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QUALITY ASSESSMENT OF EXTENDED SHELF LIFE (ESL) MILK IN COMPARISON WITH OTHER KINDS OF PASTEURIZED MILK COMMERCIALLY AVAILABLE ON THE MARKET

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Abstract: This research investigated milk commodities' physicochemical characteristics and sensory quality related to their processing techniques, namely ESL milk, compared to raw and pasteurized milk. Several chemical, physical, and sensory tests were carried out, and the obtained data were statistically evaluated. The results indicated that dry matter varied between 8.95 % and 13.11 %, while most milk samples contained more than 3.00 % fat. *p*H with values between 6.65 and 6.80 was consistent with titratable acidity results (0.135 % to 0.198 % lactic acid). The raw and ESL milk samples had positive lactoperoxidase results, while the pasteurized milk samples had negative lactoperoxidase results. The color analysis showed that the L values of the ESL milk samples were lower, and the color was darker than that of the pasteurized milk samples. The processing technology did not affect the samples' dry matter, fat content, and the a* and b* values but influenced the taste scores throughout the sensory analysis. While the scores for taste were statistically lower for ESL milk samples, the scores for odor and appearance were unaffected by the processing method. In conclusion, compared to pasteurized milk, ESL milk samples were not the first choice for the panelist's sensory scores.

Keywords: *ESL, fluid milk, physicochemical, quality, raw milk, sensory, thermal treatment*

INTRODUCTION

Milk and dairy foodstuffs are consumed worldwide, with raw milk production exceeding 910 million tons in 2021 (81 % cow milk, 15 % buffalo milk, and 4 % from other livestock, i.e., goat, sheep, and camel milk). India and the United States of America are at the top of raw cattle milk production globally (with more than 100 million tons each), followed by China and Brazil [1].

Production in the European Union was around 160 million tons of raw milk in 2022 (of which 96 % was cow milk). The leading European milk suppliers for almost 70 % of EU milk production are Germany first (with more than 32 million tons), followed by France, Poland, the Netherlands, Italy, and Ireland [2]. At the same time, Romania reached nearly 3.8 million tons of cow milk production [3]; in comparison, Türkiye accounted for approximately 21.6 million tons of milk products as a prominent producer in the region [4].

Raw milk is considered the milk secreted from the mammary glands of farm animals, not heated above 40 ºC or untreated, with an equivalent effect that could be supplied by local producers/retailers [5]. Raw milk collected from milkings within dairy farms can be stored at 18 - 21 °C or kept in cooling conditions (below 10 °C) for a couple of days. But milk safety against biological hazards such as pathogenic bacteria (e.g., *Mycobacterium tuberculosis* var. *bovis*) can be adequately ensured by suitable pasteurization as regards the temperature-time profile [6]. Milk pasteurization started to be used in the 1880s and in dairy factories in the 1910 s; scientific knowledge of milk pasteurization was popularized beginning in 1917 [7]. Afterward, milk pasteurization was recommended by the FAO/WHO in 1953. By 1963, FAO/WHO Codex Alimentarius established standards and codes of practice for milk quality and safety. Since last century, thermal treatment has been one of the main processing methods that ensure safe fluid milk with a prolonged shelf life as a worldwide commodity. Starting in the 1980s, different countries have defined through their national regulations a required minimum pasteurization level, expressed by temperature-time parameters' values, for fluid milk to ensure the food safety of drinking milk for consumers [8]. But even so, incidents and outbreaks due to microbial contamination of raw and pasteurized milk have continued in the 21st century, and Fusco *et al.* (2023) listed a few of them (caused by *Listeria monocytogenes*, *Staphylococcus spp., Campylobacter, Salmonella spp., Escherichia coli*) [9]. In addition, other pathogenic bacteria, such as *Arcobacter butzleri, Yersinia enterocolitica, Helicobacter pylori, Cronobacter spp.* (*C. sakazakii*), *Brucella spp.* can emerge in milk.

Nowadays, milk pasteurization is a commonplace processing tech in a dairy factory [7]. However, other nonthermal technologies, such as pulsed electric field, high hydrostatic pressure, carbon dioxide processes, or membrane technologies, are considered now for milk preservation, too [10].

Rankin *et al*. (2017) reviewed advancements in milk processing by thermal pasteurization, identifying a few pasteurization heat regimes for fluid milk, such as classical pasteurization in a batch of 62.8 °C to 65.6 °C for 30 min, and immediately cooled to below 10 °C; high-temperature, short-time (HTST) pasteurization at least 71.7 °C to 78.1 °C for 15 s, and immediately cooled to below 10 °C; various heat-treatments for ultra-high-temperature (UHT) pasteurization, such as 88.3 °C for 1 s or 90 °C for 0.5 s followed by rapid cooling and sealed in a sterile container [8]. Drinking milk is traditionally pasteurized by HTST (heating to 72 - 75 °C for 15 - 30 s). UHT-milk technology was developed in the 1940s to prolong conventional pasteurized milk's short shelf life, and it is considered an ultra-pasteurization, also defined as heating to at least 138 °C for 2 s that it could be done by indirect heating or by direct steam injection [11]. Novel production techniques have been developed for producing Extended Shelf Life (ESL) milk, which is situated between pasteurized and UHT milk. In this case, a thermal treatment or combination of heat treatment and membrane filtration is involved in the production of ESL milk. The thermal process requires direct or indirect heating at 123 - 127 °C with a 1 - 5 s holding time; either ESL milk can be produced by combining gentle heat treatment (pasteurization) with a mechanical filtration step (microfiltration/deep-bed filtration) [12, 13]. By applying this method, raw milk is separated into skimmed milk and milk fat. The skimmed milk is micro-filtered through ceramic membranes and subsequently pasteurized. The retentate and a specific amount of cream are heated at 123 - 127 °C, homogenized, and mixed with the skim milk permeate [14].

Regarding the food safety of heat-treated drinking milk, the main spoilages of fluid milk are caused by heat-resistant microorganisms or recontamination. While the main post-process recontamination microorganisms are Gram-positive non-spore forming bacteria and Gram-negative bacteria (*Acinetobacter, Chryseobacterium, Psychrobacter, Sphingomonas*) and the spore formers *Paenibacillus, Bacillus cereus,* and *Microbacterium spp.*, the main heat resistant microorganisms are spore-forming microorganisms (*Bacillus spp.* and *Enterococci*). The bacteria are considered significant if they are psychrophilic or psychrotrophic and can multiply under chilled conditions [15]. Pasteurized milk through HTST has a shelf life of about one week in chilled conditions, while UHT milk can be stored at room temperature for some months in sealed packages. ESL milk has a longer shelf life than conventional pasteurized milk, up to four weeks, but also in cold chain distribution. ESL milk tastes like fresh milk. Through UHT treatment of pasteurization, the milk shelf life is extended, but many changes occur during milk processing and afterward during pasteurized milk storage. Depending on the thermal pasteurization profile (i.e., temperature-time), partial denaturation of proteins undergoes during milk processing, and protein complexes and deposits can be formed; lactose isomerization and Maillard reactions occur, too [11, 16, 17]. Consequently, the processing of UHT milk is accompanied by undesired thermal reaction products, causing off-flavors like cooked and rich caramelized flavors [11, 18] or baked taste. Less or more significant losses of the nutritional value of milk may happen during heat pasteurization, even in ESL milk, due to loss of vitamins, precipitation of calcium phosphate, and essential amino acids involved in Maillard reactions [19, 21], or protein and mineral depositing on the surfaces of heat exchangers [12]. Moreover, other changes, such as gelation, protein and flavor changes, or fat separation, can appear during UHT milk storage. All of these influence both the sensory quality and nutritional value (e.g., vitamin loss, protein modifications) of pasteurized milk, affecting milk acceptance by final consumers.

So, different heat loads, as temperature-time combinations, can be applied to fluid milk, influencing processed milk quality. Several parameters are developed to evaluate the changes induced during milk processing [22, 23]. For instance, thermal time integrators (TTIs) describe the heat-sensitive compounds already present or formed in milk during heat treatment [24], type-I indicators being suitable for evaluating low heat treatment [25], while type-II indicators are more effective for assessing applied higher heat loads [19, 20, 26, 27]. It is necessary to control the heat treatment norms applied during the thermal processes and to determine the heat treatment efficiency that the milk is exposed to intending to prevent the producers from being exposed to unfair competition, to protect the expectations of the consumers, and to help in the preparation of the regulations. As in the European Union or other regions, ESL milk has no definition or precise regulation yet [28].

But, besides milk quality changes, food safety issues, and various shelf life or sensorial preferences of end-consumers, in the last decades, more attention has also focused on sustainable milk production and its environmental impacts [29]. Several opinions expressed that UHT is more environmentally friendly than HTST and ESL products due to the advantage of reducing energy consumption and greenhouse gas (GHG) emissions during storage and transportation, as a cold distribution chain is not required before UHT milk packages open. Nevertheless, UHT milk also requires refrigeration during the consumption period after unsealing the commodity package. Regarding social sustainability from a consumer standpoint, it is worth noticing that a survey performed in Switzerland revealed a gap between the offer and demand along the milk supply chain [30].

Thanks to its technology, ESL milk seems attractive in the dairy market due to its extended shelf life, natural taste, and minimal losses in nutritional value. Compared with other pasteurized milk, ESL milk should not be exposed to values close to the thermal activities applied to UHT milk. In addition to being similar to pasteurized milk in terms of sensory and nutritional values, ESL milk can maintain its freshness for a long time with a shelf life that can be extended up to 21 days under refrigeration conditions. Compared with pasteurized milk, it is stated that there is no detectable difference in quality characteristics between HTST and ESL milk. At least in the European market, it has been approximately two decades since Germany promoted this kind of dairy goods. It seems that consumer preferences have changed in favor of ESL milk, which is produced with new technology, has a longer shelf life than pasteurized milk, and has lower losses in taste and nutrients compared to UHT milk [31]. It was considered that ESL milk fills a few gaps between HTST and UHT kinds of milk, at least from shelf life and milk taste standpoints. Still, most studies on ESL milk were performed on products obtained through thermal processing (the cheaper method). Except for shelf life as a period, the quality properties, nutritional value, stability, sensory, and acceptability of commercial milk preserved by thermal treatment are influenced by a combination of factors such as the quality of the raw milk, processing techniques, and storage conditions; in this regard, several researches focused on heat transfer and effects generated by thermal processing in the dairy industry.

Various studies were performed to evaluate the quality of milk processed through many thermal pasteurization methods, inclusive of the combination of thermal pasteurization with microfiltration for ESL milk, to preserve either sensory properties or milk safety or both or even nutritional features during the milk product shelf life to be easier accepted in the consumption [15, 24, 25, 27, 32 – 34].

For this purpose, our study aimed to determine and compare some physicochemical and sensory quality characteristics of the ESL milk, raw and pasteurized milk samples obtained and collected from different manufacturers and supermarkets in Türkiye.

MATERIALS AND METHODS

Materials

Materials used in our study were commercially available milk, with different thermal treatment norms applied. Aiming to differentiate among commodities about heat treatment applied, Turkish food regulations were used as referential to define and identify the milk samples. Raw milk was defined as mentioned above, according to [5], while pasteurized milk was considered drinking milk "obtained by completely destroying the vegetative forms of pathogenic microorganisms and a large part of other microorganisms by applying pasteurization without harming the natural and biological properties of raw milk, and cooled to a temperature not exceeding 6 ºC in a short time after pasteurization" [35, 36]. According to Turkish legislation, thermal pasteurization consists of either heating at 72 ºC for at least 15 s or 30 min at 63 ºC or another heat treatment carried out under other equivalent conditions for a similar microbial effect.
For this study, the samples were taken from raw, pasteurized, and ESL milk collected from different Turkish manufacturers and supermarkets around Izmir province.
The samples consist of a varying range of milk commodities. Except for the thermal treatment, there are other criteria taken into account, such as milk origin (i.e., cow milk and goat milk), fat content, goods purpose (e.g., drinking, home processing, other uses), organic vs. conventional, and other healthy issues related to allergen potential (i.e., regular milk and lactose-free milk).
The sampling was carried out according to the standard requirements applicable in the milk industry.
Milk samples considered in these experiments are introduced in Table 1.

Table 1. *Milk samples*

Sample	Item
TCS	Full fat raw milk
OPS	Organic pasteurized milk
PPS	Pasteurized sachet milk
YPS	Pasteurized milk for yogurt production at home
GKS	Pasteurized goat milk
PSS	Pasteurized milk in glass bottle
LPS	Pasteurized milk lactose free
EGS	ESL pasteurized milk
ELS	ESL pasteurized light milk
ECS	ESL pasteurized full fat milk

Until the evaluation, the samples were stored for a short time in adequate conditions for each milk type at the Pilot Dairy Plant of the Agricultural Faculty's Department of Dairy Technology, Ege University. All samples were analyzed during their commercial shelf life as specified on labels.

Physicochemical and chemical analyses

The physicochemical and chemical analysis applied to milk samples consists of the following determinations: dry matter, fat content, protein content, *p*H, titratable acidity, and color.
Dry matter (DM) of milk samples was determined gravimetrically; a certain amount of milk samples were dried at 100 ± 2 ºC until they reached a constant weight, and the DM (expressed in %) was calculated based on the differences between the weightings [37].
Fat content was determined by the Gerber method, where 0 - 8 division milk butyrometer and Gerber Centrifuge were used. Protein content was determined by the Kjeldahl method [37].
The *p*H of the milk was determined by a Microprocessor *p*H meter (Hanna Instruments USA 584 Park East Drive, Woonsocket, RI 02895).
The titratable acidity of milk samples was determined by the Soxhelet-Henkel method [37], and results were calculated as % lactic acid (m/v).
Color measurement was performed on the surface of each sample in three different areas with a Minolta CR-400 colorimeter (Minolta, Osaka, Japan) branded device. Measurements were evaluated by looking at L* (whiteness-blackness), a* (redness-greenness), and b* (blueness-yellowness) values. Measurements based on color values (L*, a*, b*) of milk samples were determined according to Dinkci *et al.* (2011) [38].

Biochemical analysis

The lactoperoxidase activities of milk samples were determined with the Peroxtesmo MI (Macherey-Nagel, Germany) test kit.

Sensory evaluation

The assessment was performed by a group of eight trained panelists composed of Dairy Technology Department faculty members (Ege University, Izmir, Türkiye).
Milk samples were sensory evaluated as regards the following characteristics: taste, odor, appearance, and overall acceptability. During scoring, sweetness, milk taste, cooked taste, foreign taste, offs-flavors, and general characteristics of the samples were determined.
Sensory attributes were assessed using a hedonic scale from 1(dislike extremely) to 5 (extremely like).

Statistical analysis

The differences between milk samples' characteristics were statistically analyzed. For this purpose, analysis of variance was applied to the results obtained, and the Duncan test was applied to the parameters determined to be statistically significant (at the pre-set $p < 0.05$ level) between the means using SAS software (version 8; SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION

Physicochemical Properties

Table 2 shows the analyzed physicochemical properties of the milk samples, such as the DM, fat, and protein contents. Statistical analysis revealed significant differences between the milk types.

Table 2. *Physicochemical parameters of the milk samples*

Sample	Item		
	DM [%]	Fat [%]	Protein [%]
TCS	12.43±0.022 ^{C}	3.55±0.071 ^{A}	2.84±0.021 ^{E}
OPS	12.44±0.000 ^{C}	3.40±0.000 ^{C}	3.34±0.035 ^{B}
PPS	12.08±0.037 ^{E}	3.40±0.000 ^{C}	3.34±0.021 ^{B}
YPS	13.11±0.011 ^{A}	3.50±0.000 ^{AB}	4.04±0.007 ^{A}
GKS	12.65±0.065 ^{B}	3.45±0.071 ^{BC}	3.04±0.007 ^{D}
PSS	11.79±0.006 ^{G}	3.00±0.000 ^{D}	2.85±0.021 ^{E}
LPS	10.14±0.037 ^{H}	1.45±0.071 ^{E}	3.15±0.035 ^{C}
EGS	12.02±0.003 ^{F}	3.00±0.000 ^{D}	3.15±0.007 ^{C}
ELS	8.95±0.009 ^{I}	0.10±0.000 ^{F}	3.14±0.007 ^{C}
ECS	12.30±0.023 ^{D}	3.40±0.000 ^{C}	3.06±0.021 ^{D}

$^{A–H}$ Means ± standard deviations for the same item with different superscript uppercase letters are significantly different (at $p < 0.05$)

Generally speaking, chemical results for analyzed samples are accomplished with the regulations for raw and pasteurized milk applied within the Turkish dairy market [35, 36].

Regarding DM, values varied between 8.95 % for ELS sample and 13.11 % for YPS. The DM content of the samples changed according to the milk type. While the lowest DM content was found in ESL pasteurized light milk, the highest was in YPS. Except for the YPS sample, which is meant for the production of homemade yogurt, the DM of goat milk has a higher value than cow milk samples, the results following those reported by Arrichiello *et al.* (2022) [39]. There were no registered notable differences in DM content between raw milk (TCS) and organic pasteurized (OPS). Lower DM values of the ELS and LPS samples of 8.95 ± 0.009 %, respectively 10.14 ± 0.037 % are consistent with the chemical composition of milk, those samples being light milk, respectively, with a lower fat content; also, LPS lacks lactose.

The fat content of the milk samples was generally above 3.00 %, except for the ELS and pasteurized milk lactose-free (LPS) samples.

From a quality standpoint, drinking milk is classified, based on fat content expressed on 10^{-3} kg fat/100 10^{-3} L milk, according to [35] as full-fat milk (at least 3.5 g/100 mL), reduced-fat drinking milk (at least 3 g/100 mL) semi-skimmed fluid milk (at least 1.5 g/100 mL) and skimmed milk (max. 0.15 g/100 mL). Consequently, ELS was the sole sample of skimmed milk; the mean value of the fat content for the LPS sample (=1.45 %) was less than that of semi-skimmed fluid milk, its label highlighting the food claim for lactose-free.

A fat content of 3.00 % was determined for the samples PSS and EGS, while for OPS, PPS, and ECS, the mean value was 3.40 %. The sample of TCS had a higher percentage of fat than the corresponding values of thermally processed milk. No difference in fat content of pasteurized samples between conventional and organic milk was registered for the same milk fat-related category.

Regarding the processing technology of HTST vs. ESL milk, contrary to the results of Lorenzen *et al.* (2011) [33], our results did not indicate a variation in fat content related to thermal treatment. However, as a limit of our study, these commercially available samples could be normalized or fat-corrected after thermal treatment and before packaging.

These results seem to be also consistent with the protein contents to a certain extent, except for the full-fat raw milk sample. The protein content varied between 2.84 % and 4.04 %, the lower value registered for TCS and the highest for the YPS sample. Surprisingly, full-fat mılk had a lower protein content (2.84 ± 0.021 %) than all other samples.

Goat milk (GKS) had a lower protein content than all cow milk samples (PPS, OPS, ECS) for the same fat content regardless of the heat treatment.

But, differences in protein content were registered between pasteurized milk and ESL milk, no matter the fat content; in this respect, for a fat content of 3.40 %, pasteurized milk registered a higher value of 3.34 % protein compared to 3.06 % for ESL milk. In comparison, at a level of 3.00 % fat, pasteurized sample (PSS) had a lower protein content than correspondent ESL milk (EGS). Still, protein content does not offer information about milk proteins' denaturation susceptibility to thermal conditions.

Table 3 depicts the changes in *p*H and titratable acidity expressed as milk samples' lactic acid (%). According to the statistical analysis, there are significant differences between the milk types. While the lowest *p*H was measured for TCS at 6.65 value, the highest value was found for pasteurized milk in glass bottles (PSS) at 6.80 *p*H. The titratable acidity results were consistent with the *p*H values; the lactic acid values varied between 0.135 % for the PSS milk sample and 0.198 % for TCS.

Table 3. *pH and lactic acid (%) values of the milk samples*

Sample	Item	
	***p*H**	**Lactic Acid [%]**
TCS	6.65^{G}	0.198 ± 0.006^{A}
OPS	6.78^{D}	0.158 ± 0.006^{BCD}
PPS	6.80^{B}	0.144 ± 0.000^{D}
YPS	6.73^{F}	0.171 ± 0.013^{B}
GKS	6.74^{E}	0.158 ± 0.000^{BC}
PSS	6.83^{A}	0.135 ± 0.000^{D}
LPS	6.79^{C}	0.140 ± 0.006^{D}
EGS	6.78^{D}	0.153 ± 0.013^{CD}
ELS	6.78^{D}	0.149 ± 0.006^{CD}
ECS	6.80^{B}	0.149 ± 0.006^{CD}

$^{A–G}$ Means ± standard deviations for the same item with different superscript uppercase letters are significantly different (at $p < 0.05$)

*p*H values of thermally processed milk samples were higher than those of raw milk. Goat pasteurized milk had lower *p*H than cow thermal-treated milk, and these differences were

found statistically significant (at $p < 0.05$), the results being in agreement with the findings of Arrichiello *et al.* (2022) [39].
Overall, cow milk pasteurized samples had a higher *p*H than ESL milk samples. In general, titratable acidity results were consistent with *p*H, and significant differences between the milk types were statistical (at $p < 0.05$) found for lactic acid percentage.

Biochemical Properties

The analyzed peroxidase test results showed that the TCS and the ESL milk samples (ESL pasteurized milk (EGS), ESL pasteurized full fat milk (ECS), and ELS) had peroxidase positive results while the others had negative results. Peroxidase test results of the milk samples are shown in Table 4.

Table 4. *Peroxidase test results of the milk samples*

Sample	Peroxidase Test Result
TCS	Positive
OPS	Negative
PPS	Negative
YPS	Negative
GKS	Negative
PSS	Negative
LPS	Negative
EGS	Positive
ELS	Positive
ECS	Positive

Regarding the peroxidase test, it is mandatory to be used in the control of market milk against thermal treatment, and, combined with other indicators, it can give information about milk fraud [27]. As expected, (high-)pasteurized samples had peroxidase-negative results, while the raw and ESL milk samples had peroxidase-positive results.

Color

Milk's color-space parameters (L*, a*, and b*) are presented in Table 5.
Most milk samples had similar L* values to the raw milk samples. EGS, LPS, and ELS samples were respectively darker than the TCS. The raw milk sample tended to be redder for the a* value, while the ELS tended to be more green.
There were also significant differences (at $p < 0.05$) regarding the b* measurements between the samples. The ELS was observed to be more yellow, while the TCS was more blue measured.
The color parameters differed between samples due to heat treatment. Except for the PSS sample, the L* values for all pasteurized milk, regardless of fat content or milk origin, were higher than 86.18 ± 0.969^{AB}, the value for raw milk. Still, most milk pasteurized samples had similar L* values with the TCS, varying within a range of less than 0.91 %. Regarding pasteurized milk, on the contrary, a smaller value of L* was registered for LPS, although it lacks carbohydrates, a condition in which the Maillard reactions could

not occur. All of the ESL milk samples had L* values lower than TCS, which is why all these samples were darker than the raw milk.

Table 5. *Color-space parameters of the milk samples*

Sample	Item		
	L*	a*	b*
TCS	86.18±0.969^{AB}	-1.88±0.071^{E}	11.81±0.552^{A}
OPS	86.96±0.332^{A}	-2.98±0.156^{CD}	6.77±0.410^{B}
PPS	86.89±0.643^{A}	-3.22±0.186^{C}	7.34±0.481^{B}
YPS	86.97±0.276^{A}	-2.77±0.113^{D}	6.69±0.417^{B}
GKS	86.83±0.269^{A}	-2.96±0.042^{CD}	5.49±0.431^{C}
PSS	85.93±0.799^{AB}	-3.13±0.233^{CD}	6.61±0.594^{B}
LPS	83.00±0.325^{C}	-3.57±0.064^{B}	6.79±0.085^{B}
EGS	85.16±0.665^{B}	-2.98±0.186^{CD}	6.97±0.707^{B}
ELS	68.59±0.134^{D}	-5.50±0.035^{A}	-1.05±0.106^{D}
ECS	85.58±0.877^{AB}	-2.91±0.226^{CD}	7.22±0.643^{B}

$^{A–E}$ Means ± standard deviations for the same item with different superscript uppercase letters are significantly different ($p < 0.05$)

As depicted in Table 5, the raw milk sample had a* value of -1.88 ± 0.071, which tended to be more red, while the ELS sample with a* = -5.50 ± 0.035 tended to be more green. Also, pasteurized goat milk seemed to be more red compared to all thermal-treated cow milk samples.

All heat-treated cow milk samples have a* values below -2.91. As regards the b* value, significant differences (at $p < 0.05$) between the milk samples were registered. Except for ELS, which was more blue, the other samples tended to be more yellow measured, while the most yellowed was the TCS.

So, the color-space parameters of a* and b* differed between thermal processed and raw milk. Also, differences were observed between goat and cow milk. An unexpected color was evidenced in the case of the ELS sample.

Sensorial Properties

Scores for taste, odor, appearance, and overall acceptability are shown respectively in Figure 1 (A to D). The results indicated that the production technology had no significant effect (at $p < 0.05$) on the odor and appearance of the samples. The appearance was only affected by the milk fat content. The fat content also affected the samples' taste (at $p < 0.05$). PPS and organic pasteurized milk (OPS) get the highest scores for taste, and ELS the lowest.

Similar scores were found for the overall acceptability scores, probably due to taste and appearance variation. While OPS and PPS had the highest range, ELS had the lowest.

A distinct behavior was registered for the ELS sample for color parameters and sensory analysis, possibly due to a combination of milk composition (fat content) and processing. Figure 1 indicates that the heat treatment had no significant effect (at $p < 0.05$) on the odor of the samples. Significant differences (at $p < 0.05$) between the milk samples were registered for taste, with a higher score for pasteurized milk than ESL samples, which was in agreement with the findings of Lorenzen *et al.* (2011) [33].

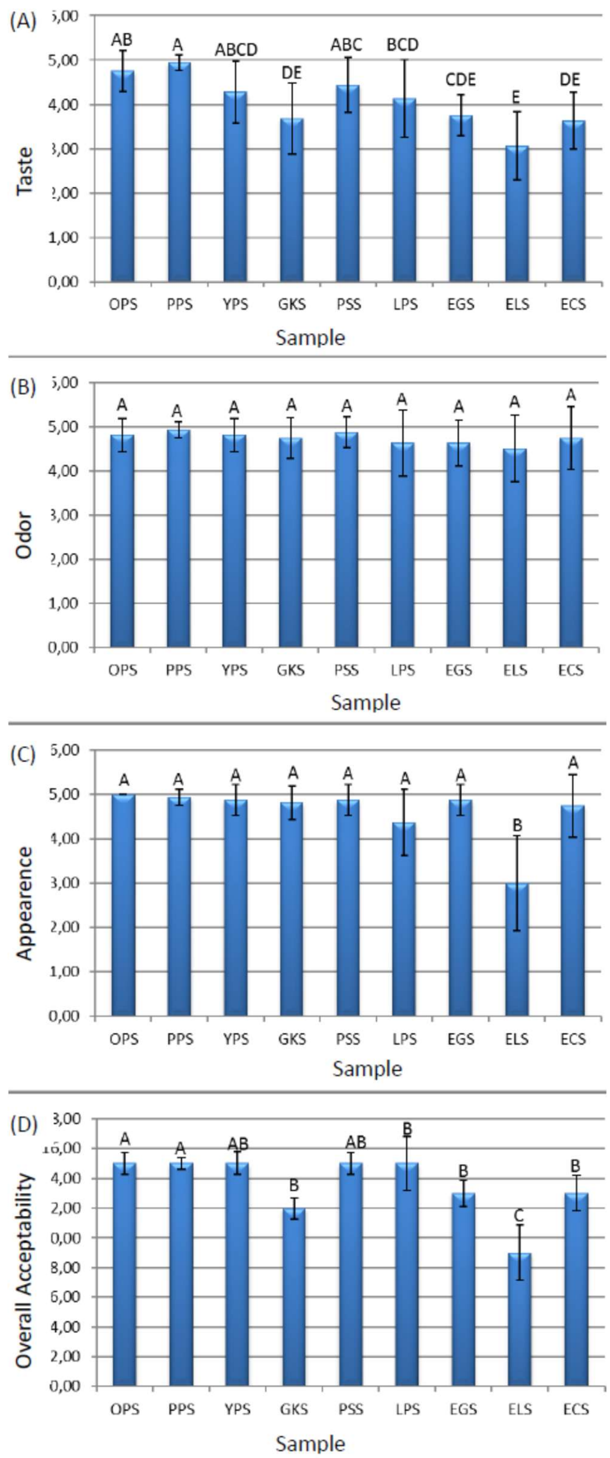

***Figure 1.** Sensory evaluation of the milk samples*

Legend: (A) Taste, (B) Odor, (C) Appearance, and (D) Overall Acceptability.

The samples were scored based on 5-point hedonic scales: 1-dislike extremely; 5-like extremely

Except for the ELS milk and lactose-free (LPA) sample, the appearance evaluation of analyzed milk varied in a narrow range (not significant at $p < 0.05$). Still, it seems that the milk samples' appearance and taste were affected by the milk fat content, which agrees with the conclusions of Li *et al.* (2018), who considered that a higher fat content increases sensory viscosity and decreases astringency [40].
Overall acceptability scores followed a similar variation as those registered for taste and appearance, with more visible differences for ESL milk and pasteurized samples. Also, better results were appreciated by panelists for raw and pasteurized milk than ESL milk.

CONCLUSIONS

The physicochemical characteristics and sensory quality of the milk commodities' were compared between raw, ESL, and pasteurized milk. Several chemical, physical, and sensory tests were carried out, and the obtained data were statistically evaluated.
Besides the differences due to their composition (such as DM, fat, or protein contents) or origin (goat vs. cow milk), the evaluated samples registered variations in some parameters related to their processing peculiarities. *p*H values, which were consistent with titratable acidity results (expressed as lactic acid %), were influenced by heat treatment. The lactoperoxidase results were influenced by thermal processing; raw and ESL milk samples had positive results, while pasteurized milk samples had negative ones.
The overall sensory properties were also affected by milk heat processing. For instance, the color analysis showed that the L values of the ESL milk samples were lower, and the color was darker than that of the pasteurized milk samples. The processing technology did not affect the samples' a* and b* values, odor, or appearance but influenced the taste scores throughout the sensory analysis.
The scores for taste were statistically lower for ESL milk samples. Based on overall acceptability assessed by sensory analysis, ESL milk samples, compared to pasteurized milk, were not the first choice for the panelist's sensory scores.

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