant PUFA in all milk samples was linoleic acid (LA, c-9,c-12, 18:2 n-6), which showed a lower concentration in HM compared to the other milk labels regardless of the sampling month (Table 3 and Appendix S3). Conversely, a-linolenic acid (ALA, 18:3 n-3) reached the highest levels in HM, followed by MP and then by HQ and ESL. Even in this case, no difference was observed in different sampling month (Fig. 1 and Appendix S3). Rumenic acid (RA, c-9,t-11, 18:2) exhibited the highest values in HM, followed by MP and then by HQ and ESL (Table 3). Interestingly, a significant difference was detected for the concentration of RA in HM samples during different sampling months, with the highest value detected in M4 (Fig. 1). Long chain FAs of the n-3 series detected in milk samples, namely eicosapentaenoic acid (EPA, 20:5 n-3) and docosapentaenoic acid (DPA, 22:5 n-3), displayed higher amounts in HM, followed by MP and then by HQ and ESL. As a result of the findings for the main n-3 (ALA, DPA, DHA) and n-6 (LA) FAs, the n-6/n-3 ratio exhibited the highest values in HQ and ESL and the lowest in HM, with MP showing intermediate values (Table 3). All BCFAs exhibited significant differences among dif-erent milk labels. On average, HM had the highest total BCFAs content, followed by MP, ESL and HQ. This was attributed to differences found in *iso*-14, *iso*-15*, anteiso*-15 and *iso*-16 (Table 3). In this case as well, few differences were found between different sampling months within the same milk label (Fig. 1 and Appendix S3).

Sensory analysis

The F values for the aroma, taste, flavour and texture parameters of the retail milk sensory profile are reported in Table 4. The results indicate that the different milk labels did not affect the appearance, taste, flavour and texture parameters. The aroma intensity was affected by the different retail milk labels. The F values for replicates and interactions were not affected in all the descriptors, while judges presented differences for all the descriptors. Differences between judges are common in sensory evaluation. due to the different use of the scale (Lea et al., 1997). No interaction between panellists x replicates and samples 9 replicates were observed. F-values for aroma, taste, flavour and texture parameters in retail milk samples highlight the excellent reproducibility of the scores given by the panellists and the homogeneity of samples during replicates.

Results obtained by the sensory analysis of the milk samples are presented in the spider plot in Fig. 2a and b. The data shows that appearance, taste, flavour and texture parameters were comparable in all the milk samples. No differences were detected for the descriptors of appearance (white colour, brightness, visual viscosity), texture (astringency, adhesivity, viscosity, persistency), taste (salty, sweet, bitter), flavour (grassy, fatty), flavour intensity and aroma (fatty aroma, grassy aroma, cooked aroma). The only significant difference among the considered milk labels was detected for the Aroma intensity descriptor, which showed the highest value in ESL and HQ, the lowest in MP and an intermediate value in HM.

Consumers' perception of milk

Socio-demographic variables about respondents to the online survey, milk consumption data and consumers knowledge about the milk labels considered in the sur- vey are presented in Appendix S4 and consumers attitudes towards foods measured with Food Values are presented in Appendix S5. The results of the analysis of the effect of labels and information on consumers attitudes towards drinking milks are presented in Fig. 3.

Overall, the Label treatment exerted an effect on the four items measuring consumers perception of drinking milk (It is healthy, it is tasty, it brings valuable nutrients for the diet, it is natural). Similar results were also found for the Information treatment that influenced all the items considered (It is healthy, it is tasty, it brings valuable nutrients for the diet, it is natural). Finally, the interaction of the two experimental factors was always not significant. Clearly, the effect of commercial labelling depends on the attitudes that consumers showed towards the ESL milk with no voluntary quality marks (ESL). Actually, ESL was perceived less healthy, less tasty, less nourishing and less natural than HM, MP and HQ. On the other hand, the analysis of the effect of the of information on perception of drinking milk, reveals more heterogeneous results. In fact, providing information positively influence consumers perception for all types milk only in terms of naturalness, while the positive effect is present only for MP, HQ and HM milk in terms of healthiness, only for MP milk in term of tastiness and only for HQ milk in term of nutritional value. Further- more, given the limited knowledge of milk labels in the sample, it is worth focusing also on the evaluation of the milk provided before and after the information treatment. In fact, information seems to have increased the differences between the ESL milk and MP, HQ and HM milks. As can be noted in Fig. 3, in fact, ESL milk was perceived as healthy as MP and HM milk and having the same nutritional value of MP milk before the information treatment. However, the description of the methods of production of the different types of milk improved the perception of MP and HM, that are considered healthier, more nourishing and more natural than ESL milk to informed consumers; additionally, MP is also considered tastier after info.

Discussion

FAs composition and nutritional quality of commercial labels for retail milk

In the present study, we observed that HM exhibited a distinctive FAs composition compared to the other labels. This designation showed the highest amounts of VA and RA, the latter being a conjugated isomer of linoleic acid (CLA). These FAs are intermediate metabolites formed during the ruminal biohydrogenation (RBH) processes of LA and a-linolenic acid ALA ultimately resulting in stearic acid (18:0) as the final product (Gomez-Cortes et al., 2018). Numerous CLAs exist, but RA is the most abundant, comprising 75– 80% of total milk CLAs. High-forage diets, particularly those from fresh grass- or pasture- based production systems, have been reported to increase the ALA in the diet, leading to elevated milk fat concentrations of RA and VA, as RBH intermediates (Bernard et al., 2009). Dairy products and ruminant meats are the sole sources of natural VA and RA in human diet and their amounts can be more than doubled in dairy products derived from animal in extensive feeding systems (Gomez-Cortes et al., 2018). In our study, we noted that, in comparison to other labels, whole milk from HM demonstrated the potential to offer higher levels of VA and RA. This implies increased RBH activity and heightened formation of intermediates, which are subsequently included in milk fat. This phenomenon is likely induced by the substantial proportion of forages in the diet, mandated by the *Haymilk* TSG Regulation, during the farming stage. Interestingly, we observed that RA was significantly higher in HM sampled in September (M4). This result is consistent with data reported by Laguna-Paredes et al.(2018), who found higher percentages of RA in retail *Haymilk* sampled in September. We can hypothesise that this phenomenon is linked to fluctuations in the cow's diet throughout the sampling season or variations in the composition and quality of forages. These variations could be associated with the phenological state of plants and their seasonal availability to farmers.

Similarly, HM resulted enriched in the content of BCFAs as well (Table 1). BCFAs are essential bioactive components synthetised by rumen cellulolytic bacteria and their introduction through the diet has positive effects on consumers health, similar to those of PUFAs and CLAs (Gomez-Cortes et al., 2018). The concentration of BCFAs in milk fat is increased by higher proportions of forage in feed rations, positively influencing rumen function and the proliferation of cellulolytic microbial strains (Fievez et al., 2012). Dairy and meat products from ruminants are the main natural source of BCFAs in human diets and it has been demonstrated that BCFAs represent a significant proportion of daily FAs intake, even surpassing the consumption of the long chain n-3 PUFAs EPA and DHA in US diets (Ran-Ressler et al., 2014). As essential components of the cellular membranes in cellulolytic strains within the rumen, BCFAs attain higher concentrations in the ruminal environment of cows fed a greater proportion of forages. This, in turn, leads to an increased incorporation of BCFAs in milk fat (Fievez et al., 2012). Our findings, which indicate elevated levels of BCFAs in HM, are likely associated with our earlier hypothesis regarding the heightened inclusion of forages, predominantly hay, in the diet of cows raised for *Haymilk* TSG production.

At the same time, HM exhibited the highest concentrations of n-3 FAs, including ALA, EPA and DPA, the lowest amount of LA and the lowest n-6/n-3 ratio. Our results align with data reported in the literature regarding the characterisation of FAs profiles in hay- milk vs. conventional or silage- milk (Werteker et al., 2017; Laguna-Paredes et al., 2018). The literature suggests that compared to milk obtained from feeding strategies reliant on maize silage and high pro- portions of concentrates, grass-fed and pasture-based milk contains higher levels of n-3 PUFAs, primarily ALA, which are considered beneficial for health (Chilliard et al., 2007; Elgersma, 2015). ALA is an essential fatty acid for cows, as mammals cannot synthetise it de novo (Veshkini et al., 2023) and cows must intro- duce it through their diet. The ALA content in milk depends on the quantity and quality of forages (which contain approximately 75% ALA) and oil seeds sup- plied to cows through their feed, as a portion of ALA escapes the RBH reactions (Chilliard et al., 2007). Subsequently, EPA and DPA, which are minor n-3 PUFAs in milk, are synthetised through desaturation and elongation pathways of ALA in the cow's liver and then delivered to the udder during milk fat synthesis or through the endogenous conversion of ALA in the mammary gland (Schwendel et al., 2015; Huang et al., 2020). The n-3 PUFAs have positive effects on cardiovascular diseases, cancer, inflammatory and immune disease and neural development. In contrast, the n-6 series PUFAs demonstrate opposite physiological functions, with detrimental effects on consumers health (Chaves et al., 2018). For this reason, the n-6/n- 3 ratio is often used as healthy index to evaluate the nutritional quality of food fat: the lower the n-6/n-3 ratio, the better the nutritional quality of the food. Modern western diets often contain elevated levels of n-6 PUFAs coupled with low levels of n-3 PUFAs. This imbalance can result in unhealthy n-6/n-3 ratios (up 20:1), instead of the optimal values represented by 4:1–5:1 (Simopoulos, 2016). Different production systems and feeding strategies adopted in dairy farms can lead to different n-6/n-3 ratios in milk. Particularly, high proportions of forages and/or grass in cows' diet, as observed in the production of grass-based milk and haymilk, are reflected in lower n-6/n-3 ratio compared to silo- milk, with consequent beneficial effects on milk functional properties (Gebreyowhans et al., 2019; van den Oever et al., 2021). These outcomes highlighted a superior nutritional quality of HM and suggested that retail HM could be distinguished by the other milk labels considered in this study based on its FAs com- position, particularly on the amounts of VA, RA, BCFAs and n-3 PUFAs (mainly, ALA).

Milk labelled as MP exhibited intermediate values for BCFAs, RA, n-3 series PUFAs and n-6/n-3 ratio compared to HM, HQ and ESL labels. Actually, the levels of beneficial FAs in MP milk were found to be comparatively lower than those in HM milk. Addition- ally, higher concentrations of LA were detected in MP, suggesting that in mountain farms, a higher pro- portion of concentrates might be supplied to animals compared to farms adherent to the STG *Haymilk* certification. Unlike the *Haymilk* certification, which comprise a TSG, the quality seal MP does not impose strict requirements regarding the composition (quality and quantity) of feedstuffs used on farms, but only restricts their geographical origin, which must be from mountain areas, accounting for at least 60% of dry matter. However, our results showed significant differences between MP and milk with no additional voluntary quality labels (HQ and ESL), showing higher values of RA, BCFAs, PUFAs and lower n-6/n-3 ratio, supporting data previously reported in the literature comparing retail milk certified as MP and non- certified milk samples (Tabacco et al., 2021). Based on these results, it could be suggested that even if the MP Regulation does not impose any strict requirement regarding the diet composition, retail MP analysed in this study was produced by cows fed by higher proportions of forages compared to HQ and ESL. Generally, mountain farming systems rely on the availability of local forages, whose characteristics and quality are closely linked to the territory of origin and higher levels of ALA, RA, MUFAs and PUFAs have been found in milk from uplands compared to lowland milk during the outdoor season, with the forage system and diet composition (herbage proportion and phenological state of plants) suggested as the main factor able to influence milk FAs profile, more than the origin *in sensu strictu* (upland vs. lowlands) (Coppa et al., 2019). Actually, along with various nutritional proper- ties, the botanical composition and conservation method of fodder influence the FAs composition delivered to milk. For example, an abundant presence of secondary plant metabolites (terpenes and polyphe-ols) on upland pastures, can partially inhibit RBH, leading to a higher concentration of PUFAs (mainly, ALA) and RBH intermediates (CLAs, VA) escaping from rumen pathways and subsequently accumulating in and being delivered to milk (Leiber et al., 2005; Bentivoglio et al., 2019; Cifuni et al., 2022). Our out- comes suggested that MP milk could be distinguished from milk produced under more intensive production systems, typically prevalent in lowlands. These diffe ences may be associated with the distinct feeding strategies commonly employed in mountain farms, where grassland is the predominant agricultural land use and fresh green feed and hay are the dominant feed sources during the year (Coppa et al., 2019).

In more conventional production systems typical of lowlands, without adherence to voluntary quality schemes, there are no restrictions set by production regulations regarding the cow feeding strategy, as compared to the guidelines in place for *Haymilk* and MP production chains. Typically, in these production systems from lowlands, the utilisation of fermented fodder in rations has replaced the practice of using fresh-fodder. Silages contain higher levels of fermentable carbohydrates and lower dietary fibre, leading to increased milk yield, milk fat and milk protein concentration. However, their use (above all for maize silage), combined with generally lower forage-to-concentrate ratios, results in a different fat composition, with lower amounts of VA, RA and PUFAs (mainly, ALA) and higher n-6/n-3 ratios (Chilliard et al., 2007; Laguna-Paredes et al., 2018). In our study, HQ and ESL displayed a FAs profile characterised by lower amounts of OCFAs and BCFAs, RA, n-3 FAs (ALA, EPA and DPA) and the highest values for LA and n-6/n-3 ratio in both groups, compared to HM and MP. Compared to HM, HQ and ESL showed lower values of VA as well. All these outcomes suggest that retail milk (either fresh and ESL) not associated to voluntary quality labels showed a FAs profile typical of milk coming from conventional production systems, which includes the utilisation of fermented fodders and higher proportion of concentrates among the farming practices, influencing its nutritional quality. With few exceptions, minimal differences were found when directly comparing the two milk types not associated with any voluntary quality marks (HQ vs. ESL), which, in commercial terms, diverged solely in terms of the thermal treatment applied to the milk.

Sensory properties of retail milk with different commercial labels

Differences in the composition and aroma of bovine milk have been attributed to diet, breed and season (Croissant et al., 2007; Larsen et al., 2013; Vanbergue et al., 2017). Badings & Roald (1980) suggested that the aroma of milk is determined by many volatile compounds, present in very low concentrations, some of which are transferred from the diet and others are the outcome of slight changes of milk constituents by oxidative or thermal, microbial and enzymatic reactions.

Conflicting results are reported in literature on the effect of different diets on milk aroma and flavour. Some authors found differences in milk flavour related to diet (Croissant et al., 2007; Bentivoglio et al., 2019). Shingfield et al. (2005) found, using descriptive sensory analysis, that different diets containing silage or hay had no effects on sensory attributes of pasteurised bovine milk. Moorby et al. (2009), using the same sensory method, showed slight effects on milk sensory properties based on diet composition. Other authors found higher values for some milk sensory descriptors such as 'yellow colour', 'consistency' and 'aroma intensity' in relation to diet composition (silage vs. forage), while no differences were found in flavour attributes (van den Oever et al., 2021). Manzocchi et al. (2021) found a lower global aroma intensity, aroma of cooked milk, barnyard and cream in milk from cows fed hay compared to cows grass-fed (supplied in barn/ grazing) and a lower intensity of cream aroma com- pared to cows fed grass-silage.

Raw milk processing, including milk fat separation, fat content standardisation, pasteurisation, homogenisation and packaging, can affect the sensory qualities of fluid milk, with some differences in sensory attributes compared to raw milk (Schiano et al., 2017). Manzocchi et al. (2021) found that pasteurisation reduced the yellowness and increased the intensity of barnyard and cooked milk aroma (considering as defects of milk), cream aroma and global aroma and flavour intensity, compared to raw milk. In our study, no differences were observed for milk descriptors of appearance, taste, flavour and texture. Only the Aroma intensity, was affected and resulted lower in MP than in HQ and the other two type of retail milk ESL, HM reach an intermediate value. Like what observed for fat quality, we did not find any differences between the two commercial milk types (HQ and ESL). The few differences detected in the sensory analysis are in agreement with the data reported that different diets had no effect on sensory parameters of pasteurised bovine milk (Shingfield et al., 2005). It is also reported that the consumers are not able to discriminate sensory differences in pasteurised milk from cows fed concentrates or hay (Kilcawley et al., 2018).

Consumers' perception towards commercial milk labels

Studies have demonstrated that certain types of drinking milk available in the market, such as grass and pasture milk, organic milk, etc., offer health benefits compared to others (Werteker et al., 2017; Coppa et al., 2019; Imperiale et al., 2021; Cifuni et al., 2022). However, our study found that despite the higher fat quality observed in HM and, to some extent, MP milk compared to other retail milk, consumers did not exhibit different perceptions between HQ, HM and MP, both before and after receiving information about their production process. These milk labels were perceived healthier, tastier, more natural and richer in valuable nutrients, than ESL, either before and after receiving information. Moreover, while receiving information about the milk label increased the perception of healthiness and naturalness for HQ, HM and MP, plus tastiness for MP and nutritional value for HQ, only the perception of naturalness was increased by the information for ESL. These results indicate that consumers perceive the ESL processing (high- temperature thermal treatment, HTT) as negative. The latter result is intriguing. Despite the significance of convenience and food safety as key factors influencing food purchases (Lusk & Briggeman, 2009), informing the respondents about the thermal treatment used in ESL milk production – enabling an extended shelf-life for convenience while maintaining a high level of food safety – did not improve the perceived quality of ESL.

On the contrary, information widened the gap in perceived healthiness and role as source of nutrients (for both MP and HM) and tastiness (only for MP), between ESL and the labels associated to additional voluntary quality schemes. This outcome suggests that the average consumer desires milk with longer shelf-life but, when informed that a more robust thermal treatment is necessary in order to extend shelf-life, perceives this milk label as less healthy, less tasty and less nutrient than others. Furthermore, we observed that the same information about the thermal treatment did not influence respondents' perception of the qual- ity features of HM, which also underwent HTT. This implies that, when evaluating HM, respondents placed greater importance on information related to the pro- duction process at the farm level, specifically related to green-feeding practices. This was an anticipated result, as previous research has indicated that grass-fed milk coveys a sense of naturalness to consumers, who view this milk label positively in various aspects, including its perceived health value (Busch et al., 2018; Peira et al., 2020).

Overall, no differences were observed in consumers perception for HM and MP if compared to HQ, neither before or after information. Similarly, Tabacco et al. (2021) found that the participants in their study were not influenced by the presence of labels associated to voluntary quality schemes, such as organic certification, or nutritional claims, when choosing milk. The authors explained this result by suggesting that consumers may view milk as a commodity and associating local milk with high-quality standards may not necessitate additional quality labels. Scozzafava et al. (2020) also found no significant effect on consumers' preferences when provided with information about the characteristic of feedstuffs fed to dairy cows or about the higher production costs associated with specific farming system, such as those employed in organic milk production. The authors explained these results by emphasising the nature of milk as a wholesome food with a straightforward transformation process, never being the subject of food scandals. In this context, modern food values such as environmental aspects, animal welfare issues, authenticity and origin are considered higher concerns compared to 'more classical' values, such as food safety and production costs.

Compared to previous literature, our findings on consumer perceptions of different retail milks affirm that there is significant opportunity for producers aligned with voluntary certifications to promote their products in the market and raise consumer awareness about their quality attributes. These products, both in terms of associated production systems and intrinsic quality (such as its tastiness and nutritional value), possess superior qualities deserving greater recognition, appreciation and valorisation (Peira et al., 2020). An effective communication and advertising strategy could enhance the market positioning of certified milk labels amid the multitude of wording and images associated with evocative milk characteristics. As highlighted by Tabacco et al. (2021), the images or claims on milk packaging often do not align with the true nutritional quality of the milk, creating a mis- leading factor for consumer decision-making. Ade- quate promotion of premium foodstuffs produced in marginal areas, such as mountains, through systems based on less intensive farming practices such as hay- and pasture- based feeding, is a fundamental co-strategy to combine with financial measures and policies implemented to sustain agriculture in disadvantaged areas and improve competitiveness of farms located in the mountains.

Conclusions

In modern large-scale retail trade, voluntary quality schemes play a crucial role. They enable producers to communicate specific quality features of their production processes and products, differentiate them in the market and add value to their quality attributes.

Our study delves into the significance of voluntary quality schemes in the modern retail landscape for drinking milk. Through FA analysis, we unveiled the superior nutritional profile of milk produced under certified schemes (*Haymilk* TSG, HM and MP), thus war- ranting added value attributed to the enriched presence of beneficial FA crucial for consumer health. However, despite the objective disparities, we noted a significant gap in consumer perception. Our findings indicate a lack of awareness among consumers regarding healthiness and content in valuable nutrients associated with HM and MP milk labels compared to High Quality fresh milk produced under conventional production systems (HQ), neither before nor after being given information about the production method. Neither tastiness and naturalness showed significant differences in consumers perception. Remarkably, consumers demonstrate a pre- disposed aversion towards extended shelf-life milk (ESL), perceiving it as overly processed and less healthy than HQ, irrespective of the additional information pro- vided. These perceptions, attributable to thermal treatment, were no supported by results on fat composition or sensory attributes compared to HQ milk.

Our study highlights the importance of implementing targeted educational initiatives and marketing strategies to align consumer perception with the superior quality offered by voluntary certifications within the drinking milk sector. This supports existing literature on various voluntary certifications that face consumer information asymmetry. Actually, the current lack of awareness may limit demand and willingness to pay for quality-labelled milk, especially in longer sup- ply chains involving large-scale retail outlets. The limited awareness among consumers highlighted in this study carries implications for multiple stakeholders within the milk supply chain. Farmers participating in voluntary quality schemes might not receive the deserved price premium for their superior-quality milk, possibly dissuading them from upholding these elevated standards. Retailers might overlook chances to distinguish their milk selections and capitalise on consumers willing to pay more for top-quality products. Meanwhile, consumers may not be making fully informed milk-purchasing decisions, as they remain unaware of the nutritional advantages tied to specific voluntary quality schemes.

Author contributions

Annalaura Lopez: Conceptualization; methodology; investigation; formal analysis; data curation; writing – original draft; writing – review and editing. Vittorio Maria Moretti: Conceptualization; validation; supervision; writing – review and editing. Eugenio Demartini: Methodology; software; validation; data curation; writing – original draft; writing – review and editing. Raffaella Rossi: Formal analysis; validation; writing – original draft; writing – review and editing. Sabrina Ratti: Formal analysis; writing – review and editing. Federica Bellagamba: Validation; resources; project administration; funding acquisition; writing – review and editing.

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Conflict of interest

The authors have not stated any conflicts of interest.

Ethical **guidelines**

Ethic approval was not required for this research.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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The abovementioned paper underscore the critical significance of appropriately leveraging and capitalizing on certifications to bolster the sustainability of the drinking milk sector, which has been grappling with a profound decline in consumption over the years. Con- currently, the authors of these papers emphasized the considerable journey ahead for certifications such as "Haymilk" and "Mountain Product" milk to garner the requisite recognition and feedback from consumers. Currently, consumers appear to lack the essential elements for fully comprehending the added value of these commercial labels. Consequently, this urges us to advance research efforts and furnish credible information aimed at delineating this value more comprehensively.

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Tables

Table 1. Descriptive of milk types collected and analysed in this study.

Heat treatment	Classical pasteurization *High-Quality Fresh milk*		High Thermal Treatment *ESL milk*	
Production system	Quality seal: *Mountain Product*	No quality seal	Quality seal: *Haymilk* (TSG)	No quality seal
Acronym used in this study	MP	HQ	HM	ESL
Average fat content [a] (mg/100 mL)	3.7	3.6	3.6	3.6
Average energy content [a] (kCal/100 mL)	66	65	66	65
Average price at retail (€/liter)	1.58	1.28	1.72	1.57
Origin of milk	Italy	Italy	Italy	Italy
Sample size *N*	20	20	20	20

[a] = as declared in the label

Table 2. Descriptors and definitions for sensory analysis of retail milks.

Descriptors		Definitions
Appearance	White colour	Intensity of white colour
	Brightness	The perceived luminance of milk
	Viscosity	Visual viscosity of milk associate with fat content
Aroma	Intensity	Overall orthonasal effect of the sample
	Fatty	Aromatics characteristic of milk fat
	Grassy	Green, sweet aromatics associated with cut grass
	Cooked	Aromatics associated with cooked milk
Taste	Salty	Fundamental taste sensation elicited by salt
	Sweet	Fundamental taste sensation elicited by sugars
	Bitter	Bitter basic taste
Flavour	Grassy	Green, sweet aromatics associated with cut grass
	Fatty	Aromatics characteristic of milk fat
	Intensity	Overall flavour effect of the sample
Texture	Astringency	Chemical feeling factor on the tongue or oral cavity described as puckering or dry
	Adhesivity	The perceived creaminess or fat film formation
	Viscosity	Characteristic viscosity of milk associate with fat content
	Persistency	The perceived sensation of persistency of fat in mouth

Table 3. Results for fatty acids found in retail milk samples (mg/100 mL of milk). Data are presented as the group means, Root Means Squared Error (RMSE) and *p-value*s for all the factors evaluated in the statistical model (M= month of sampling; L= milk label; M*L= interaction between month of sampling and milk label).

	Milk label					*p-value*		
	MP *N=20*	HQ *N=20*	HM *N=20*	ESL *N=20*	RMSE	M	L	M*L
4:0	175.8 ab	171.7 ab	180.7 a	161.7 b	17.4	*0.070*	*0.008*	*0.305*
6:0	95.8 a	84.8 c	93.4 ab	87.0 bc	9.9	*0.088*	*0.002*	*0.790*
8:0	52.0 a	45.4 b	49.0 ab	46.7 b	5.3	*0.001*	*0.001*	*0.810*
10:0	116.0 a	99.2 b	103.5 b	102.4 b	11.2	*<.0001*	*<.0001*	*0.764*
12:0	132.4 a	111.3 b	115.7 b	115.6 b	12.9	*<.0001*	*<.0001*	*0.776*
14:0	397.7 a	340.8 c	378.8 ab	353.4 bc	35.1	*0.027*	*<.0001*	*0.869*
16:0	995.5	938.4	923.8	925.3	84.9	*0.018*	*0.031*	*0.287*
18:0	276.7	263.5	268.8	269.8	29.6	*0.082*	*0.570*	*0.804*
20:0	4.2 b	3.5 c	4.9 a	3.8 bc	0.5	*0.048*	*<.0001*	*0.431*
22:0	0.8 b	0.6 c	1.1 a	0.7 bc	0.1	*0.137*	*<.0001*	*0.294*
24:0	1.0 b	0.7 c	1.4 a	0.7 c	0.3	*0.434*	*<.0001*	*0.414*
∑SFA	2247.7 a	2059.8 b	2121.0 ab	2067.1 b	187.8	*0.194*	*0.008*	*0.763*
10:1	11.5 a	9.4 c	10.5 b	9.9 bc	1.1	*0.004*	*<.0001*	*0.884*
12:1	2.9 a	2.4 b	2.5 b	2.5 b	0.3	*0.006*	*<.0001*	*0.904*
14:1	36.0 a	31.1 b	32.3 b	32.0 b	3.1	*0.021*	*<.0001*	*0.410*
cis-7, 16:1 n-9	5.4	5.3	5.7	5.3	0.5	*0.214*	*0.123*	*0.789*
cis-9, 16:1 n-7	56.0	55.8	51.0	53.9	5.6	*0.042*	*0.022*	*0.054*
trans-9, 18:1 n-9	10.9 b	15.2 a	7.7 c	13.8 a	1.5	*0.016*	*<.0001*	*0.023*
trans-11, 18:1 n-7†	28.9 b	26.5 b	46.5 a	25.4 b	9.9	*0.482*	*<.0001*	*0.382*
cis-9, 18:1 n-9†	541.8	511.4	524.4	518.2	48.7	*0.07*	*0.244*	*0.730*
cis-11, 8:1 n-7	22.0 ab	23.5a	19.8 b	23.5 a	3.0	*0.544*	*0.001*	*0.482*
20:1 n-9	1.4	1.4	1.5	1.4	0.3	*0.186*	*0.377*	*0.639*
∑MUFA	716.8	682.0	702.1	685.9	61.7	*0.116*	*0.269*	*0.649*
t-9,t-12, 18:2 n-6	7.2 a	7.6 a	5.2 b	7.2 a	0.8	*0.919*	*<.0001*	*0.060*
*c-9,t-12,*18:2 n-6	2.1 b	2.3 a	1.5 c	2.1 b	0.2	*0.965*	*<.0001*	*0.003*
t-9,c-12, 18:2 n-6	3.3 b	2.3 c	4.9 a	2.5 c	1.0	*0.364*	*<.0001*	*0.259*
c-9, c-12, 18:2 n-6	71.5 a	73.3 a	57.7 b	71.8 a	9.9	*0.541*	*<.0001*	*0.767*
18:3 n-6	0.8	0.8	0.9	0.8	0.2	*0.241*	*0.093*	*0.984*
18:3 n-3	14.2 b	10.1 c	18.5 a	10.3 c	1.8	*0.149*	*<.0001*	*0.525*
c-9,t-11, 18:2 n-7	16.9 b	15.1 c	35.8 a	14.4 c	2.6	*<.0001*	*<.0001*	*<.0001*
20:2 n-6	0.8	0.7	0.8	0.7	0.2	*0.482*	*0.466*	*0.952*
20:3 n-6	3.2	3.3	2.6	3.1	0.5	*0.809*	*0.000*	*0.483*
20:4 n-6	4.7	4.7	3.9	4.8	0.7	*0.432*	*0.000*	*0.901*
20:5 n-3	1.2 b	1.0 c	1.8 a	0.9 c	0.3	*0.168*	*<.0001*	*0.750*
22:2 n-6	1.0 b	0.8 c	1.4 a	0.9 bc	0.4	*<.0001*	*<.0001*	*0.296*
22:5 n-3	2.1 b	1.7 c	2.7 a	1.8 c	0.3	*0.138*	*<.0001*	*0.950*

∑PUFA	129.0 ab	123.3 b	137.7 a	121.3 b	16.7	*0.638*	*0.003*	*0.248*
n-6/n-3	5.5 b	7.6 a	3.5 c	7.3 a	2.2	*0.107*	*<.0001*	*0.666*
11:0	3.1 a	2.8 a	1.7 b	2.8 a	0.5	*<.0001*	*<.0001*	*0.014*
13:0	4.9 a	4.1 b	3.3 c	4.4 ab	0.6	*<.0001*	*<.0001*	*0.141*
15:0	42.9 a	36.0 c	40.3 ab	38.4 bc	3.9	*0.007*	*<.0001*	*0.356*
17:0	18.5 b	15.9 c	20.3 a	17.4 bc	1.8	*0.200*	*<.0001*	*0.743*
17:1	7.8 ab	7.2 b	8.6 a	7.4 b	0.9	*0.103*	*<.0001*	*0.280*
21:0	0.8 b	0.6 c	1.0 a	0.7 bc	0.2	*0.617*	*<.0001*	*0.317*
∑OCFA	78.0 a	66.6 c	75.2 ab	71.1 bc	7.3	*0.014*	*<.0001*	*0.411*
iso-13	0.9 a	0.7 b	1.0 a	0.8 b	0.1	*0.974*	*<.0001*	*0.647*
anteiso-13	5.5 a	4.4 b	4.6 b	4.5 b	0.5	*0.001*	*<.0001*	*0.683*
iso-14	5.3 b	3.3 d	7.4 a	4.0 c	0.8	*0.708*	*<.0001*	*0.361*
iso-15	9.4 b	6.8 d	11.4 a	7.7 c	1.2	*0.903*	*<.0001*	*0.704*
anteiso-15	18.7 b	14.4 d	20.7 a	16.0 c	1.7	*0.769*	*<.0001*	*0.831*
iso-16	12.2 b	8.5 d	14.9 a	9.9 c	1.4	*0.742*	*<.0001*	*0.274*
anteiso-17	15.9 a	13.2 b	16.5 a	14.4 b	1.7	*0.035*	*<.0001*	*0.715*
iso-18	2.0 b	1.7 c	2.6 a	1.9 b	0.3	*0.005*	*<.0001*	*0.029*
∑BCFA	70.0 b	52.7 d	79.1 a	59.9 c	6.8	*0.630*	*<.0001*	*0.770*

MP, high-quality fresh milk labelled as MP; HQ, high-quality fresh milk with no additional label; HM, ESL milk labelled as *Haymilk*; ESL, ESL milk with no additional labels.

Different letters (a, b, c and d) across different milk labels denote statistically significant differences (P < 0.05) between LSMeans throughout the entire sampling season (MP, HQ, HM and ESL).

**trans*-11, 18:1 n-7 peak could include *trans*-10, 18:1; cis-9, 18:1 n-9 peak could include *trans*-13, 18:1 and cis-10, 18:1.

Table 4. Sensory evaluation: F value and statistical significance of samples (MP, HQ, HM, and ESL), Judges (n=10), Replicates (n=3) and their interaction for each sensory descriptor.

	F value					
Descriptors	**Samples**	**Judges**	**Replicates**	**S*J**	**S*R**	**J*R**
Appearance						
White colour	2.08 n.s.	80.07***	0.13 n.s.	6.26***	1.05 n.s.	1.03 n.s.
Brightness	2.04 n.s.	78.72***	0.44 n.s.	2.36*	1.28 n.s.	1,84 n.s.
Viscosity	2.55 n.s.	72.71***	0.96 n.s.	6.53***	0.17 n.s.	1.03 n.s.
Aroma						
intensity	8.40*	70.95***	1.23 n.s.	13.84***	0.99 n.s.	1.08 n.s.
Fatty	2.22 n.s.	42.52***	0.49 n.s.	13.82***	1.42 n.s.	0.48 n.s.
Grassy	1.93 n.s.	49.51***	0.11 n.s.	12.08***	0.64 n.s.	1.76 n.s.
Cooked	1.47 n.s.	69.74***	1.57 n.s.	16.98***	0.59 n.s.	1.53 n.s.
Taste						
Salty	2.54 n.s.	18.11***	1.00 n.s.	12.30***	0.93 n.s.	0.65 n.s.
Sweet	2.22 n.s.	29.20***	0.05 n.s.	12.90***	0.36 n.s.	0.97 n.s.
Bitter	2.24 n.s.	50.28***	1.80 n.s.	40.07***	1.17 n.s.	1.22 n.s.
Flavour						
Intensity	1.54 n.s.	49.88***	1.70 n.s.	6.66***	1.63 n.s.	1.34 n.s.
Fatty	2.65 n.s.	49.87***	0.55 n.s.	8.85***	0.63 n.s.	0.75 n.s.
Grassy	1.04 n.s.	55.84***	0.68 n.s.	6.97***	0.60 n.s.	1.31 n.s.
Texture						
Astringency	2.19 n.s.	43.15***	1.27 n.s.	13.01***	0.76 n.s.	1.19 n.s.
Adhesivity	1.49 n.s.	70.94***	1.23 n.s.	8.50***	0.53 n.s.	1.23 n.s.
Viscosity	2.37 n.s.	88.75***	1.63 n.s.	10.37***	0.39 n.s.	0.97 n.s.
Persistency	1.25 n.s.	89.15***	1.06 n.s.	14.60***	0.47 n.s.	1.26 n.s.

ESL, ESL milk with no voluntary quality label; HM, ESL milk labelled as *Haymilk*; HQ, high-quality fresh milk with no voluntary quality label; J 9 R, Judges 9 Replicates; MP, high-quality fresh milk labelled as MP; S 9 J, Samples 9 Judges; S 9 R, Samples 9 Replicates.

Significance: ***P < 0.001; *P < 0.05.

Figures

Figure 1. Results from the multifactorial ANOVA with milk Label and Month of sampling on fatty acids data for rumenic acid (*c*9,*t*11-18:2), vaccenic acid (*trans*11-18:1), branched-chain fatty acids (BCFAs) and linolenic acid (18:3 n-3). Data are presented as mean and standard error (SE) bars. *Legend*. — MP: high-quality fresh milk labelled as Mountain Product, — HQ: high-quality fresh milk with no voluntary quality label — HM: ESL milk labelled as *Haymilk*, — ESL: ESL milk with no voluntary quality label. M1: March; M2: May; M3: July; M4: September. Different capital letters (A, B) associated to the same bar show significant differences (p<0.05) between different sampling months within the same milk label (M1, M2, M3, M4); different lower-case letters (a, b, c) associated to different bars show significant differences (*p*<0.05) between different milk labels (MP, HQ, HM, ESL) at each sampling month.

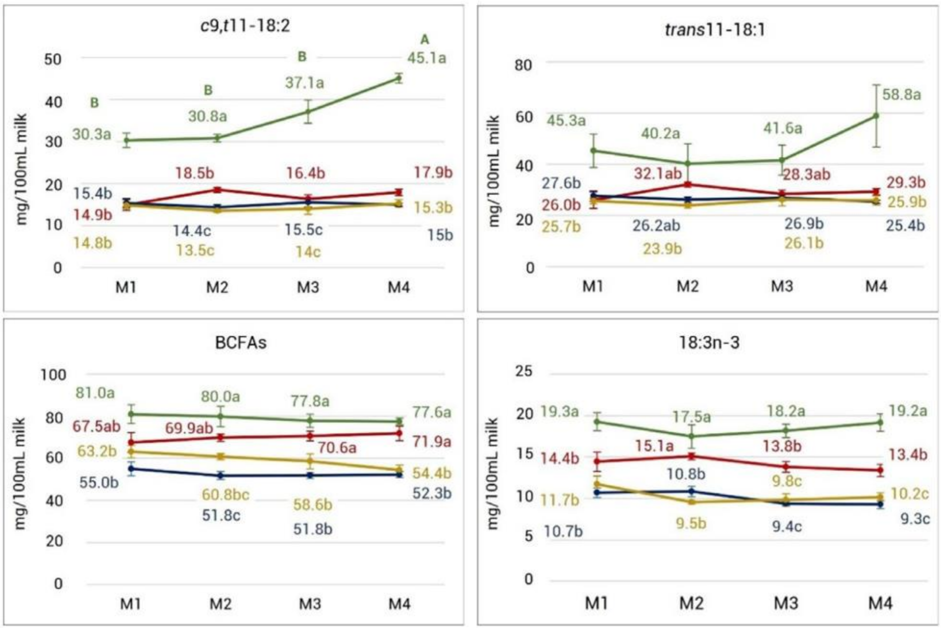


Figure 2a. Spider plot of the sensory analysis of retail milk samples and results from the ANOVA. Data are presented as mean values. Means associated to different letters were significatively different (p<0.05). **Figure 2b.** Results from the ANOVA on the *aroma intensity* parameter. Data are presented as means and standard error bars. Means associated to different letters are significatively different. *Legend.* — MP: high-quality fresh milk labelled as Mountain Product, — HQ: high-quality fresh milk with no voluntary quality label — HM: ESL milk labelled as *Haymilk*, — ESL: ESL milk with no voluntary quality label.

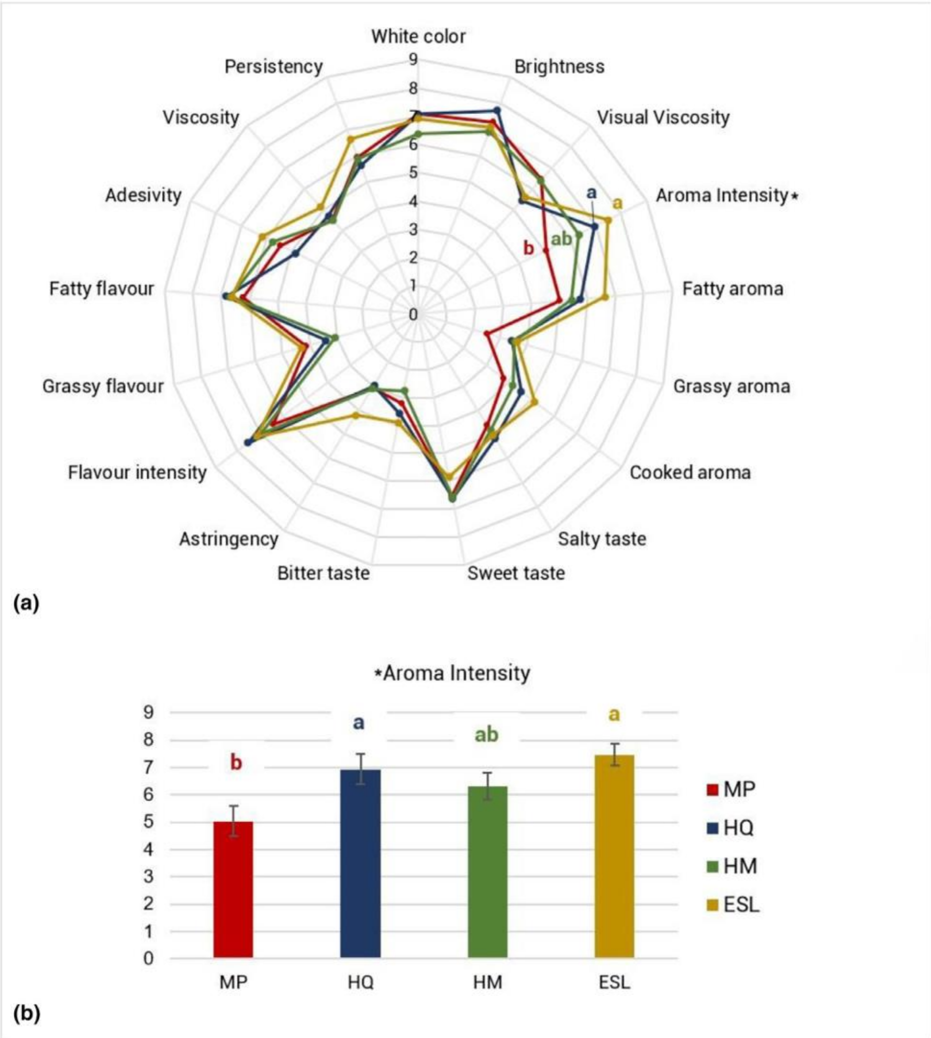
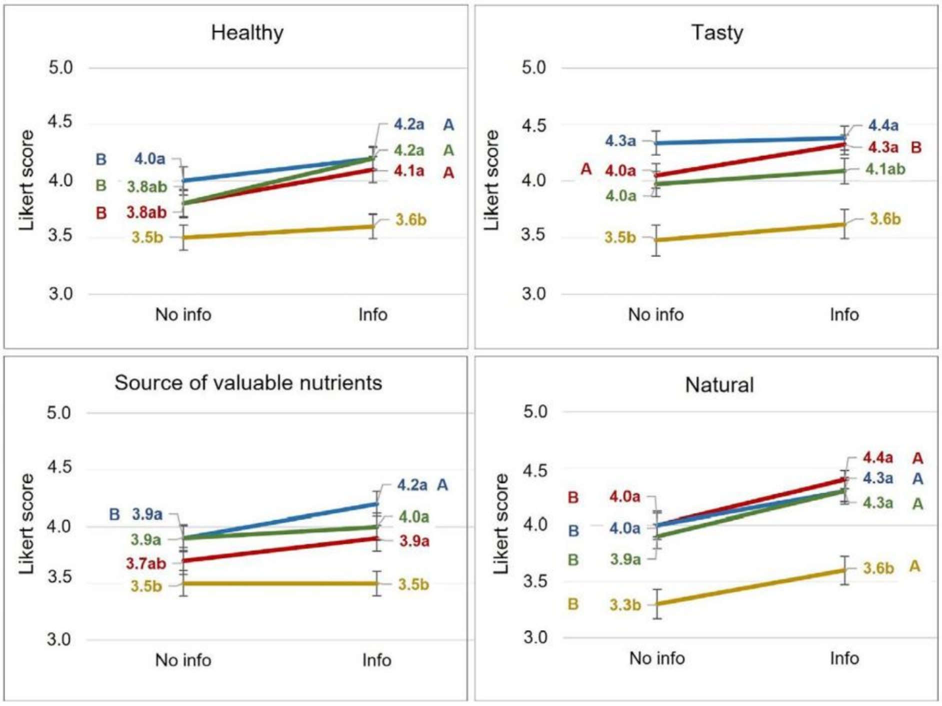


Figure 3. Results from the mixed ANOVA on the survey scores for the four retail milk labels. Data are presented as mean and standard error (SE) bars. *Legend*. — MP: high-quality fresh milk labelled as Mountain Product, — HQ: high-quality fresh milk with no voluntary quality label — HM: ESL milk labelled as *Haymilk*, — ESL: ESL milk with no voluntary quality label. Different capital letters (A, B) associated to the same bar show significant differences (p<0.05) for *within-treatment* comparisons (No info, Info); different lower-case letters (a, b, c) associated to different bars show significant differences (p<0.05) for *between-treatment* comparisons (MP, HQ, HM, ESL).



Appendix S1. Technical characteristics of the types of milk considered in the study.

Supplemental Material S1

TECHNICAL CHARACTERISTICS OF THE TYPES OF MILK CONSIDERED IN THE STUDY

1. **High-Quality fresh milk, voluntary quality label: Mountain Product (MP)**

   This mark was introduced by Regulation (EU) no. 1151/2012 (European Parliament and Council of the European Union, 2012) and then updated by Regulation (EU) no. 665/2014 (European Commission, 2014). According to these Regulations, the designation *Mountain product* for milk is reserved for cases where the primary raw materials and feedstuffs for cows originate predominantly (at least, 60% of dry matter) from mountain areas. Additionally, the processing stages, including heat treatment and packaging, must occur within 30 km of the specified mountain area; in Italy this distance is further reduced to 10 km by a decision from the Ministry (Ministero delle Politiche Agricole Alimentari e Forestali, 2016). The Mountain product seal for milk does not establish specific constrains for the livestock system adopted in farms, but emphasizes the necessity of a connection with the territory of origin. According to the Regulation (EC) no. 1257/1999 (Council of the European Union, 1999), mountain areas are characterised by altitude and/ or difficult climatic conditions, which lead to a considerable limitation of the possibilities for using the land and an appreciable increase in the cost of working.

2. **High-Quality fresh milk (HQ), no voluntary quality labels**

   According to the Italian regulation ("Legge 3 Maggio 1989, n. 169. Disciplina Del Trattamento e Della Commercializzazione Del Latte Alimentare Vaccino," 1989), in order to be labelled as High-Quality fresh milk, raw milk must have higher quality requirements than other milks, including a minimum fat and protein content. Further, High-Quality fresh milk comes from raw milk which underwent a single heat treatment (pasteurization) within 48 hours of milking, to make it suitable for human consumption. The heat treatment applied employs the minimum hygienically safe pasteurization temperature (heating to approximately 72°C for 15 seconds), with minimal negative repercussions on the nutritional composition of the milk. High-Quality fresh milk has a shelf life of 6 days in the refrigerator.

3. **Extended shelf-life milk, voluntary quality label*: Haymilk* (HM), TSG**

   Haymilk is a TSG introduced by Regulation (EU) no. 2016/304 (European Commission, 2016). According to the Regulation, *Haymilk* comes from dairy farms managed following differentiated production system, linked to more traditional and sustainable practices. The key difference between standard milk and *Haymilk* stems from the fact that, as in the earliest form of milk production, animals are not fed fermented fodder. In order to fulfil *Haymilk* production requirements, the feeding procedure is adapted to match seasonal changes: in the green-feeding period, animals are fed fresh grass, foliage plus some hay, other roughages, cereal crops, etc.; in the winter period, animals are mainly fed hay plus other roughages, cereal crops, etc. It is mandatory that, whatever the season, roughage make up at least 75% of the yearly ration of dry matter. Fermented fodder, such as silage, and fermented hay are strictly prohibited.

4. Extended shelf-life milk (ESL), no voluntary quality label

Extended Shelf-Life milk - Pasteurized at High Temperature - is a type of milk that can be stored for longer in the refrigerator (up to 21 days) compared to fresh milk. This is possible because the starting raw milk undergoes a pasteurization process at a higher temperature (135°C for 1-2 seconds) compared to the classic pasteurization process (72°C for 15 seconds). Furthermore, Extended Shelf-Life milk - Pasteurized at High Temperature is packaged in aseptic containers, thus guaranteeing its wholesomeness throughout the supply chain and allowing it to be preserved for several days.

Appendix S2. Overview of the questionnaire.

Supplemental Material S2

OVERVIEW OF THE QUESTIONNAIRE

0. Informed consent
1. Please, indicate your age
2. Please, indicate your gender
3. Have you bought or consumed milk at least once during last six months?
   - ○ yes
   - ○ no
4. (Evaluation before informative) Would you agree or disagree with the following statements about the bottle of milk you are shown in the figure? (Those statements where not categorized and appeared in mixed order).

Treatment 1 High-Quality Fresh milk	*Treatment 2* High-Quality Fresh milk Mountain Product certified	*Treatment 3* Extended Shelf-Life milk	*Treatment 4* Extended Shelf-Life milk *Haymilk* certified
			

	Strongly disagree (1)	(2)	Neither disagree nor agree (3)	(4)	Completely agree (5)
It is healthy	○	○	○	○	○
It is tasty	○	○	○	○	○
It brings valuable nutrients for the diet	○	○	○	○	○
It is natural	○	○	○	○	○

6. Informative. Now you will be provided with some information about the type of milk you have evaluated, selected by us from those available on the Italian market, some of which are associated with quality brands that guarantee compliance with specific production practices.

Please read the following information carefully and answer the questions you will be asked later.

HQ	In order to be labelled as *High-Quality* milk, raw milk must have higher quality requirements than other milks, including a minimum fat and protein content. Furthermore, to be marketed as *High-Quality Fresh Milk*, raw milk must undergo a single heat treatment (pasteurization) within 48 hours of milking, to make it suitable for human consumption. Starting from superior quality milk, coming from carefully selected farms, the heat treatment can be applied using the minimum hygienically safe pasteurization temperature (heating to approximately 72°C for 15 seconds), with minimal negative repercussions on the nutritional composition of the milk. High Quality Fresh Milk has a shelf life of 6 days in the refrigerator.
MP	In order to obtain the *Mountain Product* certification, the milk must be produced by animals raised in mountain areas, i.e. areas located in municipalities classified as totally or partially mountainous. At least 60% of the raw materials and feed used for the animals must come from these same areas. Furthermore, to meet the requirements for the definition of *High-Quality Fresh Milk*, the raw milk must undergo a single heat treatment (pasteurization) within 48 hours of milking and must meet higher quality requirements than other milks, including a minimum protein and fat content. Starting from superior quality milk, coming from carefully selected farms, the heat treatment can be applied using the minimum hygienically safe pasteurization temperature (heating to approximately 72°C for 15 seconds), with minimal negative repercussions on the nutritional composition of the milk. The High-Quality Fresh Milk with the *Mountain Product* certification has a shelf life of 6 days in the refrigerator.
ESL	*Extended Shelf-Life* milk - Pasteurized at High Temperature is a type of milk that can be stored for longer in the refrigerator (up to 21 days) compared to fresh milk (which has a maximum shelf life of 6 days). This is possible because the starting raw milk undergoes a pasteurization process at a higher temperature (135°C for 1-2 seconds) compared to the classic pasteurization process (72°C for 15 seconds). Furthermore, *Extended Shelf-Life* milk - Pasteurized at High Temperature is packaged in aseptic containers, thus guaranteeing its wholesomeness throughout the procurement process and allowing it to be preserved "for several days". The higher heat treatment can induce a slight loss of thermolabile micronutrients (especially vitamins) but is able to preserve the nutritional and organoleptic characteristics of fresh milk in a much more efficient manner compared to the UHT sterilization system (approximately 150°C for 1- 5 seconds), used for the production of UHT milk.
HM	*Haymilk* is a Traditional Specialty Guaranteed (TSG) which certifies that the milk comes from traditional and sustainable farms, in which the animals are fed exclusively with fresh grass, hay and small quantities of cereals (based on seasonal availability) and completely to fermented fodder (ensilage), on the contrary widely used in conventional farming systems. Coming mostly from production areas distant from urban centres and difficult to reach, the TSG *Haymilk* available in the refrigerated counters of supermarkets is generally pasteurized at high temperatures (135°C for 1-2 seconds) and packaged in aseptic containers, thus guaranteeing its healthiness throughout the procurement process and allowing storage at refrigerator temperatures for up to 21 days. The higher heat treatment compared to that used in the classic pasteurization process (72°C for approximately 15 seconds) can induce a slight loss of thermolabile micronutrients (especially vitamins), but allows the nutritional and organoleptic characteristics of fresh milk to be preserved in a much more efficient than the UHT sterilization system (about 150°C for 1-5 seconds), used for the production of UHT milk.

7. (Evaluation after informative) Would you agree or disagree with the following statements about the bottle of milk you are shown in the figure? (Those statements where not categorized and appeared in mixed order).

Treatment 1 High-Quality Fresh milk	*Treatment 2* High-Quality Fresh milk Mountain Product certified	*Treatment 3* Extended Shelf-Life milk	*Treatment 4* Extended Shelf-Life milk *Haymilk* certified
			

	Strongly disagree (1)	(2)	Neither disagree nor agree (3)	(4)	Completely agree (5)
It is healthy	o	o	o	o	o
It is tasty	o	o	o	o	o
It brings valuable nutrients for the diet	o	o	o	o	o
It is natural	o	o	o	o	o

8. FOOD VALUES. For each statement, please indicate how important the following characteristics are to you when purchasing milk.

	Not important at all (1)	(2)	Neither important nor not important (3)	(4)	Extremely important (5)
Naturalness	○	○	○	○	○
Taste	○	○	○	○	○
Price	○	○	○	○	○
Food safety	○	○	○	○	○
Convenience	○	○	○	○	○
Nutrition	○	○	○	○	○
Geographical Origin	○	○	○	○	○
Fairness	○	○	○	○	○
Appearance	○	○	○	○	○
Environmental Impact	○	○	○	○	○

9. Do you personally take care of the food shopping for you and your family?

○ yes
○ no

10. Have you reduced your consumption of milk and its derivatives in the last three years?

○ yes
○ no

11. If you answered yes to the previous question, please indicate how much did you reduce milk and dairies consumption:

○ 20%
○ 40%
○ 60%
○ 80%
○ 100%

12. Please, indicate for which of the following reasons you have reduced the consumption of milk and its derivatives (you can also indicate more than one reason):

○ Health concerns
○ Reasons related to food safety
○ Economic reasons
○ Concern for animal welfare

13. Please, indicate the consumption frequency in the following context:

	Never	Maximum 3 times for year	Once in a month	Once every 2 weeks	Once a week	2/3 times a week
At the bar (for cappuccino, etc)	○	○	○	○	○	○
At home, for breakfast	○	○	○	○	○	○
At home as a snack	○	○	○	○	○	○
Others (please, specify): _______________	○	○	○	○	○	○

14. Do you know the features of the following milk types?

	definitely no	more no than yes	more yes than no	definitely yes
High-Quality Fresh milk	○	○	○	○
Extended Shelf-Life milk	○	○	○	○
High-Quality Fresh milk *Mountain Product* certified	○	○	○	○
Extended Shelf-Life milk *Haymilk* certified	○	○	○	○

15. Please, indicate the consumption frequency for the following types of milk:

	Never	Maximum 3 times for year	Once in a month	Once every 2 weeks	Once a week	2/3 times a week
High-Quality Fresh milk	○	○	○	○	○	○
Extended Shelf-Life milk	○	○	○	○	○	○
High-Quality Fresh milk *Mountain Product* certified	○	○	○	○	○	○
Extended Shelf-Life milk *Haymilk* certified	○	○	○	○	○	○

16. Demographics

Appendix S3. Results from the multifactorial ANOVA on FA data. Means are splitted for each milk label and each sampling month.

Supplemental Material S3

RESULTS FROM THE MULTIFACTORIAL ANOVA ON FAs DATA. MEANS ARE SPLITTED FOR EACH MIL LABEL AND EACH SAMPLING MONTH

	MP					HQ					HM					ESL								
	M1	**M2**	**M3**	**M4**		**M1**	**M2**	**M3**	**M4**		**M1**	**M2**	**M3**	**M4**		**M1**	**M2**	**M3**	**M4**		RMSE	M	L	M*L
4:0	184.0	175.6	177.7	166.0	AB	178.4	162.9	173.5	172.0	AB	186.1	178.1	167.2	191.4	A	176.3a	168.0ab	149.5b	152.7ab	B	17.4	0.070	0.008	0.305
6:0	99.3	94.6	99.9	89.6	A	92.8	85.1	80.3	80.8	C	94.3	92.0	93.0	94.3	AB	92.4	89.4	84.3	82.0	BC	9.9	0.088	0.002	0.790
8:0	56.0	52.0	52.3	47.5	A	50.7	46.3	42.4	42.2	B	50.7	49.5	46.7	48.9	AB	50.9	49.1	43.3	43.3	B	5.3	0.001	0.001	0.810
10:0	127.7a	112.3ab	116.6ab	107.2b	A	111.7	99.4	92.2	93.5	B	109.3	104.4	97.8	102.6	B	113.9a	106.7ab	95.7b	93.3b	B	11.2	<.0001	<.0001	0.764
12:0	147.2	124.8	132.6	125.1	A	125.1	108.9	104.1	107.0	B	123.4	115.5	108.8	115.2	B	129.8a	118.8ab	108.4b	105.4b	B	12.9	<.0001	<.0001	0.776
14:0	412.1	381.0	404.4	393.4	A	365.6	329.7	333.5	334.4	C	396.6	376.9	359.4	382.2	AB	381.4	359.9	339.8	332.7	BC	35.1	0.027	<.0001	0.869
16:0	986.2ab	910.5b	1071.1a	1013.7ab		972.1	881.6	964.7	935.0		950.3	921.9	897.0	925.8		965.1	939.4	911.7	885.0		84.9	0.018	0.031	0.287
18:0	258.3	281.1	289.3	278.2		269.7	256.8	263.9	263.5		249.6	257.1	289.6	279.1		263.5	258.2	288.0	269.4		29.6	0.082	0.570	0.804
20:0	3.7	4.2	4.3	4.4	B	3.7	3.3	3.6	3.5	C	4.5	4.8	5.2	5.0	A	3.7	3.6	4.2	3.6	BC	0.5	0.048	<.0001	0.431
22:0	0.6	0.8	0.8	0.8	B	0.6	0.6	0.6	0.6	C	1.1	1.1	1.2	1.2	A	0.7	0.6	0.7	0.6	BC	0.1	0.137	<.0001	0.294
24:0	0.8	1.0	1.0	1.1	B	0.9	0.6	0.7	0.6	C	1.2	1.5	1.5	1.5	A	0.7	0.6	0.8	0.8	C	0.3	0.434	<.0001	0.414
ΣSFA	2275.9	2137.8	2350.1	2227.1	A	2171.2	1975.3	2059.6	2033.2	B	2167.0	2102.9	2067.2	2147.0	AB	2178.4	2094.4	2026.5	1968.9	B	187.8	0.194	0.008	0.763
10:1	12.3	11.1	11.5	11.0	A	10.3	9.1	9.0	9.4	C	11.2	10.5	9.7	10.7	B	10.7	10.1	9.3	9.4	BC	1.1	0.004	<.0001	0.884
12:1	3.2	2.7	2.9	2.9	A	2.5	2.2	2.3	2.4	B	2.7	2.5	2.3	2.5	B	2.8	2.6	2.3	2.4	B	0.3	0.006	<.0001	0.904
14:1	37.1	33.0	36.8	37.3	A	32.8	28.9	30.8	31.9	B	33.8	32.1	30.5	33.0	B	34.4	32.8	29.8	31.1	B	3.1	0.021	<.0001	0.410
16:1 *cis*-7	5.3	5.2	5.8	5.4		5.6	5.0	5.5	5.2		5.6	5.5	5.8	5.8		5.5	5.3	5.3	5.1		0.5	0.214	0.123	0.789
16:1 *cis*-9	57.0ab	48.7b	59.0a	59.2a		59.4	50.0	57.4	56.4		51.1	50.7	51.0	51.2		58.1a	55.8ab	50.2b	51.4ab		5.6	0.042	0.022	0.054
18:1 *trans*-9	11.6	10.6	11.3	10.1	B	17.4a	15.0ab	14.8ab	13.7b	A	7.4	6.8	8.2	8.5	C	15.2	14.0	12.4	13.8	A	1.5	0.016	<.0001	0.023
18:1 *trans*-11	26.0	32.1	28.3	29.3	B	27.6	26.2	26.9	25.4	B	45.3	40.2	41.6	58.8	A	25.7	23.9	26.1	25.9	B	9.9	0.482	<.0001	0.382
18:1 *cis*-9	509.8	528.1	562.7	566.5		527.7	477.3	518.8	522.0		494.9	505.9	549.1	547.8		524.8	507.8	521.4	518.9		48.7	0.07	0.244	0.730
18:1 *cis*-11	21.8	20.2	22.9	23.0	AB	25.1	21.7	23.5	23.5	A	18.8	19.4	21.2	20.0	B	24.9	24.1	21.8	23.0	A	3.0	0.544	0.001	0.482
20:1n-9	1.2	1.4	1.5	1.5		1.5	1.3	1.4	1.3		1.4	1.5	1.7	1.5		1.3	1.3	1.6	1.4		0.3	0.186	0.377	0.639

ΣMUFA	685.2	693.1	742.7	746.2		710.0	636.6	690.4	691.1		672.1	675.2	721.1	739.9		703.3	677.6	680.2	682.5		61.7	0.116	0.269	0.649
11:0	4.3a	2.6b	3.1ab	2.5b	A	3.2	2.7	2.4	2.8	A	1.8	1.6	1.6	1.6	B	3.5a	3.0b	2.3c	2.5c	A	0.5	<.0001	<.0001	0.014
13:0	5.9a	4.2b	4.7ab	4.6b	A	4.6	4.0	3.8	4.2	B	3.5	3.3	3.3	3.3	C	5.1a	4.6ab	3.8c	4.2bc	AB	0.6	<.0001	<.0001	0.141
15:0	47.1a	38.9b	43.6ab	41.8ab	A	38.2	34.2	35.1	36.6	C	40.7	39.5	39.9	40.9	AB	42.3a	39.0ab	35.6b	36.5b	BC	3.9	0.007	<.0001	0.356
17:0	18.9	17.6	19.1	18.6	B	16.9	14.9	15.9	16.0	C	19.9	20.2	21.2	20.1	A	18.6	17.3	17.2	16.3	BC	1.8	0.200	<.0001	0.743
17:1	7.9	7.0	8.2	8.2	AB	7.5a	6.3b	7.4a	7.4ab	B	8.3	8.6	9.0	8.3	A	8.1	7.4	7.2	7.0	B	0.9	0.103	<.0001	0.280
21:0	0.7	0.8	0.8	0.7	B	0.6	0.6	0.6	0.5	C	0.8	1.0	1.0	1.1	A	0.8	0.5	0.7	0.7	BC	0.2	0.617	<.0001	0.317
ΣOCFA	84.8	71.1	79.6	76.5	A	71.0	62.6	65.3	67.6	C	75.1	74.1	76.1	75.3	AB	78.4a	71.8ab	66.9b	67.2b	BC	7.3	0.014	<.0001	0.411
iso-13	0.9	0.9	1.0	1.0	A	0.7	0.7	0.7	0.7	B	1.1	1.0	0.9	1.1	A	0.8	0.8	0.8	0.7	B	0.1	0.974	<.0001	0.647
anteiso-13	6.1	5.1	5.3	5.4	A	4.7	4.2	4.1	4.4	B	4.9	4.8	4.2	4.6	B	5.0	4.7	4.2	4.2	B	0.5	0.001	<.0001	0.683
iso-14	4.7	5.7	5.1	5.7	B	3.1	3.2	3.0	3.1	D	7.7	7.4	7.3	7.1	A	4.1	4.1	4.3	3.4	C	0.8	0.708	<.0001	0.361
iso-15	8.7	9.3	9.6	9.8	B	7.0	6.5	6.7	6.9	D	11.9	11.4	10.7	11.6	A	8.1	7.7	7.8	7.2	C	1.2	0.903	<.0001	0.704
anteiso-15	18.3	18.5	18.9	19.1	B	14.7	14.1	14.4	14.4	D	21.0	20.8	20.1	21.0	A	17.2	16.1	15.8	15.0	C	1.7	0.769	<.0001	0.831
iso-16	10.9	12.8	12.0	13.1	B	8.8	8.3	8.5	8.4	D	15.0	15.0	15.2	14.3	A	10.4	10.2	10.2	8.7	C	1.4	0.742	<.0001	0.274
anteiso-17	16.1	15.6	16.2	15.7	A	14.2	13.1	12.9	12.7	B	17.0	17.3	16.3	15.5	A	15.8a	15.3ab	13.5b	13.2b	B	1.7	0.035	<.0001	0.715
iso-18	1.7b	1.9b	2.4a	2.1ab	B	1.6	1.7	1.6	1.7	C	2.5ab	2.3b	3.0a	2.5ab	A	1.9	1.9	1.9	2.0	B	0.3	0.005	<.0001	0.029
ΣBCFA	67.5	69.9	70.6	71.9	B	55.0	51.8	51.8	52.3	D	81.0	80.0	77.8	77.6	A	63.2	60.8	58.6	54.4	C	6.8	0.630	<.0001	0.770
18:2 *t*-9,*t*-12	7.5	7.4	7.3	6.7	A	8.1	7.7	7.3	7.4	A	4.4	4.8	5.6	5.9	B	7.3	6.8	7.2	7.3	A	0.8	0.919	<.0001	0.060
18:2 *c*-9,*t*-12	2.0	2.2	2.2	1.9	B	2.5	2.2	2.3	2.2	A	1.3	1.3	1.6	1.8	C	2.3a	2.2ab	1.9b	2.1ab	B	0.2	0.965	<.0001	0.003
c18:2 *t*-9,*c*-12	3.0	3.7	3.1	3.3	B	2.3	2.3	2.2	2.2	C	5.0	4.4	4.1	6.3	A	2.6	2.4	2.6	2.4	C	1.0	0.364	<.0001	0.259
18:2 *c*-9,*c*-12	76.7a	68.9ab	73.5ab	66.9b	A	78.9	71.5	70.4	72.2	A	54.7	54.9	62.7	58.4	B	72.9	70.5	70.4	73.5	A	9.9	0.541	<.0001	0.767
18:3n-6	0.8	0.8	0.9	0.7		0.7	0.7	0.8	0.7		0.8	0.8	0.9	0.9		0.9	0.9	0.8	0.8		0.2	0.241	0.093	0.984
18:3n-3	14.4	15.1	13.8	13.4	B	10.7	10.8	9.4	9.3	C	19.3	17.5	18.2	19.2	A	11.7	9.5	9.8	10.2	C	1.8	0.149	<.0001	0.525
18:2 *c*-9,*t*-11	14.9	18.5	16.4	17.9	B	15.4	14.4	15.5	15.0	C	30.3b	30.8b	37.1b	45.1a	A	14.8	13.5	14.0	15.3	C	2.6	<.0001	<.0001	<.0001
20:2n-6	0.7	0.8	0.8	0.8		0.7	0.6	0.7	0.7		0.7	0.7	0.8	0.9		0.7	0.7	0.7	0.8		0.2	0.482	0.466	0.952
20:3n-6	3.1	3.0	3.4	3.1		3.7	3.2	3.1	3.2		2.3	2.5	2.9	2.5		3.1	3.2	3.1	3.1		0.5	0.809	0.000	0.483
20:4n-6	4.9	4.4	5.0	4.6		4.9	4.5	4.7	4.7		3.6	3.7	4.3	4.0		4.9	4.8	4.9	4.5		0.7	0.432	0.000	0.901
20:5n-3	1.2	1.3	1.2	1.2	B	1.3	0.9	0.8	0.9	C	2.0	1.8	1.7	1.9	A	0.9	1.0	0.8	0.9	C	0.3	0.168	<.0001	0.750

22:2n-6	0.7b	1.2ab	1.2a	1.0ab	B	0.7	0.9	0.8	0.7	C	1.0	1.5	1.9	1.4	A	0.7	0.8	1.3	0.6	BC	0.4	<.0001	<.0001	0.296
22:5n-3	2.2	2.1	2.1	2.0	B	1.8a	1.8a	1.6ab	1.5b	C	2.8	2.7	2.7	2.6	A	2.0	1.7	1.7	1.7	C	0.3	0.138	<.0001	0.950
ΣPUFA	132.0	129.5	130.8	123.5	AB	131.7	121.6	119.6	120.4	B	128.1	123.1	144.4	150.8	A	124.8	118.0	119.1	123.1	B	16.7	0.638	0.003	0.248
n-6/n-3	5.7	5.0	5.7	5.4	B	7.4ab	7.0b	7.8ab	8.1a	A	3.1	3.5	3.7	3.5	C	6.6	7.5	7.7	7.5	A	2.2	0.107	<.0001	0.666

Legend. MP: high-quality fresh milk labelled as Mountain Product, HQ: high-quality fresh milk with no voluntary quality label; HM: ESL milk labelled as *Haymilk*; ESL: ESL milk with no voluntary quality label. M1: March; M2: May; M3: July; M4: September. Different capital letters (A, B, C) in the same line show significant differences (p<0.05) between different milk labels (MP, HQ, HM, ESL); different lower-case letters (a, b, c) in the same line show significant differences (p<0.05) between within the same milk label in different sampling months (M1, M2, M3, M4).

Appendix S4. Socio-demographic variables of the sample (N = 335).

Supplemental Material S4

S4.1. SOCIO-DEMOGRAPHIC VARIABLES OF THE SAMPLE (N = 335)

Characteristic	%	Characteristic	%
Gender		*Number of family members*	
Female	71.9	1	10.1
Male	27.5	2	23.9
I prefer not to answer	0.3	3	23.3
Others	0.3	4	32.5
Age		5	8.7
18-25	19.4	>5	1.5
26-35	21.2	*Number of children < 13 years old*	
36-45	20.9	0	70.7
46-55	20.0	1	17
56-65	15.5	2	10.4
66-75	2.7	3	1.2
>75	0.3	>3	0.6
Educational Level		*Number of children > 13 years old*	
Primary school	0.3	0	53.7
Lower secondary school	3.0	1	18.8
Upper secondary school	39.7	2	22.1
Bachelor's degree	17.9	3	4.8
Master's degree	33.1		
PhD	6.0		
Geographical area			
Northern Italy	82.4	Hills or mountains (uplands)	19.4
Central Italy and Islands	14.4	Internal areas/plane (lowlands)	70.1
Southern Italy	3.3	Coastal area	10.4

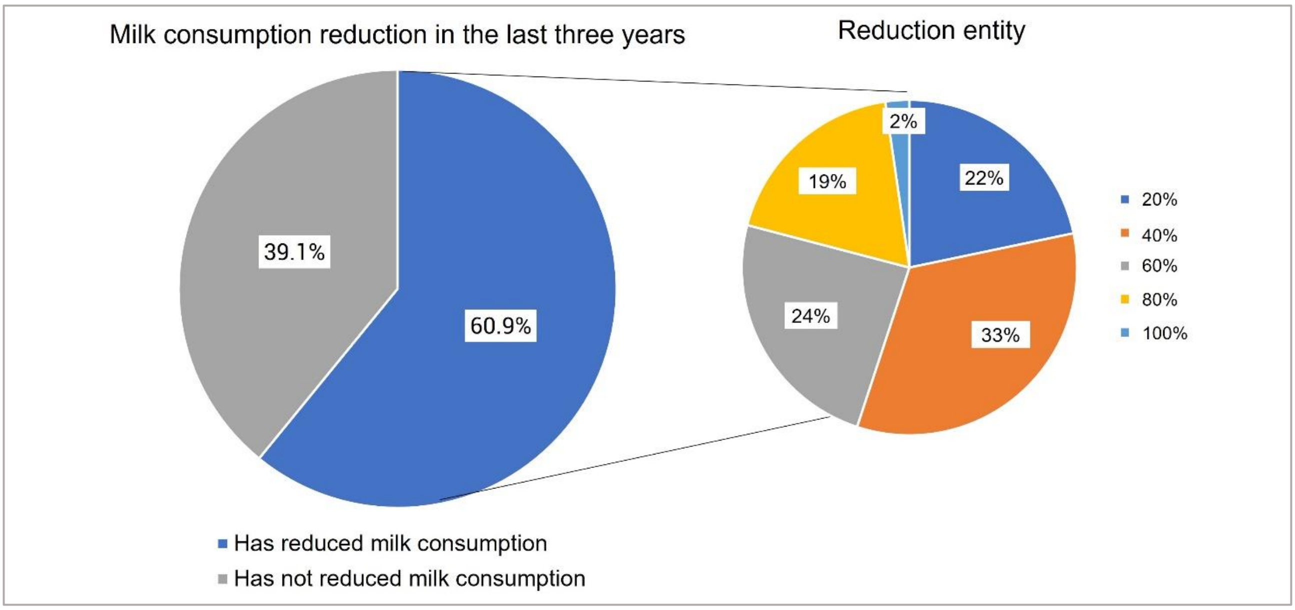
S4.2 FREQUENCY DISTRIBUTION OF CONSUMPTION OCCURRENCE

Occurrence	*Respondents (%)*
At the bar (cappuccino, latte, etc.)	
Up to 2-3 times a week	23.6
Once a week	12.2
Once every 2 weeks	11.3
Once a month	17.3
Maximum 3 times a year	13.7
Never	21.8
At home, for breakfast	
Up to 2-3 times a week	57.9
Once a week	11.0
Once every 2 weeks	5.1
Once a month	7.2
Maximum 3 times a year	5.4
Never	13.4
At home, as a snack	
Up to 2-3 times a week	14.6
Once a week	9.6
Once every 2 weeks	6.3
Once a month	10.4
Maximum 3 times a year	10.7
Never	49.0
At home, for other purposes (cooking, pastry, etc.)	
Up to 2-3 times a week	14.0
Once a week	12.2
Once every 2 weeks	14.6
Once a month	15.5
Maximum 3 times a year	7.8
Never	35.8

S4.3 CONSUMPTION HABITS AND MILK LABELS KNOWLEDGE OF THE SAMPLE (N = 335)

Consumption habits		Milk labels knowledge	
MP			
Consumption frequency	*Respondents (%)*	*Knowledge of the label*	*Respondents (%)*
Up to 3 times a week	9.0	Definitely yes	21.8
Once a week	5.7	More yes than no	34.6
Once every 2 weeks	5.1	More no than yes	29.9
Once a month	7.8	Definitely no	13.7
Maximum 3 times a year	20.3		
Never	52.2		
CM			
Consumption frequency	*Respondents (%)*	*Knowledge of the label*	*Respondents (%)*
Up to 3 times a week	29.9	Definitely yes	28.4
Once a week	8.1	More yes than no	41.8
Once every 2 weeks	7.5	More no than yes	23.0
Once a month	14.6	Definitely no	6.9
Maximum 3 times a year	15.5		
Never	24.5		
HM			
Consumption frequency	*Respondents (%)*	*Knowledge of the label*	*Respondents (%)*
Up to 3 times a week	5.7	Definitely yes	16.7
Once a week	3.9	More yes than no	19.1
Once every 2 weeks	2.1	More no than yes	31.6
Once a month	2.7	Definitely no	32.5
Maximum 3 times a year	9.3		
Never	76.4		
ESL			
Consumption frequency	*Respondents (%)*	*Knowledge of the label*	*Respondents (%)*
Up to 3 times a week	22.4	Definitely yes	23.0
Once a week	7.5	More yes than no	33.1
Once every 2 weeks	6.3	More no than yes	30.1
Once a month	10.4	Definitely no	13.7
Maximum 3 times a year	9.0		
Never	44.5		

S4.4 DESCRIPTIVE ANALYSIS OF MILK CONSUMPTION REDUCTION DURING LAST THREE YEARS OF THE RESPONDENTS TO THE ONLINE SURVEY IN OUR STUDY (N=335)



S4.5 FREQUENCY DISTRIBUTION OF REDUCTION MOTIVATION

Reduction motivation	Respondents (%)
Health	50.3
Animal welfare	13.8
Finance	11.5
Health + animal welfare	7.7
Food safety	6.9
Finance + animal welfare	3.1
Health + food safety	3.1
Health + finance	1.5
Health + food safety + animal welfare + finance	0.8
Health + food safety + animal welfare	0.8
Health + finance + animal welfare	0.8
Other combinations of the main concerns	10.1

Appendix S5. Frequency distribution of food values.

Supplemental Material S5

FREQUENCY DISTRIBUTION OF FOOD VALUES

Food value 1: **Naturalness**			Food value 6: **Nutrition**		
Likert value	*Respondents (%)*	*Consumers ‘segment*	*Likert value*	*Respondents (%)*	*Consumers’ segment*
1	-	Not interested	1	-	Not interested
2	0.6		2	1.5	
3	6.0	Neutral	3	11.9	Neutral
4	27.8	Interested	4	28.4	Interested
5	65.7		5	58.2	
Food value 2: **Taste**			Food value 7: **Geographical origin**		
Likert value	*Respondents (%)*	*Consumers ‘segment*	*Likert value*	*Respondents (%)*	*Consumers ‘segment*
1	0.6	Not interested	1	1.8	Not interested
2	0.3		2	2.1	
3	3.3	Neutral	3	16.7	Neutral
4	26.3	Interested	4	25.7	Interested
5	69.6		5	53.7	
Food value 3: **Price**			Food value 8: **Fairness**		
Likert value	*Respondents (%)*	*Consumers’ segment*	*Likert value*	*Respondents (%)*	*Consumers’ segment*
1	3.0	Not interested	1	2.4	Not interested
2	4.8		2	3.0	
3	21.2	Neutral	3	17.0	Neutral
4	33.4	Interested	4	27.2	Interested
5	37.6		5	50.4	
Food value 4: **Food safety**			Food value 9: **Appearance**		
Likert value	*Respondents (%)*	*Consumers’ segment*	*Likert value*	*Respondents (%)*	*Consumers’ segment*
1	0.6	Not interested	1	11.6	Not interested
2	0.6		2	10.1	
3	3.0	Neutral	3	35.8	Neutral
4	16.4	Interested	4	21.8	Interested
5	79.4		5	20.6	
Food value 5: **Convenience**			Food value 10: ***Environmental Impact***		
Likert value	*Respondents (%)*	*Consumers ‘segment*	*Likert value*	*Respondents (%)*	*Consumers ‘segment*
1	2.7	Not interested	1	1.8	Not interested
2	4.5		2	1.8	
3	25.7	Neutral	3	13.1	Neutral
4	31.9	Interested	4	28.4	Interested
5	35.2		5	54.9	

1= Not important at all; 3= Neither important nor not important, 5= extremely important