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Hedonic pricing model for ultra-high-temperature milk market in Juiz de Fora – Brazil

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ABSTRACT
The dairy industry stands as one of the most significant sectors within the Brazilian food industry. Ultra-high-temperature (UHT) milk has notably expanded its market presence in terms of fluid milk sales. Moreover, UHT milk is available in various options, including varying fat content, added nutrients, and diverse packaging. This study aims to estimate a hedonic price model for UHT milk in the Juiz de Fora market, Brazil, with a focus on discerning premiums associated with packaging characteristics, the presence of added nutrients, fat content, supermarket chains, and location. Data for the year 2016, collected from all supermarkets in the municipality, were used. The most robust model revealed a price premium over the baseline product, with increments of +0.44 R$/liter (+12.31%) for the screw cap, +2.38 R$/liter (+51.88%) for iron, +0.89 R$/liter (+21.06%) for calcium, +2.10 R$/liter (+46.28%) for the Lactose-free attribute, and +0.27 R$/liter (+7.22%) for semi-skimmed milk. These findings hold significant implications for the dairy industry, guiding product portfolio strategies, market share considerations, and profitability assessments.

KEYWORDS
UHT milk, Milk fat content, Hedonic price model

Modelo de precificação hedônica para o mercado de leite UHT em Juiz de Fora – Brasil

RESUMO
A indústria de laticínios é uma das principais no setor brasileiro de alimentação e o leite UHT tem ganhado importância nas vendas de leite fluido, sendo comercializado com diferentes teores de gordura, adição de vitaminas e minerais e embalagem. Este estudo tem como objetivo estimar um modelo de preços hedônicos para o leite UHT no mercado de Juiz de Fora, Brasil, observando os prêmios associados às características da embalagem, à presença de nutrientes adicionados, ao teor de gordura, às redes de supermercados e à localização. Foram utilizados dados para o ano de 2016, que foram coletados em todos os supermercados do município. O modelo mais robusto revelou um prêmio de preço sobre o produto básico, com acréscimos de +0,44 R$/litro (+12,31%) para a tampa de rosca, +2,38 R$/litro (+51,88%) para o ferro, +0,89 R$/litro (+21,06%) para o cálcio, +2,10 R$/litro (+46,28%) para o atributo sem lactose, e +0,27 R$/litro (+7,22%) para o leite semidesnatado. Essas evidências podem ser de interesse para a indústria de laticínios, orientando estratégias de portfólio de produtos, considerações de participação de mercado e avaliações de rentabilidade.

PALAVRAS-CHAVE
Leite UHT, Teor de gordura do leite, Modelo de preços hedônicos

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1. Introduction

The global ultra-high-temperature (UHT)[1] market was estimated to be 114,2 billion liters in 2019 with an expected compound annual growth rate of 5.1% from 2020 to 2025 (IMARC, 2020). The European Union is the largest UHT milk market, followed by North America and South America. Despite the importance of the UHT market worldwide and the low margin faced by manufacturers, few analyses have been performed to evaluate premium attributes of UHT milk, as part of a product differentiation strategy (Loke et al., 2015; Bimbo et al., 2017; Trestini e Stiletto, 2020). In Brazil, the UHT milk represents about 86% of Brazilian fluid milk consumption (ABLV, 2020). The UHT milk is the second most consumed dairy product in the country. However, it is a market with tight margins requiring strategies in product differentiation and value-adding (Chaves et al., 2022). Bimbo et al. (2017) researched this issue for the Italian market by evaluating enriched UHT milk features and other characteristics. Recently, there has been a growing trend of differentiation in the food industry to meet consumer requirements and preferences (Ueland et al., 2020).

UHT milk is one of the main innovations that generates structural changes in the milk production chain (Azevedo e de Politi, 2008). The roots of UHT milk can be traced back to the 1960s, when the dairy industry responded to increasing consumer demand for milk with an extended shelf life. Before the introduction of UHT processing, milk underwent pasteurization at lower temperatures and for longer durations, resulting in a shorter shelf life and more noticeable alterations in taste and color. The breakthrough in UHT technology occurred with the introduction of the Tetra Pak aseptic packaging system, which facilitated packaging milk in a sterile environment, shielding it from the infiltration of microorganisms. The combination of UHT treatment and aseptic packaging revolutionized the dairy industry, facilitating the expansion of the UHT milk sector and the widespread availability of shelf-stable milk products (UHT Milk FAQ, 2000).

Besides, the expansion of UHT can be attributed to the practicality of storage and increased shelf life (Lorenzen et al., 2011). Moreover, social factors and changes in habits and routines related to professional activities are presented as vectors for reducing the time dedicated to carrying out domestic activities, which, in the search for convenience, contributes to changes in food consumption patterns and increases the preference for this product (Pearson et al., 1990).

The long-life characteristic of UHT milk has also enabled the reduction of transportation costs in the industrial sector, because this milk does not need the same refrigerated distribution as pasteurized milk. Additionally, UHT milk is a viable com-

[1]UHT milk is obtained after treatment of Ultra High Temperature of Pasteurization of milk as raw material in which it is subjected to a temperature between 130ºC and 150ºC for 2 to 4 seconds, and then cooled to a temperature below 32ºC. The purpose of this treatment is to eliminate micro-organisms in order to extend product's shelf-life. Together with sterile packaging, this process allows the closed product to be consumed within 180 days. For this reason, UHT milk is known as long-life milk (Vidal-Martins et al., 2005).

mercial solution in cases where milk preservation is difficult to achieve, such as in poor or tropical regions where refrigeration is unavailable or expensive (Gedam et al., 2007). Actually, this substitution of pasteurized milk with UHT increased the commercialization of fluid milk and the improved domestic performance rendered several companies commercially viable. Therefore, there was a process of commoditization of fluid milk, which led to increased competition and demanded greater attention to the issues of product differentiation and increased quality (Lopez e Lopez, 2009). Furthermore, to the detriment of bakeries and small businesses, UHT milk represented the strengthening of the power of super and hypermarkets in the distribution of dairy products (Farina, 2002).

At the same time, there has been a greater interest in food containing components that influence physiological and metabolic activities or that are enriched with substances and properties; such food is known as functional food (Gama et al., 2015). For dairy products, there is a growing offer of products enriched with vitamins and minerals, products with different levels of fat, flavors, and absence of lactose, among others. Other products associated with UHT milk and packaged similarly, such as whey protein, have become more readily available in stores and supermarkets. This trend can be attributed to shifts in people's lifestyles, with a growing inclination towards sports and physical exercise, including activities like bodybuilding (Deeth, 2010).

In terms of disadvantages of UHT milk compared to pasteurized milk, the high-heat treatment can impart a slightly cooked or burnt taste that some individuals find less appealing in comparison to the fresher taste of pasteurized milk. Additionally, certain heat-sensitive vitamins may experience greater reduction in UHT milk than in pasteurized milk. Moreover, enzymes that can be beneficial for digestion may be deactivated during the UHT process (Kosaric et al., 1981). Poushi e Sharifi (2024) outline various methods employed in milk processing to eliminate bacteria and other pathogens from milk, including the UHT method.

UHT milk has been marketed with numerous differentiating characteristics and attributes, including fat content, absence of lactose, addition of vitamins, minerals, and even the profile of the packaging. Considering that the UHT milk market is quite competitive, at generally low margins, estimating values for the characteristics of UHT milk can improve the positioning of companies operating in this market (Bimbo et al., 2017). Therefore, it is strategic to know the way in which specific attributes can be priced, taking advantage of specific opportunities to generate better profitability.

Specifically, regarding milk fat content, studies have indicated that the fat in ruminant milk, due to the particularities of their digestive system and mammary metabolism, contains bioactive compounds beneficial to human health. Additionally, milk could provide important fatty acids with potentially positive effects on the biomarkers of chronic diseases (Shingfield et al., 2008; Kratz et al., 2013; Astrup, 2014; Mozaffarian, 2014; Yakoob et al., 2014; Gama et al., 2015).

Estimating the monetary value of key features can provide strategic information for dairy companies to improve profitability. Trestini e Stiletto (2020) found a positive premium on prices related to refrigerated and pasteurized fluid milk in the Italian market. The production of local and organic fluid milk has also added value to the product. Smith et al. (2009) found that the premium of the organic attribute of fluid milk for the United States market was the highest among all the analyzed attributes. Loke et al. (2015) found price premiums for both organic and local over imported, conventional, and whole fluid milk in the lmarket. Among the main motivations for the search for organic milk are environmental sustainability and concern for animal welfare (Scozzafava et al., 2020).

The lactose-free market has also expanded. In Europe, sales of lactose-free products are estimated to have grown by around 75% between 2014 and 2016 (Lactose-free, 2012). The lactose-free market is the fastest growing segment in the dairy industry. Europe is the region where the growth of this market has accelerated, followed by Latin America. This variety helps individuals who are lactose intolerant and seek alternative sources of nutrients in relation to traditional dairy products. In addition, the dairy industry has made innovations, producing diverse types of lactose-free products to penetrate the market and attract traditional consumers (Dekker et al., 2019).

The new models of production, market integration, technological developments, and changes in the sector's practices, as well as the expansion and modernization of the retail sector, presuppose that these characteristics have been evaluated in the milk pricing system. The UHT milk product available on the market has incorporated all these elements. Until the year 2024, no studies have aimed to measure the effect of these elements incorporated into UHT milk in the Brazilian market.

Brazil is South America's leading dairy market and the world's third-largest milk producer, behind the United States and India (FAO, 2018). The Brazilian dairy sector has undergone major changes in recent decades, especially after the end of price fixing, which existed until 1991 due to a sectoral regulation policy (Farina et al., 2005). This opened a space for increased competition in the sector, with the arrival of multinationals and investments in primary production, logistics processes, and industrial parks (Farina, 2002). This resulted in several processes being subsequently implemented, such as bulk collection, payment for milk quality, and change in the type of fluid milk predominantly consumed; the refrigerated, pasteurized type was gradually replaced by UHT. According to the Brazilian UHT Milk Association (ABLV), UHT milk represents about 86% of Brazilian fluid milk consumption (about 6.8 billion liters) (ABLV, 2020).

Therefore, Brazil plays important role internationally by considering the overall production and consumption. Globally, lactose-free products market size is valued at USD 13.5 billion in 2023, and the forecast indicates nearly US$23,9 billion by 2033 according to Future Market Insight (FMI, 2023). This market is expected to grow in Brazill as well. However, there is no information about the pricing premium for this

attribute in Brazil. Estimates about the premium of this attribute and others are of interest to the Brazilian dairy industry, which can outline market strategies in terms of expansion and diversification of the product line. Given this context, this study aims to estimate a hedonic price model for UHT milk in the Juiz de Fora market, Brazil, with a focus on discerning premiums associated with several characteristics: packaging (with screw cap, common box, easy-to-open packaging, and plastic bottle); fat content (whole, skimmed and semi-skimmed); addition of vitamins (A, B1, B2, B6, B9, B12, C, D, E and K); addition of minerals (iron, calcium and zinc); lactose-free; geographical location (Central, North, South, East, West, and Northeast regions); and finally, the supermarket chain (Super Mais, Sales, Villefort, Mart Minas, Makro, Atacadão, Carrefour, Bretas, Bahamas or Empório Bahamas). In December 2016, data were collected from all of the chain supermarkets operating in the city of Juiz de Fora. Therefore, this paper uses primary, un-aggregated pricing data collected directly from retail establishments. This is what differentiates this study in relation to the others observed in the literature (Smith et al., 2009; Xiao, 2012; Loke et al., 2015; Bimbo et al., 2017).

The municipality of Juiz de Fora was chosen for two main reasons. The first is that the study was conducted in partnership with Embrapa Gado de Leite, whose headquarters are located in Juiz de Fora, which provided funding for data collection in the municipality. Due to some financial and scope limitations, the research was restricted to the municipality of Juiz de Fora. Data were collected from all supermarket establishments in the municipality. This data collection task represented a significant effort in the research. The second reason is that a study focused solely on Juiz de Fora can provide insights into the UHT milk market and its attributes, as Juiz de Fora is a medium-sized city, with approximately 550,000 inhabitants, located near both the cities of Rio de Janeiro and Belo Horizonte (in addition to having easy access to São Paulo).

The paper contributes to literature in two key aspects. The first pertains to data collection, as it enabled the creation of a database specific to the municipality of Juiz de Fora. Information of the type used in this study is not publicly available, either at the national level in Brazil or for other Brazilian regions. The second contribution relates to obtaining estimates of premiums for UHT milk attributes in a localized Brazilian market. Therefore, the estimates derived from this study provide the first evidence of how companies charge premiums for specific attributes added to UHT milk in Brazil. This type of information can be valuable for companies and consumers as an indication of whether certain trends might gain relevance by incorporating attributes into products. For instance, this study examines attributes such as milk fat content and packaging differentiation.

This paper is organized into four sections, in addition to this introduction. The second section presents the theoretical and empirical foundation of the study. The third section discusses the materials and methods employed in the research, empha-

sizing the description of the model used, the data collection process, and the variables considered. The fourth section focuses on the results of the research, and finally, the fifth section presents the study's main conclusions.

2. Theoretical and empirical background

The discussion about milk pricing is not trivial, being in fact complex, due to the various components that make up such a product, in addition to other issues that can be added such as location and presence of microorganisms (Cook, 1954). Most hedonic price models for milk consider components such as fat, non-fat solids, and water in the analysis, with the first models developed considering those components alone (Ladd e Dunn, 1979; Perrin, 1980; Kirkland e Mittelhammer, 1986). As these components, as well as others that can be added to raw milk, have different compositions in various milk products, each one has an implicit value (Ahmad et al., 2017). The evaluation of the implicit value of these and other existing or added characteristics or attributes to milk can be derived at the retail level (Ladd e Suvannunt, 1976; Xiao, 2012) or at the level of productive establishments (e.g. farms) (Ladd e Martin, 1976).

In Brazil, the milk produced is normally sold through cooperatives to dairy processing industries. The prerogative of the hedonic pricing approach for milk is that if the dairy marketing system is efficient in transmitting price signals for milk from products sold at retail to the agricultural market, then the implicit value of milk components at the productive establishment level will be equal to the value derived from the retail market (Gillmeister et al., 1996).

The hedonic pricing approach developed at the level of productive establishments is based on information on prices paid to producers. Gillmeister et al. (1996) developed a hedonic price model to analyze the value of milk components based on data from 4684 farms in four states in the United States in 1990. Buccola e Iizuka (1997) used data from 1924 farms in four states in the United States on costs associated with feeding the herd.

Based on information from a Census applied in the United States between 1977 and 1978, Lenz et al. (1991) considered in their analysis only three milk characteristics that were available: protein, calcium, and fat content. Ahmad et al. (2017) had a similar objective and used data collected from milk consumption at the level of family units for Pakistan. The results of this study indicated, unlike the studies by Lenz et al. (1991, 1994), that there was no additional payment for milk due to the fat content, but there was an additional payment for milk with a higher content of non-fat solids.

The studies that had the results exposed above were not developed with the objective of determining the values of the milk components in retail. It is noticed that they used data at the level of productive establishment or Census of families, which have a more restricted set of information in terms of characteristics of processed milk that

arrives at retail. Any analysis not considering, for example, the fat content can make the milk pricing system inefficient (Legault et al., 2004; Brandt et al., 2009). Similarly, the failure to consider other important components in a more modern production and marketing scheme such as the current one, can make the pricing system even more ineffective (Ahmad et al., 2017). To overcome these possible inefficiencies, a larger set of components for pricing has been suggested as an alternative system that would pay amounts explicitly for the various components of milk.

Finally, it is noteworthy to highlight recent research that has explored various issues within the milk and dairy market. Kim (2024) investigated the determinants of demand for milk and dairy products, considering variables such as population growth, taxes on alternative beverages, regulations, and governmental policies. The primary findings of this study indicated that government subsidy policies can enhance accessibility to milk, particularly within educational settings. Additionally, dairy products may exhibit greater market potential when positioned as complements to other products such as coffee, with increased competitiveness observed with product diversification.

Studies by Parzonko et al. (2024) and Prehn (2024) focused on investigating issues related to the competitiveness of milk-producing farms. Factors including land prices, labor costs, and input storage strategies for feeding the milk-producing matrix were identified as significant determinants of milk production and, consequently, market price formation. These factors hold considerable importance in various regional dietary contexts.

In a related context, Headey et al. (2024) sought to evaluate the relationship between dairy market development and nutritional concerns in middle- and low-income countries. Dairy products have significant potential to alleviate malnutrition due to their rich nutritional profile. Therefore, promoting the consumption of dairy products, particularly in regions where child malnutrition is prevalent, appears to be a reasonable strategy. The main conclusions of this study suggest that evidence was found indicating that consumer-oriented interventions, such as nutritional education and demand incentives, have the potential to mitigate nutritional issues. However, concurrent industrial and commercial development of the sector is necessary. Public policies could play a crucial role in promoting both consumer and producer interests within the dairy sector, thereby addressing nutritional vulnerabilities within the population.

3. Material and method

Primary data from a field survey regarding the prices and attributes of UHT milk were used. The regions were defined according to data made available on the City Hall website of Juiz de Fora. All wholesale and retail outlets part of supermarket chains were surveyed. Product characteristics, such as types of packaging, added nutrients, fat, and lactose content, were considered according to the availability of sales. It is worth mentioning that the analysis carried out for this municipality has a high relative representativeness, considering the potential of its consumer market. According to IBGE, in 2010, Juiz de Fora had the fourth largest population in the state of Minas Gerais, with around 516,247 people. In 2014, it had the 5th largest GDP in the state and the 61st in Brazil (IBGE, 2017). These characteristics make the city of Juiz de Fora an adequate place for the evaluation of a specific market for UHT milk.

This research focused analysis on UHT milk for the final consumer. Other milk products that have market segmentation were not considered (i.e., milk formula for children and powdered milk). Therefore, the products considered in the analysis have specific characteristics, but they do not offer restrictions to the general consumer.

3.1 Data Collection

Data collection was conducted in December 2016 in 37 supermarkets in the municipality of Juiz de Fora. This supermarket set represents all those that make up the chains in the municipality. Thus, a census was conducted since all supermarkets were surveyed[2]. The supermarket chains represent the relevant UHT milk market. Such a strategy, which concentrates the analysis on UHT milk, avoids distortions, since other commercial establishments (e.g., bakeries) focus on sale of pasteurized milk. As shown in Table 1, the following information on UHT milk was collected: a) prices; b) the types of packaging available; c) supermarket chains; d) the location of establishments by neighborhood; e) vitamins and minerals; and f) the fat content present in the products and lactose-free milk.

Despite being concentrated in only one municipality, Juiz de Fora exhibits several characteristics that make it conducive to conducting the study. This city has one of the largest populations and economies in the state of Minas Gerais. In addition, Juiz de Fora has a wide consumer market, a wide variety of supermarket chains, and access to major wholesale and retail dairy brands. Furthermore, it also houses a national milk research center, the *Embrapa Gado de Leite*, and a technical school specialized in dairy production, the *Instituto de Laticínios Cândido Tostes*.

Price collection was carried out in December to mimic possible distortions and

[2]The research was conducted through a partnership between Embrapa Gado de Leite and the Federal University of Juiz de Fora (UFJF). Data collection was carried out entirely by Embrapa, while data tabulation, econometric estimations, and manuscript preparation were undertaken by members from both institutions.

exogenous price effects, caused both by variations in milk supply (seasonality) and by regional reallocation of the product. In December, the prices are lower than in the middle of the year, due to the seasonality of supply (Carvalho et al., 2017). In December, the main milk producing states (Minas Gerais, Paraná, and Rio Grande do Sul) in Brazil are in the harvest season. In general, during harvest periods, companies are better supplied and do not need to seek milk from other states and regions (Simões et al., 2023). In addition, the fact that December has relatively lower prices avoids the spurious effects of attributes on the price. By analyzing the UHT consumer price across the year 2019, this study determined that in December the price was about 3.4% lower than the annual average. Moreover, the UHT price ranged from -5.2% to 5.4% at the minimum and maximum monthly base prices in comparison with the annual average consumer price (IBGE, 2020).

This study is limited by not considering prices throughout the entire year. However, a factor that mitigates this limitation is that we make no distinction between the different attributes related to UHT milk. Therefore, seasonality would have an even smaller effect on the implicit price of milk attributes, since evaluation is carried out in terms of a characteristic product (Simões et al., 2023). Finally, it is worth noting that all prices were collected during a two-week period.[3]

Table 1 shows the predominance of product packaging with a screw cap (about 81.5% of the total). Such predominance can denote a market trend in which producers and consumers value the existence of such attributes in products, in relative terms. In Brazil, the common packaging represents the type of packaging widely used for UHT milk. This packaging is a multilayer box formed by three materials: paper, plastic, and aluminum (Walter et al., 2010). To open the package, it is necessary to stretch and cut one end of the box. The screw cap packaging is similar to common packaging and is made of the same materials. However, the screw cap package contains a screw cap on the top of the package to facilitate its opening. Usually, screw cap packaging is longer than the common packaging to improve the handling of the product when serving the milk. The screw cap itself is small and is attached to the packaging. The design of the packaging, the materials used to build the packaging and the screw cap itself are quite different from those found in plastic bottle-type packaging. “Plastic bottles” are terephthalate polyethylene bottles. Therefore, each package was analyzed separately.

[3]Data was corrected for December 2019 according to the General Price Index - Internal Availability (IGP-DI) (FGV, 2020).

Table 1. Statistics and description of the variables collected on UHT milk (price in R$/liter)

Variables	N	Aver. Price	S-D	Min. Price	Max. Price	Variable Description
Price	825	3.45	1.05	2.17	8.54	Price of 1 liter of UHT milk
Type of packaging						
Screw cap	672	3.60	1.04	2.27	8.54	Screw cap = 1; others = 0
Common	121	2.61	0.40	2.17	4.55	Common = 1; others = 0
Easy-to-open	22	2.52	0.28	2.27	3.41	Easy-to-open = 1; others = 0
Plastic bottle	10	5.55	0.43	4.32	5.69	Plastic bottle = 1; others = 0
Supermarket chains						
Super Mais	79	4.02	1.77	2.27	7.97	Super Mais =1; others = 0
Sales	20	4.02	1.52	2.27	8.54	Sales = 1; others = 0
Villefort	14	2.73	0.51	2.35	3.86	Villefort = 1; others = 0
Mart Minas	12	3.23	0.77	2.26	4.54	Mart Minas = 1; others = 0
Makro	6	2.74	0.18	2.45	2.91	Makro = 1; others = 0
Atacadão	10	2.67	0.38	2.27	3.64	Atacadão = 1; others = 0
Carrefour	50	3.85	1.15	2.27	7.05	Carrefour = 1; others = 0
Bretas	145	3.54	1.07	2.27	7.51	Bretas = 1; others = 0
Bahamas	380	3.28	0.82	2.17	5.69	Bahamas = 1; others = 0
Empório Bahamas	109	3.47	0.75	2.61	5.69	Empório Bahamas = 1; others = 0
City region						
Central	320	3.41	0.85	2.17	7.51	Central = 1; others = 0
North	156	3.16	1.08	2.17	7.97	North = 1; others = 0
South	167	3.48	1.03	2.27	7.51	South = 1; others = 0
East	57	3.82	1.33	2.17	7.97	East = 1; others = 0
West	65	3.81	1.35	2.27	7.97	West = 1; others = 0
Northeast	60	3.59	1.15	2.27	8.54	Northeast = 1; others = 0
Added nutrients						
Folic acid	27	4.38	0.45	3.98	5.69	Folic acid = 1; others = 0
Vitamin K	28	5.08	1.29	3.98	7.97	Vitamin K = 1; others = 0
Vitamin A	180	3.89	1.09	2.35	7.97	Vitamin A = 1; others = 0
Vitamin B1	27	4.38	0.45	3.98	5.69	Vitamin B1 = 1; others = 0
Vitamin B2	16	4.32	0.57	3.98	5.69	Vitamin B2 = 1; others = 0
Vitamin B6	16	4.32	0.57	3.98	5.69	Vitamin B6 = 1; others = 0
Vitamin B12	16	4.32	0.57	3.98	5.69	Vitamin B12 = 1; others = 0
Vitamin C	180	4.20	1.19	2.35	7.97	Vitamin C = 1; others = 0
Vitamin E	30	4.38	0.43	3.98	5.69	Vitamin E = 1; others = 0
Vitamin D	228	4.09	1.14	2.35	7.97	Vitamin D = 1; others = 0
Iron	102	4.58	0.93	3.29	7.97	Iron = 1; others = 0
Zinc	68	4.69	1.10	3.29	7.97	Zinc = 1; others = 0
Calcium	107	4.23	1.16	2.45	8.54	Calcium = 1; others = 0
Fat and Lactose content						
Lactose-free	158	4.53	0.95	2.61	8.54	Lactose-free = 1; others = 0
Whole	367	3.37	1.02	2.17	7.97	Whole = 1; others = 0
Skimmed	269	3.37	1.11	2.17	8.54	Skimmed = 1; others = 0
Semi-skimmed	189	3.73	1.00	2.17	7.97	Semi-skimmed = 1; others = 0

Source: Own elaboration based on research data.
Abbreviations: N: number of observations. S-D: Standard deviation.

Most products were surveyed in the Bahamas chain (46.1 of the total), which in fact has the largest number of establishments in the municipality. In addition, the number of observations from each chain may reflect the ability to offer diversified products. The region with the highest number of surveys was the central one (38.8% of the total), since it has the highest concentration of establishments. It should be highlighted that the North region has a greater share of establishments with sales focused on wholesale (Atacadão, Makro, Villefort, and Mart Minas).

This study found a relatively low concentration of nutrient-added milk. The highest frequency was observed for vitamin D, which represented about 22% of the products

surveyed. About 37.3% of the products considered were whole milk. Also, 16.1% of the products were lactose-free. It is worth noting that there were over 825 observations of added nutrients, as well as full fat and lactose content, since milk may have more than one type of nutrient added. Likewise, whole milk can also be lactose-free (Table 1).

3.2 Model Specification

The conceptual model used in this study is based on the economic theory pertaining to the analysis of hedonic prices regarding the consumption decisions of a representative agent. In other words, consumer theory represents the main conceptual pillar. More specifically, the analysis of demand behavior is based on the hedonic assessment of product characteristics. The main notion underlying the model is that the consumer agent aims to maximize the utility derived from consumption, which is a function of the characteristics of the products consumed subject to spending limits set by disposable income (Lenz et al., 1991). Thus, food can be seen as a package of characteristics, each of which determines price differentials. For example, the level of satisfaction provided by the consumption of whole milk can be seen as the aggregate level of satisfaction obtained by its taste, texture, protein, calcium, vitamins, and fat content. Two types of whole milk that have identical characteristics, except for protein level, can provide a different level of satisfaction to the consumer. As a result, consumers attribute value to milk protein components.

As in the present study, Lenz et al. (1991, 1994) presented a formulation based on consumer theory, which is the most consistent formulation in terms of behavior that can describe the decision of final milk consumption by the representative agent. The most recent studies that assessed premiums paid to individual milk components (e.g., Smith et al. (2009); Xiao (2012); Loke et al. (2015); Bimbo et al. (2017)) have not developed theoretical models to support the applied analysis. Apart from studies by Lenz et al. (1991, 1994), there is mainly a formalization based on firm-specific theories about the behavior of the optimizing agents (Kirkland e Mittelhammer, 1986; Gillmeister et al., 1996; Buccola e Iizuka, 1997). In addition, similar formalizations have been established to use the hedonic price model to analyze the market for intermediate inputs to milk production (Rudstrom, 2004) or milk used as an input to produce other dairy products, such as cheese and yogurt (Hillers et al., 1980).

The studies of Lancaster (1966) and Rosen (1974) provide all the requisite background for comprehending the mathematical derivation of the hedonic model approach. Additionally, studies by Lenz et al. (1991, 1994); Rudstrom (2004), and Ballco e de Magistris (2018) have also employed this approach. Drawing upon the succinct presentation by Carvalho et al. (2022), let us consider a set of characteristics in the hedonic price function represented by a vector X of attributes:

$$X = (X_1, X_2, ..., X_n) \tag{1}$$

There is a utility function of a representative agent considering the characteristics of the product:

$$U = U(x_1, x_2, ..., x_n, \alpha) \tag{2}$$

where x_j is the attribute j of the consumed product and α is a fixed parameter for consumer preferences.

In the maximization problem, the consumer wants to maximize utility subject to a budget constraint. As a result, it is possible to specify product prices as a function of attributes based on the equilibrium between supply and demand (Rosen, 1974):

$$p_i = G(X_j) \tag{3}$$

where $G(.)$ is a function of hedonic prices specified in general terms of the attributes associated with product i. Therefore, this price represents the consumer's willingness to pay for the attribute j. This price is equal to the producer's marginal cost of offering this attribute j.

Following Lenz et al. (1991), if a product has n characteristics, the amount paid by the consumer for the product can be represented as follows:

$$p = \sum_{j=1}^{n} A_j D_j \tag{4}$$

where A_j is the implicit value assigned by the consumer to a unit of characteristic j, and D_j is the number of units of characteristic j.

Therefore, equation (7) provides a conceptual framework for the development of an empirical representation of the decomposition of product price, facilitating statistical estimation. In this study, the vector X of product attributes comprises five sub-vectors. Following the nomenclature employed by Bimbo et al. (2016), analogous sub-vectors are delineated: X^E, X^S, X^R, X^N and X^G. The sub-vector XE encompasses packaging characteristics, either present or absent. The underlying hypothesis regarding the presence of these characteristics posits that packaging features such as a screw cap and plastic exert a positive effect on milk prices.

The second sub-vector, X^S, signifies the supermarket chain. Regarding this attribute, two effects are expected. Firstly, chains with higher consumer frequency might indicate a broader assortment of milk types and brands. In this scenario, the effect on prices would be positive, as the supermarket would need to allocate smaller quantities of each type to accommodate the greater variety. Conversely, the presence of chains with lower observation frequencies could suggest a focus on fewer product

types or a smaller selection of brands. Consequently, they may offer a greater quantity of a few types, potentially resulting in lower prices due to the trade-off in diversification, considering the finite physical shelf space available. Such behavior is commonly associated with wholesale chains, which often stock more essential products and competitive brands. The second effect pertains to competitiveness. Chains with higher observation frequencies might indicate greater competitiveness and, consequently, a broader capacity to offer a diverse array of types and brands. In this scenario, the effect of these chains with greater diversification would be negative on prices.

The third sub-vector, X^R, denotes the region within the municipality where the price data were collected. It is anticipated that this variable exerts a negative effect on prices in regions with higher observation frequencies. This anticipation stems from the notion that regions with greater observation frequency tend to offer a wider variety of products. Consequently, the competitive dynamics among these product types may contribute to lower prices. The fourth sub-vector, X^N, indicates the presence or absence of added nutrients in milk. The inclusion of nutrients such as calcium and iron is expected to positively influence prices. The fifth sub-vector, X^G, encompasses attributes related to fat content and the lactose-free status of the milk. It is hypothesized that lower fat content and lactose-free characteristics lead to increased milk prices.

Following the concept presented in equation (4) and the terminologies adopted for the milk characteristics, we derived the model to be estimated (equation 5). The theoretical framework does not suggest a specific functional form for equation (3) concerning the relationship between the product's price and its attributes. Given this ambiguity, the literature suggests considering linear and semi-logarithmic functions, as well as the Box–Cox transformation (Costanigro e McCluskey, 2011). As an initial step, the literature advises conducting the Box–Cox test to determine the most suitable functional form. However, the Box–Cox test conducted in this study did not provide a conclusive indication of the most appropriate functional form with more robust results. Consequently, we followed the recommendation to adopt the semi-logarithmic specification of the hedonic price equation (Rudstrom, 2004; Costanigro e McCluskey, 2011; Loke et al., 2015; Bimbo et al., 2017; Carvalho et al., 2022):

$$ln(p_i) = \beta_0 + \sum_{e=1}^{E} \beta_e X_e^E + \sum_{s=1}^{S} \beta_s X_s^S + \sum_{r=1}^{R} \beta_r X_r^R + \sum_{n=1}^{N} \beta_n X_n^N + \sum_{g=1}^{G} \beta_g X_g^G + \varepsilon_i \qquad (5)$$

where β_s are the coefficients to be estimated and represent the implicit values associated with the different attributes of milk, and ε_i is the error term. The packaging attribute sub-vector, X^E, is indexed by e, where $e = 1, ..., E$. The indexing of the other sub-vectors follows the same pattern.

As per Rudstrom (2004), the marginal value of each attribute corresponds to the implicit price of that attribute and signifies a change in the price given a marginal

alteration in the characteristic. The marginal value of this characteristic is derived from the partial derivative of equation (5) concerning that characteristic, considering that price is a continuous variable:

$$\frac{\partial ln(p)}{\partial x_i} = \left(\frac{\partial p}{\partial x_i}\right)\left(\frac{1}{p}\right) = \beta_i \tag{6}$$

Equation (6) outlines the calculation of the implicit marginal price. An alternative method to present the marginal effect of each attribute is in percentage terms of the price. To achieve this, it is necessary to apply the correction proposed by Kennedy (1981), as the explanatory variables in the estimations are dummy variables. The correction for the semi-logarithmic form is as follows:

$$\hat{p} = 100 \times \left\{\left[exp(\hat{c} - \frac{1}{2}V(\hat{c}))\right] - 1\right\} \tag{7}$$

where $\hat{p}$ is the marginal price of the attribute, $\hat{c}$ is the estimated coefficient, and $V(\hat{c})$ is the variance of $\hat{c}$.

The most recent literature on hedonic price models for milk and dairy markets has used this procedure and additionally presents this result (Costanigro e McCluskey, 2011; Loke et al., 2015; Bimbo et al., 2017; Ballco e de Magistris, 2018; Carvalho et al., 2022). In addition, the reporting of a premium or a relative discount facilitates the comparison of the results with other studies developed for different economies and analytical contexts, since this procedure controls the reference period, currency, and general price level.

At least one variable belonging to each sub-vector (binary) had to be removed from the model to avoid the presence of perfect multicollinearity. Thus, for each attribute sub-vector, an attribute was chosen to be considered the base variable. As Ladd e Suvannunt (1976) proposed, a product can be described according to its inherent characteristics or attributes, thus requiring a basic unit of analysis. Therefore, the attributes were omitted to form what would be the "characteristic product" (base variable). Such a product was defined as Common, Bretas, Central and Whole milk, without added vitamins and with lactose. Alternatively, the estimation could consider the complete vector of characteristics, excluding the constant.

The first estimation of equation (5) was by OLS, considering all the attributes described in Table 1, except those that form the "characteristic product." Initially, the presence of multicollinearity was detected, which was verified by means of the variance inflation factor (VIF) measure[4]. In this step, the attributes vitamin B1 and vitamin B12 were removed, because they presented a VIF above 10[5]. Then, a stepwise

[4]Such measure verifies the correlation between one variable and the other variables of the model, measuring how much the variance of the estimated coefficients is increasing due to the collinearity.

[5]The high standard errors were not compensated by the variability of the variables as a possible

procedure was adopted to select the variables within each attribute sub-vector. This procedure was based on the Schwarz Bayesian criterion (BIC) values for each estimation. It is worth noting that this strategy does not create the possibility of bias caused by an omitted variable, since nutrient variables were added and disaggregated. In the literature, a similar procedure was adopted by Bimbo et al. (2017) in an aggregated form.

Thus, the estimation of equation (2) considered the following attributes selected within each sub-vector: $X^E = (Screw\ cap,\ Easy - to - open,\ Plastic\ bottle)$, $X^S = (Super\ Mais,\ Atacado,\ Bahamas,$
$Emprio\ Bahamas)$, $X^R = (North,\ East,\ West)$, $X^N = (Vitamin\ K,\ Iron,\ Calcium)$, and $X^G = (Lactose - free,\ Skimmed,\ Semi - skimmed)$.

According to the result shown in Table 2, the Breusch-Pagan/Cook-Weisberg test rejected the hypothesis of homoscedasticity. Therefore, White's robust correction model was used. The estimation was made by OLS, and the reported tests were performed based on robust standard errors (Model 1). In addition, two other estimates (Models 2 and 3) were conducted, considering different treatments for the variables (weighting). The Model 2 estimation aimed to capture the distortion resulting from the influence of supermarket chains. As some chains sell more than others, there is a difference in the frequency of each chain. The possible effects of chains can occur via diversification or competition regarding the different types of products offered. The idea is to check whether any of these effects affect milk pricing for each attribute.

One effect would be that chains with a higher frequency could signal that they offer greater diversification of types of milk and brands. In this case, the effect would be positive on prices, since the supermarket would have to offer a smaller quantity of each type to accommodate more types. On the other hand, the existence of chains with less frequency of observations may indicate that they bet on fewer types of products or on a smaller number of brands. Thus, they offer a greater quantity of a few types of products. Therefore, the sacrifice of diversification, given the physical limitation of space on the shelves, would be to offer lower prices. Such behavior is expected from wholesale chains that, in many cases, have more basic products and more competitive brands. According to Wan et al. (2017), wholesale tends to have a reducing effect on prices, since the sensitivity of buyers to prices is greater. The other effect would be related to competitiveness. The presence of chains that present a higher frequency of observations could indicate that they are more competitive and, therefore, have a greater capacity to offer a wider range of types and brands. In this case, the effect of these chains with greater diversification would be negative on prices.

Therefore, the estimation of Model 2 was performed using weighted least squares, that is, ordinary least squares, in which the frequency of each supermarket chain was

solution to the problem (Wooldridge, 2002). This was due to the addition of some vitamins or nutrients to milk being made together, that is, the milk types with the addition of vitamin B1 were also those that had the addition of vitamin B12.

used as a weighting factor in the estimation. Technically, the square root of the chain frequency was used as a weight, as done by Loke et al. (2015) and Bimbo et al. (2017). This strategy was used to control the influence of different supermarket chains. The Bahamas is the main supermarket chain in Juiz de Fora. Of all products surveyed, 46% were from Bahamas. Despite this, data collection was carried out in all supermarket chains in the city, totaling 10 different chains (Table 1). Among these establishments, some have their sales directed to wholesale, which tends to increase the competitiveness between supermarket chains. However, we highlight that the effect of these chains was controlled in the estimation of Model 2.

On the other hand, Model 3 estimation by weighted least squares aimed to capture the distortion of different brands. Analogous to the treatment for the chains, the square root of the brand frequency was used as a weight. The proposal checks whether the frequency of sales of the brands influences the effect of the attributes and on the price. The database has great heterogeneity among the different brands offered; information was collected for 22 different brands of UHT milk. Brands that appear more frequently may indicate that they are more in demand, which can contribute negatively or positively to prices. These brands may also have greater market power, which can also have either a negative or a positive effect on prices.

It is worth mentioning that the data collection is about the qualitative information of the product (UHT milk), so there is no way to directly relate the product's attributes to consumers' loyalty to specific brands. However, a proxy that can capture this, in part, is the frequency with which the product is offered. This information is used in the estimation of Model 3, which aims to control the effect of the brands.

4. Results and discussion

Table 2 presents the results of the estimates of equation (2) of hedonic prices for UHT milk by OLS for Models 1, 2, and 3. The models have a high degree of adjustment to the data, which can be observed by the determination coefficients (R^2). The F test indicates that the coefficients are jointly statistically significant and different from zero. Most of the variables had significant coefficients at 1%; and the signs of the coefficients and the level of significance also remained robust in most cases when comparing the different estimates. It is worth remembering that the UHT milk taken as a reference base is the one with common packaging. In addition, it was whole milk, with lactose, no added vitamins and minerals, and offered in Bretas in the Central region; it was sold at an average price of R$ 2.47 per liter. As done by Rudstrom (2004), calculation of the implicit price/marginal value of the characteristics was made based on the average price of milk in each characteristic.

The results indicate that screw cap packaging has a positive and significant effect on the price of UHT milk. A premium to this attribute of +0.49 R$/liter (+13.54%) was estimated, ceteris paribus. Controlling for supermarket chains, the estimated

premium for this attribute is +0.44 R$/liter (12.31%). Controlling for brands, the estimated premium is equal to +0.46 R$/liter (+12.74%). Xiao (2012) found a +0.18 $/liter premium for the screw cap in his research on retail milk in Canada. As indicated by Suwannaporn (2015), people tend to prefer this type of packaging as a way of opening beverage products, and the prices of these tend to be higher. Regarding the plastic bottle, the effect on price was also positive and significant as well as much higher +6.84 R$/liter (+123.27%). Controlling for supermarket chains, the estimated premium for this attribute is +6.64 R$/liter (119.70%). Controlling for brands, the estimated premium is equal to +7.02 R$/liter (+126.43%). Xiao (2012) found a premium of +0.41 $/liter for this attribute in his research for Canada. It turns out that there were only two brands that sold UHT milk with this attribute in this study. By controlling for chains, this attribute effect reduces. Yet, when controlled by brand, the effect is greater. When controlling for chains, the easy-to-open packaging had significant and negative effects compared with the baseline product (-0.14 R$/liter or -5.37%). For many years, this type of packaging has been one of the main alternatives to common packaging in Brazil. However, this type of packaging is less used today. Screw cap packaging is increasingly replacing these easy-to-open packaging.

Regarding supermarkets, there is a negative and significant effect on the prices of -0.16 R$/liter (-5.95%), -0.25 R$/liter (-7.53%) and -0.20 R$/liter (-5.67%) for Atacadão, Bahamas and Empório Bahamas, respectively, compared with the baseline product. Although Empório Bahamas sells more specialized products than the Bahamas, the offer of UHT milk there does not tend to change much from the original version of the establishment. In any case, the effect of the Bahamas was greater than that of the Empório Bahamas, considering the treatment for the chains and the brands, which was the expected result. The Atacadão effect was also expected since it contributed negatively to the price. According to Wan et al. (2017), wholesale tends to have a price-reducing effect, as buyers exhibit greater price sensitivity. However, when the brands are taken into consideration, this effect is reduced, since Atacadão offers relatively less product diversity due to its sales focused on wholesale. Therefore, there is a negative effect on price, both due to competitiveness, observed by the Bahamas coefficients, since this is a chain that offers a greater variety of products, and through the effect of wholesale specialization, given by the strategy of focusing on offer in few types, but in large quantities.

The regional effects indicate the North had a negative and significant influence on the price compared with the standard product. This region accommodates virtually all wholesale supermarkets in the city. When there is treatment for the chains, the relative effect is more intensive, that is, the premium was equal to -0.22 R$/liter (-7.07%) for Model 2 and -0.20 R$/liter (-6.29%) for Model 1. The East region, on the other hand, had a positive and significant effect on the price (+ 0.30 R$/liter or +7.89% for Model 1). Again, the Model 2 estimate showed a higher premium over the price (+0.56 R$/liter or +14.57%). This region has fewer supermarket units when compared with the Central region, which is the baseline. The West region was not significant

in the estimation of Model 1, indicating, in this case, that it did not have statistically different prices from the Central region. In general, Model 3 presented estimates of coefficients with more intensive relative effects than the estimation of Model 1 and less intensive ones than the estimation of Model 2. Such a result was expected as the regional profile is more defined by chains and, consequently, it tends to indicate the degree of product diversification and availability in terms of brands offered.

Regarding the addition of vitamins and minerals, in the estimation of Model 1 compared with the reference product, the coefficients were positive and significant with premium prices of +1.67 R$/liter (+32.93%) for vitamin K, +1.85 R$/liter (+40.46%) for iron and +0.62 R$/liter (+14.62%) for calcium. Gulseven e Wohlgenant (2017) also found positive effects on the price of milk by adding vitamins and minerals. The results of Bimbo et al. (2017) indicated a premium equal to +0.269 €/liter (+21.05%) for calcium in his analysis carried out for UHT milk sold at retail in Italy. The effects of the treatment for the chains were more intensive [+2.16 R$/liter (+42.55%), +2.38 R$/liter (+51.88%) and +0.89 R$/liter (+21.06%), respectively]. Model 3 estimates indicate greater effects on premiums for iron (+1.91 R$/liter or +41.78%) and calcium (+0.76 R$/liter or +17.96%) compared to the relative effects of the Model 1 estimate.

The lactose-free attribute had significant and positive coefficients in all estimates and premiums on milk price equal to +1.83 R$/liter (+40.40%) for Model 1, +2.10 R$/liter (+46.28%) for Model 2, and +1.88 R$/liter (+41.47%) for Model 3, ceteris paribus. Bimbo et al. (2017) found a premium of +0.244 €/liter (+19.07%) for this attribute. This result indicates the current trend of greater adaptation of products to the market previously restrictive to the population with lactose intolerance. At the same time, the number of lactose-intolerant individuals willing to pay premiums for the option of lactose-free milk appears to be growing. In addition, there has been growing demand for products that make up diets aimed at esthetic and athletic improvement. General consumers, not just lactose intolerants, are increasingly more likely to pay extra premiums for these products, including lactose-free milk (Zingone et al., 2017).

Table 2. Estimated parameters and implicit attribute prices for UHT milk

	Model 1 – Ordinary Least Squares 1				Model 2 – Weighted Least Squares (chains)				Model 3 – Weighted Least Squares (brands)			
Variable	Coefficients (β)	Robust standard error	Implicit price (R$/liter)[1]	Relative Effect (%)	Coefficients (β)	Robust standard error	Implicit price (R$/liter)[1]	Relative Effect (%)	Coefficients (β)	Robust standard error	Implicit price (R$/liter)[1]	Relative Effect (%)
Screw Cap	0.127***	0.014	0.49	13.54	0.116***	0.008	0.44	12.31	0.120***	0.004	0.46	12.74
Easy-to-open	-0.023	0.027	-0.06	-2.36	-0.055***	0.013	-0.14	-5.37	-0.010	0.008	-0.02	-0.95
Plastic bottle	0.804***	0.039	6.84	123.27	0.788***	0.034	6.64	119.70	0.817***	0.007	7.02	126.43
Super Mais	0.093***	0.029	0.39	9.67	0.071***	0.011	0.29	7.32	0.044***	0.009	0.18	4.47
Atacadão	-0.061**	0.030	-0.16	-5.95	-0.039***	0.014	-0.10	-3.79	-0.013	0.010	-0.03	-1.27
Bahamas	-0.078***	0.013	-0.25	-7.53	-0.088***	0.007	-0.28	-8.41	-0.068***	0.005	-0.21	-6.55
Empório Bahamas	-0.058***	0.016	-0.20	-5.67	-0.074***	0.014	-0.25	-7.10	-0.037***	0.006	-0.13	-3.66
North	-0.065***	0.014	-0.20	-6.29	-0.073***	0.008	-0.22	-7.07	-0.067***	0.005	-0.21	-6.53
East	0.076***	0.026	0.30	7.89	0.136***	0.014	0.56	14.57	0.114***	0.009	0.46	12.05
West	0.025	0.023	0.10	2.50	0.026**	0.013	0.10	2.60	0.001	0.008	0.00	0.03
Vitamin K	0.286***	0.042	1.67	32.93	0.355***	0.029	2.16	42.55	0.255***	0.024	1.48	29.05
Iron	0.340***	0.016	1.85	40.46	0.418***	0.010	2.38	51.88	0.349***	0.009	1.91	41.78
Calcium	0.137***	0.021	0.62	14.62	0.191***	0.015	0.89	21.06	0.165***	0.014	0.76	17.96
Lactose-free	0.339***	0.014	1.83	40.40	0.380***	0.009	2.10	46.28	0.347***	0.010	1.88	41.47
Skimmed	-0.007	0.012	-0.03	-0.74	-0.005	0.007	-0.02	-0.49	0.003	0.004	0.01	0.29
Semi-skimmed	0.065***	0.014	0.25	6.72	0.070***	0.008	0.27	7.22	0.053***	0.006	0.20	5.44
Constant	0.979***	0.017			0.968***	0.009			0.975***	0.005		
N	825											
R^2	0.725				0.744				0.736			
F statistic (16, 808)	142.58***				490.55***				1258.73***			
Breusch-Pagan/Cook-Weisberg test for heteroscedasticity: χ^2 = 10.84***												

Source: Own elaboration.

Dependent variable = lnPrice

Significance level: *** p < 0.01%, ** p < 0.05%, * p < 0.10%.

Note: 1) Implicit prices were calculated based on the average milk price for each characteristic.

The semi-skimmed attribute also showed positive and significant coefficients in all estimates but, when compared with the baseline UHT milk, the price premium was much lower than the lactose-free option. The relative effect was equal to +0.25 R$/liter (+6.72%) in the estimation of Model 1 and equal to +0.27 R$/liter (+7.22%) and +0.20 R$/liter (+5.44%) in the estimates of Models 2 and 3, respectively. This result was also expected, since there is the possibility of charging a premium for the option with lower fat content compared to the baseline of whole milk. No significant marginal effect was found for the skimmed attribute. This indicates that the producer and consumer markets have considered skim milk as a substitute for whole milk. To confirm this hypothesis, estimates were carried out again by controlling for skimmed milk instead of whole milk. The estimates had almost identical values, including for the whole attribute coefficient. The results for the semi-skimmed and skimmed attributes are new in the literature, which has shown negative effects on prices, as shown in the study for the Italian milk market (-0.131 €/liter or -10.25% for semi-skimmed milk and -0.155 €/liter or -12.14% for skim) and Hawaii (-3% for skimmed) (Bimbo et al., 2017; Loke et al., 2015).

5. Conclusions

The dairy sector represents an important part of Brazilian agribusiness, and the dairy industry stands out as primary within the food industry segment. UHT milk is the main fluid milk consumed, and the existence of different types offered on the market indicates that consumers have specific preferences according to the intrinsic utility involved in their willingness to pay for each attribute. The analysis carried out in this paper indicates a great synergy between supply and demand for UHT milk, given the movements of consumer preferences and production adjustments.

The hedonic pricing approach was employed to assess the premium for each attribute of UHT milk. This approach holds the advantage of capturing consumer willingness to pay for product attributes and yielding reliable estimates when data are sourced from comprehensive surveys. However, its primary disadvantage lies in its reliance on data that is challenging to obtain. Publicly accessible data, for instance, are more difficult to utilize with the hedonic pricing method. Moreover, estimates from hedonic pricing models may be biased due to missing variables (Chin e Chau, 2003). Another limitation of the methodological approach used in this paper is the absence of control for variables such as consumer income, gender, and age. Consequently, this study exclusively focuses on the product attributes associated with its availability. The estimation of willingness to pay (implicit effect on prices for each characteristic) assumes a homogeneous consumer base in terms of income, age, gender, and educational attainment.

The main results found indicated a positive and significant premium for the screw cap variable in the three estimates made (+13.54% in the uncontrolled model, +12.31% in the model controlling for supermarket chains, and +12.74% in the model control-

ling for brands). Concerning packaging, the plastic bottle emerged as another significant variable. This packaging type was only observed in one variant of UHT milk, distinguished by its unique characteristics. Consequently, the observed effect was anticipated. Additionally, significant impacts of different supermarket chains were identified. Chains with a wholesale sales orientation exhibited negative estimated marginal effects, whereas those with a retail sales focus demonstrated positive estimated effects. Notably, a specific chain, Bahamas, exhibited a negative impact on pricing, possibly attributable to its market strategy of offering multiple brands of the same product type. Some of these brands are locally produced, which contributes to price reduction in comparison to more conventional brands.

Another attribute examined was the product's point-of-sale location. Regions with a higher concentration of supermarkets emphasizing wholesale sales exhibited a negative estimate, whereas regions catering more to retail customers displayed a positive estimate. The estimates pertaining to the addition of vitamins were also significant and positive. Indeed, the populace often seeks enriched foods to supplement their diet, and the evidence presented in this manuscript underscores a positive consumer willingness to pay for these attributes.

It is also noteworthy to underscore the compelling evidence of a significant and positive premium associated with Semi-skimmed, particularly in comparison with the reference UHT milk version, but notably for the Lactose-free option as well (+40.40% in the uncontrolled model, +46.28% in the model controlling for supermarket chains, and +41.47% in the model controlling for brands). Conversely, it was observed that Skimmed had no significant effect. This finding regarding semi-skimmed milk is novel in the literature, although the rationale behind the result is intuitive. Shifting consumer preferences concerning dairy products suggest that the Skimmed option aligns closely with whole milk in terms of marginal adjustments in demand and supply. Conversely, the partial removal of fat content yields a premium for the intermediate option (Semi-skimmed), owing to the demand and supply dynamics associated with this attribute.

Therefore, the dairy industry must focus on technology innovation to add value to dairy products and improve profitability. The UHT market is competitive, and product differentiation can benefit leading companies by improving both market share and turnover. As a consequence of low barriers to entry, innovations will be copied by competitors. The premium for new technology should decrease over time as new companies enter the market and increase supply. The Brazilian market is a large population, and segmentation should be considered as a strategy. Nowadays, there are market niches for everything, and industry needs to focus on trends such as lactose-free milk, A2 milk, functional fluid milk, fortified milk with vitamins, minerals, and probiotics.

Some of the results found, such as the high premium for lactose-free attributes, can encourage the industry to invest in technologies to adapt the product to seg-

mented markets. Indeed, as observed for lactose-free milk, there is a trend in niche attributes reaching general consumers. The question of the product's practicality is also increasingly preferred, as reflected in friendlier packaging. Therefore, the results of this study can help the UHT milk sector to formulate a product portfolio with different characteristics that meet consumer preferences. In addition, companies in the sector can adopt segmentation strategies to search for greater market share.

Therefore, innovation should be a recurring practice in the dairy industry. Leading companies can reap greater benefits by getting ahead. As for dairy farmers, they should invest in milk quality in order to guarantee a better dairy product with high shelf life and low food preservatives. Moreover, trends in animal welfare, traceability, and local production have been increasingly demanded by consumers. This paper does not address such factors. However, as a future research agenda, it aims to estimate their premiums in milk prices. Nevertheless, they need to be considered by dairy farmers.

References

ABLV (2020). Associação brasileira da indústria de lácteos longa vida. annual report, 2019. Available at: https://ablv.org.br/wp-content/uploads/2020/05/ABLV-Relatorio-Anual-2019...pdf.

Ahmad, W., Ahmed, T., e Ahmad, B. (2017). Hedonic pricing of milk at retail level: A case of faisalabad, pakistan. *Pakistan Journal of Applied Economics*, 27(1):29–39.

Astrup, A. (2014). A changing view on saturated fatty acids and dairy: from enemy to friend. *The American Journal of Clinical Nutrition*, 100:1407–1408.

Azevedo, P. F. e de Politi, R. B. (2008). Concorrência e estratégias de precificação no sistema agroindustrial do leite. *Revista de Economia e Sociologia Rural*, 46:767–802.

Ballco, P. e de Magistris, T. (2018). Valuation of nutritional and health claims for yoghurts in spain: A hedonic price approach. *Spanish Journal of Agricultural Research*, 16.

Bimbo, F., Bonanno, A., Liu, X., e Viscecchia, R. (2017). Hedonic analysis of the price of uht-treated milk in italy. *Journal of Dairy Science*, 99:1095–1102.

Brandt, M., Moss, J., e Ferguson, N. (2009). The 2006-2007 food label and package survey (flaps): Nutrition labeling. *Journal of Food Composition and Analysis*, 22:74–77.

Buccola, S. e Iizuka, Y. (1997). Hedonic cost models and the pricing of milk components. *American Journal of Agricultural Economics*, 79(2):452–462.

Carvalho, G. R., Faria, W. R., Nardy, V. P. D. R., e Betarelli Junior, A. A. (2022). Hedonic pricing analysis for semen of dairy bulls in brazil. *PLOS ONE*, 17(4):e0267109.

Carvalho, G. R., Oliveira, S. J. M., e Beskow, W. B. (2017). Mudanças da produção leiteira na geografia brasileira: o avanço do sul. *Agropecuária Catarinense*, 30:13–16.

Chaves, D. O., Carvalho, G. R., Pinha, L. C., e da Rocha, D. T. (2022). Oscilações e correlações no mercado de leite brasileiro. *Revista de Política Agrícola*, 31:9–18.

Chin, T. L. e Chau, K. W. (2003). A critical review of literature on the hedonic price model. *International Journal for Housing and Its Applications*, 27(2):145–165.

Cook, H. L. (1954). The place of fat and solids-not-fat in pricing milk for manufacturing. *Journal of Farm Economics*, 36(5):1107–1117.

Costanigro, M. e McCluskey, J. J. (2011). Hedonic price analysis in food markets. In: *The Oxford Handbook of the Economics of Food Consumption and Policy*. Oxford University Press.

Deeth, H. (2010). Improving uht processing and uht milk products. In: Griffiths, M. W., editor, *Improving the Safety and Quality of Milk*, Página 302–329. Woodhead Publishing.

Dekker, P. J. T., Koenders, D., e Bruins, M. J. (2019). Lactose-free dairy products: Market developments, production, nutrition and health benefits. *Nutrients*, 11:551.

Farina, E. M. M. Q. (2002). Consolidation, multinationalisation, and competition in brazil: Impacts on horticulture and dairy products systems. *Development Policy Review*, 20:441–457.

Farina, E. M. M. Q., Gutman, G. E., Lavarello, P. J., Nunes, R., e Reardon, T. (2005). Private and public milk standards in argentina and brazil. *Food Policy*, 30(3):302–315.

FGV (2020). General price index - internal availability (igp-di). Available at: `https://portalibre.fgv.br/estudos-e-pesquisas/indices-de-precos/indices-de-precos.htm`.

FMI (2023). Future market insight. lactose-free products market outlook. Available at: `https://www.futuremarketinsights.com/reports/lactose-free-products-market`.

Gama, M. A. S., Raposo, N. R. B., Mury, F. B., Lopes, F. C. F., Dias-Neto, E., Talib, L. L., e Gattaz, W. F. (2015). Conjugated linoleic acid-enriched butter improved memory and up-regulated phospholipase a2 encoding-genes in rat brain tissue. *Journal of Neural Transmission*, 122:1371–1380.

Gedam, K., Prasad, R., e Vijay, V. K. (2007). The study on uht processing of milk: A versatile option for rural sector. *World Journal of Dairy & Food Sciences*, 2(2):49–53.

Gillmeister, W. J., Yonkers, R. D., e Dunn, J. W. (1996). Hedonic pricing of milk components at the farm level. *Review of Agricultural Economics*, 18(2):181–192.

Gulseven, O. e Wohlgenant, M. (2017). What are the factors affecting the consumers' milk choices? *Agricultural Economics (Zemědělská Ekonomika)*, 63:271–282.

Headey, D. D., Alderman, H., Hoddinott, J., e Narayanan, S. (2024). The glass of milk half-empty? dairy development and nutrition in low and middle income countries. *Food Policy*, 122:102585.

Hillers, J. K., Nielsen, V. H., Freeman, A. E., Dommerholt, J., e Deiter, R. E. (1980). Value of fat and protein in producer milk. *Journal of Dairy Science*, 63:322–327.

IBGE (2017). Instituto brasileiro de geografia e estatística. portal cidades. Available at: `https://cidades.ibge.gov.br/v4/brasil/mg/juiz-de-fora/panorama`.

IBGE (2020). Índice de preços ao consumidor amplo (ipca). Instituto Brasileiro de Geografia e Estatística.

IMARC (2020). Uht milk market: Global industry trends, share, size, growth, opportunity and forecast 2020-2025. Available at: `https://www.imarcgroup.com/uht-milk-processing-plant`.

Kim, H. (2024). What factors drive higher demand for dairy milk in terms of the regional economics and politics. *Research Square*. Preprint.

Kirkland, J. J. e Mittelhammer, R. C. (1986). A nonlinear programming analysis of production response to multiple component milk pricing. *American Journal of Agricultural Economics*, 68(1):44–54.

Kosaric, N., Kitchen, B., Panchal, C. J., Sheppard, J. D., Kennedy, K., Sargant, A., e Arnott, D. R. (1981). Uht milk: Production, quality, and economics. *C R C Critical Reviews in Food Science and Nutrition*, 14(2):153–199.

Kratz, M., Baars, T., e Guyenet, S. (2013). The relationship between high-fat dairy consumption and obesity, cardiovascular, and metabolic disease. *European Journal of Nutrition*, 52:1–24.

Lactose-free (2012). Dairy market is booming, says new report. FoodBev Media Ltd., Bath, UK.

Ladd, G. W. e Dunn, J. R. (1979). Estimating values of milk components to a dairy manufacturer. *Journal of Dairy Science*, 62(11):1705–1712.

Ladd, G. W. e Martin, M. B. (1976). Prices and demands for input characteristics. *American Journal of Agricultural Economics*, 58(1):21–30.

Ladd, G. W. e Suvannunt, V. A. (1976). Model of consumer goods characteristics. *American Journal of Agricultural Economics*, 58:504–510.

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, 74:132–157.

Legault, L., Brandt, M. B., McCabe, N., Adler, C., Brown, A. M., e Brecher, S. (2004). Food label and package survey: An update on prevalence of nutrition labeling and claims on processed, packaged foods. *Journal of the American Dietetic Association*, 104(6):952–958.

Lenz, J. E., Mittelhammer, R. C., e Hillers, J. K. (1991). Pricing milk components at retail via hedonic analysis. *Journal of Dairy Science*, 74:1803–1814.

Lenz, J. E., Mittelhammer, R. C., e Shi, H. (1994). Retail-level hedonics and the valuation of milk components. *American Journal of Agricultural Economics*, 76:492–503.

Loke, M. K., Xu, X., e Leung, P. (2015). Estimating organic, local, and other price premiums in the hawaii fluid milk market. *Journal of Dairy Science*, 98:2824–2830.

Lopez, E. e Lopez, R. A. (2009). Demand for differentiated milk products: implications for price competition. *Agribusiness*, 25:453–465.

Lorenzen, P. C., Clawin-Rädecker, I., Einhoff, K., Hammer, P., Hartmann, R., Hoffmann, W., Martin, D., Molkentin, J., Walte, H. G., e Devrese, M. (2011). A survey of the quality of extended shelf life (esl) milk in relation to htst and uht milk. *International Journal of Dairy Technology*, 64:166–178.

Mozaffarian, D. (2014). Saturated fatty acids and type 2 diabetes: more evidence to re-invent dietary guidelines. *The Lancet Diabetes & Endocrinology*, 2:770–772.

Parzonko, A., Parzonko, A. J., e Bórawski, P. (2024). Economic competitiveness of dairy farms from the top milk-producing countries in the eu: Assessment in 2014–2021. *Agriculture*, 14(1):123.

Pearson, J. M., Phillips, J. A., e McGilliard, M. L. (1990). Adult consumers of uht milk and their descriptions of the product. *Journal of Consumer Studies & Home Economics*, 14(2):115–121.

Perrin, R. K. (1980). The impact of component pricing of soybeans and milk. *American Journal of Agricultural Economics*, 62(3):445–455.

Poushi, M. K. e Sharifi, D. (2024). State-of-the-art in milk processing for improvement of the quality of pasteurized milk and uht milk. In: Rana, T., editor, *Developments in Microbiology, The Microbiology, Pathogenesis and Zoonosis of Milk Borne Diseases*, Página 19–27. Academic Press.

Prehn, S. (2024). Why hedging, as practiced for storable commodities, is not an option for dairy farmers: A critical discussion. Discussion paper, Institute of Agricultural Development in Transition Economies (IAMO).

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, 82:34–55.

Rudstrom, M. (2004). Determining implicit prices for hay quality and bale characteristics. *Review of Agricultural Economics*, 26(4):552–562.

Scozzafava, G., Gerini, F., Boncinelli, F., Contini, C., Marone, E., e Casini, L. (2020). Organic milk preference: is it a matter of information? *Appetite*, 144.

Shingfield, K. J., Chilliard, Y., Toivonen, V., Kairenius, P., e Givens, D. I. (2008). Trans fatty acids and bioactive lipids in ruminant milk. In: German, J. B., Dillard, C. J., e Ward, R. E., editores, *Bioactive components of milk*. Springer, New York.

Simões, A. R. P., Nicholson, C. F., e Carvalho, G. R. (2023). Components of farm milk price behavior in brazil from 2005 to 2020. *Revista Brasileira de Zootecnia*, 52.

Smith, T., Huang, C., e Lin, B. (2009). Estimating organic premiums in the us fluid milk market. *Renewable Agriculture and Food Systems*, 24:197–204.

Suwannaporn, T. J. P. (2015). Trade-off analysis of packaging attributes for foods and drinks. *British Food Journal*, 117.

Trestini, S. e Stiletto, A. (2020). Does italian origin really determine a price premium for fluid milk? evidences from a hedonic price analysis. *Economia agro-alimentare/Food Economy-Open Access*, 22:1–22.

Ueland, O., Altintzoglou, T., Kirkhus, B., Lindberg, D., Rognså, G. H., Rosnes, J. T., e Varela, P. (2020). Perspectives on personalised food. *Trends in Food Science & Technology*, 102:169–177.

Vidal-Martins, A. M., Salotti, B. M., Rossi Junior, O. D., e Penna, A. L. B. (2005). Evolução do índice proteolítico e do comportamento reológico durante a vida de prateleira de leite uat/uht. *Ciência e Tecnologia de Alimentos*, 4:698–704.

Walter, E. H. M., Faria, J. A. F., e Cruz, A. G. (2010). Sistemas de embalagens para produtos lácteos. *Leite & Derivados*, 19:40–48.

Wan, M., Wang, D., Goldman, M., Taddy, M., Rao, J., Liu, J., e McAuley, J. (2017). Modeling consumer preferences and price sensitivities from large-scale grocery shopping transaction logs. In: *International Conference on World Wide Web*, Perth, Australia.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*. MIT Press, England.

Xiao, J. A. (2012). *Hedonic analysis of retail milk and oat meat attributes in Quebec*. Tese de Doutorado, Department of Agricultural Economics, McGill University, Montreal, Canada. Available at: `https://pdfs.semanticscholar.org/d2e9/b513e742cac8d3111c9fa2f17a8e31017b6d.pdf`.

Yakoob, M. Y., Shi, P., Hu, F. B., Campos, H., Rexrode, K. M., Orav, E. J., Willett, W. C., e Mozaffarian, D. (2014). Circulating biomarkers of dairy fat and risk of incident

stroke among u.s. men and women in 2 large prospective cohorts. *The American Journal of Clinical Nutrition*, 100:1437–1447.

Zingone, F., Bucci, C., Lovino, P., e Ciacci, C. (2017). Consumption of milk and dairy products: Facts and figures. *Nutrition*, 33:322–325.

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