The Impact of Package Design On Fermented Milk Waste

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Research Article

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Abstract

One of the main goals of food packaging is the food waste reduction. However, some package designs may contradict this premise. This present work aimed to evaluate the effect of package design on fermented milk waste. Twenty-six packages of fermented milk of eight different designs were weighted to obtain the following masses: i) mass of the liquid removed from the package through a consumption simulation; ii) mass of the package without food and before the washing and drying processes; and, iii) mass of the cleaned and dried package. The main package factor in the fermented milk waste was the shape of the bottleneck. The packages that provided greater removal of the liquid content did not offer resistance to the food flow in the bottleneck. Other aspects that contributed to the food waste were straight angles and curves of the package. Thus, the package design impacts in the fermented milk waste.

1 Introduction

Fermented milk has an important role in the human health and consists of a food prepared with milk and/or milk product submitted to microbial action with consequent pH reduction. There are many types of fermented milk that differ by fermentation method and microorganisms involved [1]. In addition, it has a relatively low cost and it is easily found by consumers in small and large retail stores.

Packaging is essential in the food industry to maintain the quality of the product and to avoid the food waste through the prevention or inhibition of biological, physical, chemical and biochemical changes, ensuring longer shelf life [2, 3]. If the packaging has, as one of its main characteristics, the food waste reduction and the industry chooses a design that only meets the marketing appeal, it may be going against this premise.

Another objective of packages is to be self-saleable [3]. In this aspect, it is acceptable that the package design presents a commercial appeal. However, nowadays, the consumers also demand for food packages that do not contribute to pollution [4].

The economic and social importance that packaging adds to their products is unquestionable, however, food manufacturers and consumers need to be aware of the environmental impact generated by food waste. When a package wastes food, it is not only this content that is being discarded, but also the water used for milk and fermented milk production, site sanitation, and pasture growth; the electricity; and, all deforestation carried out for the animal management.

Besides that, there has been an increase in world hunger. After the prevalence of undernourishment (PoU) remains around 8.4 for 5 years, in 2020, it increased to approximately 9.9 as a result of the COVID-19 pandemic [5]. One way to reduce the world hunger is through loss and waste food reduction.

Food losses corresponds to the reduction in edible food mass “along the food supply chain from harvest/slaughter/catch up to, but not including, the retail level”. While food waste refers to the food
discarded at the retail level, food services and by consumers [6].

The food losses and food waste are a global problem that to be solved needs to join efforts of producers and consumers through the adoption of measures that reduce this situation. The lack or the bad planning of food packaging contributes to this scenario. Thus, in addition to bundling, conserving and transporting the product, the packaging needs to allow the total consumption of its content. Therefore, the aim of this work was to investigate the effect of packaging design on fermented milk waste.

2 Material And Methods

2.1 Material

Twenty-six packages of eight different formats from seven fermented milk manufacturers were acquired in the retail market of Salinas (MG) - Brazil. To maintain the impartiality of the experiment, the packages had their labels defaced and were identified with letters from A to H as shown in Figure 1.

2.2 Determination of Fermented Milk Waste Obtained During a Consumption Simulation

The plastic packages (A, B, C, D, E, F and H), after removing the labels, had their liquid content removed and remained poured for 10 s to consumption simulation. Regarding sample G (carton packaging), the package was perforated with the straw itself attached and the liquid was removed with the aid of manual agitation during 10 s. The removed liquid was weighed on a semi-analytical balance, model AD200 (Marte, Brazil) to obtain the total mass removed from fermented milk packaging ($M_M$). Immediately, the package was weighed to obtain the package mass without the liquid ($M_E$). Then, the packages were washed and dried in a drying oven, model 314 D 272 (Quimis, Brazil), with forced air circulation without heating, and weighed again to determine the mass of the package after cleaning ($M_C$). The fermented milk waste provided by each package was determined by Equation 1.

$$\% \text{Fermented milk waste} = \frac{(M_E - M_C) \times 100}{M_M + (M_E - M_C)} \quad \text{Eq. 1}$$

Where, $M_C$ is the mass of the package after cleaning; $M_E$ is the mass of the package without the fermented milk; $e$, $M_M$, the total mass of fermented milk removed from the packaging.

2.3 Bottleneck Measurements
As can be seen in Figure 1, the plastic packages of fermented milk present differences in the bottleneck that can directly impact the greater or lesser waste of food. Therefore, measurements of height, depth and circumference of these bottlenecks were performed with the aid of a caliper rule to obtain the measurements shown in Figure 2.

For packages with two edge levels (C, D, E and F, Figure 1), the bottleneck area was obtained according to Equation 2.

\[
\text{Bottleneck area} = CS \times PS \times AS + CI \times PI \times AI \quad \text{Eq. 2}
\]

For packages with one edge level (B and H), the bottleneck area was obtained according to Equation 3.

\[
\text{Bottleneck area} = CT \times AT \times PT \quad \text{Eq. 3}
\]

The packages A and G did not have their measurements calculated because they do not have edges and bottleneck (Figure 1), respectively.

2.4 Statistical Analysis

A minimum of three units per packaging type was used, with the exception of sample B, where only 2 units were available. The results were submitted to Analysis of Variance (ANOVA) (\(\alpha = 0.05\)) and the difference between the samples was detected by the Tukey test using the Statistica™ 12 software.

3 Results E Discussion

Informations of each type of fermented milk package were presented in Table 1.
Table 1
Description of the fermented milk packages used in the experiment.

| Package | Material | Net content* (g) | $M_M$ (g) | $M_E$ (g) | $M_C$ (g) |
|---------|----------|------------------|-----------|-----------|-----------|
| A       | PP       | 80               | 82.65 ± 0.74 | 4.83 ± 0.05 | 4.23 ± 0.02 |
| B       | PET      | 75               | 74.26 ± 0.42 | 6.42 ± 0.24 | 5.48 ± 0.27 |
| C       | HDPE     | 75               | 73.18 ± 0.54 | 5.77 ± 0.07 | 4.64 ± 0.07 |
| D       | LDPE     | 100              | 97.96 ± 0.70 | 8.63 ± 0.33 | 6.67 ± 0.06 |
| E       | HDPE     | 80               | 78.08 ± 1.26 | 6.57 ± 0.14 | 5.09 ± 0.11 |
| F       | HDPE     | 75               | 74.81 ± 1.28 | 6.24 ± 0.00 | 4.98 ± 0.05 |
| G       | Carton   | 80               | 79.71 ± 0.47 | 6.40 ± 0.24 | 4.65 ± 0.05 |
| H       | HDPE     | 75               | 73.60 ± 0.30 | 5.77 ± 0.08 | 4.44 ± 0.05 |

PP: polypropylene; PET: polyethylene terephthalate; HDPE: high-density polyethylene; LDPE: low-density polyethylene; $M_M$: the total mass of fermented milk removed from the packaging; $M_E$: the mass of the package without the fermented milk; $M_C$: the mass of the package after cleaning. *Net content as indicated on package label.

The percentage of fermented milk waste observed in each package was described in Figure 3. According to them, the package A differs from all others ($p<0.05$), being considered the package that provides less waste, followed by packages B, C and F, and packages D, E, G and H, those that produce the greatest waste.

When we analyze the package A in Figure 1, it is the only one with edge facing outwards, not allowing liquid accumulation in the bottleneck, which justifies its lower waste. Also in Figure 1, it is possible to see why packaging G (carton) is among those that waste the most fermented milk, due to the existence of straight angles and corners.

For the others packages, it was necessary to discuss the results regarding the size of the bottleneck edges (Table 2).
Table 2
Measurements of the packaging bottleneck edges.

| Package | CT (mm) | PT (mm) | AT (mm) | CI (mm) | PI (mm) | AI (mm) | CS (mm) | PS (mm) | AS (mm) | Area (mm²) |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|------------|
| B       | 84.8    | 3.0     | 4.0     | -       | -       | -       | -       | -       | -       | 1053.4     |
| C       | -       | -       | -       | 113.0   | 4.0     | 2.5     | 103.6   | 3.0     | 4.0     | 2373.8     |
| D       | -       | -       | -       | 109.9   | 4.0     | 3.0     | 103.6   | 3.0     | 4.0     | 2562.2     |
| E       | -       | -       | -       | 87.9    | 4.0     | 4.0     | 81.6    | 3.0     | 4.0     | 2386.4     |
| F       | -       | -       | -       | 109.9   | 4.0     | 3.0     | 103.6   | 3.0     | 4.0     | 2562.2     |
| H       | 87.9    | 4.0     | 7.0     | -       | -       | -       | -       | -       | -       | 2461.8     |

AT: total height; PT: full depth; PS: upper depth; PI: bottom depth; AS: top height; AI: lower height; CT: total circumference; CI: lower circumference; CS: upper circumference.

In addition to package G, the packages D, E, F and H were also among those that provided greater waste. This behavior may be related to the larger bottleneck area (from 2386.4 to 2562.2 mm²), promoting a greater barrier to the fermented milk flow. Although sample C has a neck area close to sample E, the curves at the body of package E (Figure 1) may have been responsible for its greater waste.

During the development of a package, it is considered, in addition to the practicality, the convenience, use facility, comfort, safety and product protection, besides the visual impact as a sales promoter. Packaging design plays a fundamental role in product characterization, as it is responsible for its differentiation and identification, attracting the consumer and constituting an emotional relationship with him [7]. However, currently, we cannot think of a packaging design without considering the environmental impact it causes.

According to the Brazilian Institute of Geography and Statistics – IBGE [8], in 2008-2009, the fermented milk consumption annual per capita was equivalent to 0.718 kg. Considering that the consumption has remained in the current years and that Brazil has 209.3 million inhabitants [9], there is a total Brazilian consumption of 150,28 thousand tons of fermented milk per year. If all the fermented milk were produced in a type A package, there would be an annual waste of 1.09 t. On the other hand, if the example were carried out with package G, 3.20 t of fermented milk would be wasted annually, around three times greater.

The amount of fermented milk wasted as a result of residues accumulation in packages is worrying. The problem gets worse when we consider that it is food rich in health benefits and there is a large portion of the world population that suffers from malnutrition.

It is necessary to be aware of how harmful waste is for everyone and to develop strategies that minimize this problem as much as possible, through packages that optimizes the consumption of its food and that
can be reused or recycled at the end of its use, or even to be produced with material that ensure the proper development of its primary functions, but which has a short degradation time.

4 Conclusions

There is a wide variety of fermented milk package designs that differ in terms of material (plastic and carton), bottleneck and edge that impact in the amount of fermented milk consumed. The package design that promotes most waste (2.14%) contains edge, bottleneck and embossed printing (drawing) where accumulates fermented milk, on the other hand, the package design that generated the minimum waste (0.73%) presents curved outwards edge that facilitates the total removal of the liquid.

So the package design of fermented milk has an influence on the level of residue retention and, consequently, on the waste amount. The package with a bottleneck edge outwards curved prevents the accumulation of fermented milk, reducing its waste, when compared to package with an inward edge. Also, as greater the height and depth of the inwardly curved edges, and more right angles has the package, higher amount of fermented milk waste is generated. We must be aware of how harmful is the waste of fermented milk in the world and that companies can produce packages that optimizes the total consumption of the product by developing bottle with outward edges.

Statements And Declarations

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Figures

Figure 1

Eight different types of fermented milk packages investigated.
Figure 2

Bottleneck of plastic packages measurements. A) Measurements of bottleneck with two-level. B) Measurements of bottleneck with one-level. A1) Al - lower height; AS - top height; PI - bottom depth; e, PS - upper depth. A2) CI - lower circumference; and, CS - upper circumference. B1) AT – total height; and, PT – full depth. B2) CT – total circumference.
Figure 3

Fermented milk waste (%) of each type of package. * Same letters demonstrate that the packages did not differ from each other at a 5% level of significance.