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Exploring the Potential of Kishk-like Novel Product in Solving the Acidic Whey Conundrum in the Dairy Industry

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ABSTRACT

Background: Acidic whey, unlike sweet whey, poses significant environmental challenges in the dairy industry. The Lebanese population consumes large quantities of labneh (strained yogurt) and white cheese, resulting in substantial acidic whey production, which presents disposal issues and pollution risks. Kishk, a fermented-milk cereal mixture, has a characteristic acidic taste. This study developed a Kishk-Like product using concentrated acidic whey as a substitute for fermented milk, addressing the disposal problem while enhancing dairy industry profitability.

Methods: This study was conducted from April to June 2023. As consumer acceptance is the first step in food product development, a triangle sensory test was performed three times with 30 panelists each time, who attempted to differentiate between an established fermented cow's milk kishk (CMK) and the new Kishk-Like product (KLP) made with three-fold concentrated acidic whey.

Result: In the three runs, 11, 9 and 13 out of 30 panelists were able to differentiate between the CMK and KLP samples, yielding p-values of 0.415, 0.713 and 0.166, respectively. These findings, coupled with the fact that approximately 12 kg of acidic whey is required to produce 1 kg of KLP, highlight its potential as a straightforward, economically viable solution for the acidic whey disposal dilemma, warranting further research into its development, characterization and standardization.

Key words: Acidic whey, Fermented-milk, Kishk, Kishk-Like product, Triangle test.

INTRODUCTION

The interconnection between food, water and energy has become increasingly precarious, necessitating careful and innovative adjustments across all sectors of human activity. At the heart of this challenge lies the food supply chain, which is currently burdened by unsustainable practices (Menchik, 2019). The high biochemical oxygen demand (BOD) of whey poses a significant global challenge in terms of waste management and environmental pollution.

Whey and whey permeates can be effectively managed through biological wastewater treatment technology, although this approach incurs considerable financial costs (Marwaha and Kennedy, 1988; Panesar *et al*., 2007; Ali, 2016; Chandrapala *et al*., 2017; Buchanan *et al*., 2023). Recently, there has been increasing interest in high-value whey-based ingredients within the food industry, attributed to their exceptional functional and nutritional properties. Whey protein plays a crucial role in the development of functional foods and has therapeutic applications. Additionally, whey protein is widely utilized as an antimicrobial agent in edible films and as a protective material to enhance the shelf life of food products (Marwaha and Kennedy, 1988; Kumar *et al*., 2018; Buchanan *et al*., 2023).

The utilization of local knowledge to transform industrial food waste into viable products should be fully leveraged. An illustrative example is a study conducted in India that assessed the quality and stability of chhana whey produced during the preparation of chhana and chhana-based sweetmeats- when fermented with lactic acid bacteria. The resulting beverage was found acceptable for up to 20 days when stored at 7±2°C (Saha *et al*., 2017). While acid whey is often considered less desirable due to its low protein concentration, high mineral content, low pH, sweet whey, a byproduct of rennet cheeses, can be converted into protein powders for sports nutrition and meal fortification (Marwaha and Kennedy, 1988; Buchanan *et al*., 2023). However, the high biological oxygen demand (BOD) and mineral content of acid whey can pose environmental risks if disposed of directly (Ali, 2016; Chandrapala *et al*., 2017; Buchanan *et al*., 2023).

In recent years, the production of acid whey has risen significantly due to the increasing demand for Greek yogurt and acid-coagulated cheeses (Rocha-Mendoza *et al*., 2021). In Lebanon and other Middle Eastern countries, labneh is a traditional product made by straining cow's milk yogurt through a cloth bag (Al-Kadamany *et al*., 2002; Kaaki *et al*., 2012). Labneh is considered an essential staple, commonly consumed in Lebanese households, with an estimated consumption of 20 kg per person per year (Saadeh, 2016; Daou and Azzi, 2021).

Fermented milk combined with grains has a long-standing tradition in many cultures. For instance, rabdi, a well-known dairy product from the northwestern region of

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India, is produced by combining a lactic acid-fermented milk product with pearl millet (Sarkar *et al.*, 2015; Sathe and Mandal, 2016). A fermented milk-wheat blend, known as kishk in the Middle East and tarhana in Greece and Turkey, is also produced and regarded as a staple food (Morcos *et al.*, 1973; Toufeili *et al.*, 1998). Kishk is made by combining fermented milk with wheat, which is subsequently sun-dried (Van Veen *et al.*, 1969; Hafez and Hamada, 1984; Salameh *et al.*, 2016). While the processing methods for kishk vary across regions, the primary ingredients typically include yogurt and parboiled wheat meal, commonly referred to as bulgur (Van Veen *et al.*, 1969; Hafez and Hamada, 1984; Nassar *et al.*, 2016).

Due to the dependence of kishk on the materials used and the methods selected for its production, there is significant variability in the documented physicochemical properties both within and across geographical regions, as well as among traditional production practices (Morcos *et al.*, 1973; Toufeili *et al.*, 1998; Muir *et al.*, 2000; Tamer *et al.*, 2007; Abou-Zeid, 2016; Nassar *et al.*, 2016; Gadallah and Hassan, 2019; Hajj *et al.*, 2019). This diversity facilitates innovation and the development of new products. For instance, a patent filed in Austria claims a method for producing a kishk-like product by substituting bulgur with high-starch raw materials of plant origin (Emmerich, 1988).

The aim of this study is to conduct a preliminary investigation into consumer acceptability of an acidic whey kishk-like product, specifically evaluating its sensory attributes and distinguishing features compared to an established product, namely fermented cow's milk kishk. This assessment will provide valuable insights into the marketability of the product, highlighting its potential to meet consumer preferences and fill gaps in the current market.

MATERIALS AND METHODS

The experiment was conducted from April to June 2023 in collaboration with a small dairy producer in Sidon, Lebanon. Acidic whey was obtained as a by-product of labneh production, a popular strained yogurt product in Lebanon (Al-Kadamany *et al.*, 2002; Dimassi *et al.*, 2020). All tests were performed in triplicate to ensure reliability and accuracy.

Moisture content was determined using the drying oven method as outlined in ISO (Iso5537:2004). Fat content was assessed using the Soxhlet extraction method described in AOAC 922.06 (Helrich, 1990). Protein content was measured via the Kjeldahl method according to AOAC 991.20 (Helrich, 1990). Ash content was analyzed using the AOAC 942.05 method (Helrich, 1990). Total carbohydrate content was calculated by difference (BeMiller, 2017). pH, conductivity, total dissolved solids (TDS), salinity and temperature were measured using a microcomputer-based pocket meter (Model pH/EC80, Jenco Vision). Water activity was assessed with a Pawkit water activity meter, where samples were flattened to cover the bottom of the cup before measurement at room temperature (Tounsi *et al.*, 2017).

The acidic whey was concentrated by heating to 90°C until its volume was reduced by one-third. This concentrated whey was then employed in the production of the Kishk-Like product (KLP) according to the method described by Abd El-Razik, which specifies a 4:1 ratio of fermented cow's milk and concentrated acidic whey to bulgur (Abd El-Razik *et al.*, 2016) (Fig 1).

One-way ANOVA was employed to compare the protein, fat, carbohydrate, ash, moisture content, water activity and pH values of the Kishk-Like product (KLP) and fermented cow's milk kishk (CMK). To assess whether there were significant sensory differences between CMK and KLP made from concentrated acidic whey, a sensory discrimination test, specifically a triangle test, was conducted (Sinkinson, 2017). For this test, three batches of 10 kg each of both CMK and KLP were produced and 30 panelists per batch, with their consent, were asked to detect differences between the two products. Four coded kishk samples were prepared (Table 1). Each panelist received three samples: two from the same product and one from the other and they were tasked with identifying the differing sample (Table 1).

RESULTS AND DISCUSSION

The acidic whey collected from labneh production exhibited a pH value of 4.231±0.022, consistent with findings by Wail-Alomari, who investigated the optimization of lactose hydrolysis in acidic labneh whey using immobilized Beta-

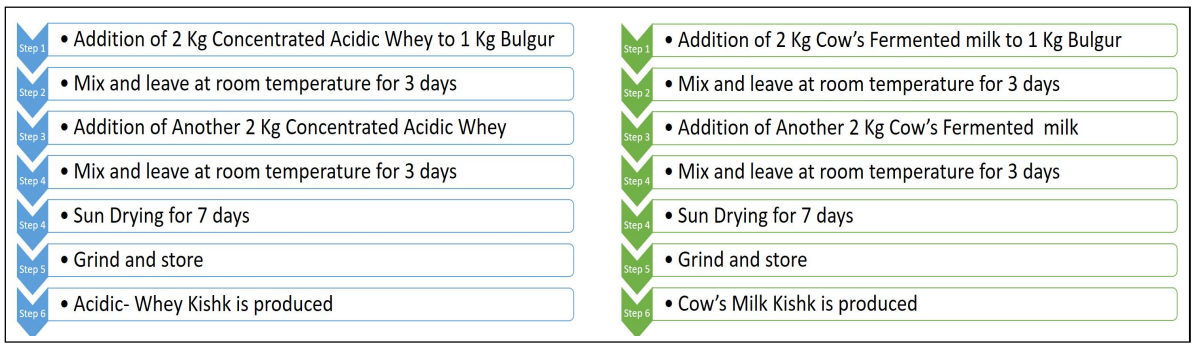

Fig 1: Kishk-Like product and fermented cow's milk kishk flow chart.

Galactosidase from *Kluyveromyces lactis* (Wail-Alomari *et al.*, 2011). This pH value did not differ significantly from that of cow's fermented milk. Additionally, the total solids content of the collected acidic whey was measured at 6.254%±0.543. The total solids of the Kishk-Like product (KLP) made with concentrated acidic whey and cow's milk kishk (CMK) showed no significant difference, nor did the water activity values between concentrated KLP and CMK.

The protein and fat content of the Kishk-Like product (KLP) were significantly lower than those of cow's milk kishk (CMK) (Table 2). In contrast, the carbohydrate content of KLP was significantly higher than that of CMK (Table 2). This variation is likely due to the differing concentrations of protein and fat in acidic whey compared to yogurt (Menchik, 2019; Rocha-Mendoza *et al.*, 2021). Furthermore, the moisture content, ash content, water activity and pH values of KLP did not differ significantly from those of CMK.

The results of the triangle test indicated that, in the first run, 11 out of 30 participants correctly identified the samples (p= 0.415). In the second run, 9 out of 30 participants responded correctly (p= 0.714), while in the third run, 13 out of 30 participants did so (p= 0.166) (Table 3). These findings suggest that there was no significant difference detected between cow's milk kishk (CMK) and the Kishk-Like product (KLP) made with concentrated acidic whey.

Preliminary results demonstrate significant potential for addressing the acidic whey disposal issue. If validated by future research, this could provide an effective solution for Lebanon, the Middle East (Wail-Alomari *et al.*, 2011) and potentially on a global scale (Marwaha and Kennedy, 1988; Panesar *et al.*, 2007; Ali, 2016; Chandrapala *et al.*, 2017; Buchanan *et al.*, 2023). The production of acid whey has risen in recent years due to increasing demand for Greek yogurt and acid-coagulated cheeses (Rocha-Mendoza *et al.*, 2021).

Labneh, a popular fermented milk product in the Middle

Table 1: Discriminate sensory data filling form.

Panelist	Sample 1*	Sample 2*	Sample 3*	Panelist's answer	Correct answer*	Correct/Incorrect[1]
1	K4	K1	K3		K4	
2	K3	K1	K4		K4	
3	K4	K2	K3		K3	
4	K1	K2	K4		K1	
5	K3	K2	K1		K2	
6	K3	K1	K2		K2	
7	K1	K2	K3		K2	
8	K1	K3	K2		K2	
9	K2	K4	K1		K1	
10	K2	K3	K1		K2	
11	K1	K4	K3		K4	
12	K1	K4	K2		K1	
13	K1	K3	K4		K4	
14	K3	K4	K2		K3	
15	K4	K3	K1		K4	
16	K2	K3	K4		K3	
17	K2	K4	K3		K3	
18	K3	K2	K4		K3	
19	K2	K1	K4		K1	
20	K4	K2	K1		K1	
21	K4	K1	K3		K4	
22	K3	K1	K4		K4	
23	K4	K2	K3		K3	
24	K1	K2	K4		K1	
25	K3	K2	K1		K2	
26	K3	K1	K2		K2	
27	K1	K4	K3		K4	
28	K1	K4	K2		K1	
29	K1	K3	K4		K4	
30	K3	K4	K2		K3	

*: Are the hidden Part of the data where the panelist would fill the non-colored part.

K1 and K3 are fermented cow's milk kishk; K2 and K4 are concentrated acidic whey kishk like product

1: This column is filled by the test conductor after the panelist fill his answer

Table 2: Acidic whey and cow's milk kishk chemical and physical components.

%	KLP	CM Kishk	Total	P value
	Mean±SE	Mean±SE	Mean±SE	
Protein	14.209±0.090	23.077±2.312	18.643±2.237	0.019
Fat	3.481±0.024	9.833±0.493	6.657±1.437	0.001
Total carbohydrate	71.711±0.443	52.340±1.615	62.025±4.396	0.001
Ash	1.712±0.011	3.747±1.342	2.729±0.753	0.204
Moisture	4.254±0.026	4.627±0.578	4.440±0.272	0.554
Water activity	0.436±0.054	0.432±0.052	0.434±0.034	0.96
pH	3.877±0.051	3.857±0.171	3.866±0.080	0.915

KLP: Kishk like product; CM: Cow's milk; P Value.

Table 3: Result of the triangle test conducted on KLP from concentrated acidic whey and CMK.

	Total number of taste panelist	Actually gave the correct answer	Calculated p value
Run 1	30	11	0.415
Run 2	30	9	0.713
Run 3	30	13	0.166

KLP: Kishk-Like product; CMK: Fermented cow's milk Kishk.

East and Balkans, is known for generating substantial amounts of acidic whey (Kaaki *et al.*, 2012). With a milk-to-labneh conversion rate of approximately 5 kg of milk per kg of labneh (Dimassi *et al.*, 2020), each kilogram of labneh produces around 4 kg of acidic whey. Considering Lebanon's population of approximately 5.3 million (Worldometer, 2023) and an average consumption of 20 kg of labneh per person annually (Saadeh, 2016), this results in an estimated 21.3 million kg of acidic whey generated each year.

Disposing of this whey through sewage systems can increase maintenance needs and contribute to environmental pollution. Our data indicate that producing 1 kg of the Kishk-Like product (KLP) requires approximately 12 kg of acidic whey, derived from around 3 kg of labneh. If characterized and standardized, KLP could offer a low-fat dairy option with the benefits of fermentation -achieved over a 6-day period (Fig 1) while also reducing wastewater treatment costs and enhancing the overall sustainability of production facilities. This estimate does not include other products that also generate acidic whey, such as Shanklish (Tamime *et al.*, 2011). Moreover, further studies are necessary to evaluate KLP using acidic whey from bovine, ovine, caprine sources, as these differ significantly in total solids, protein and lactose content (Tamime *et al.*, 2011).

Furthermore, utilization of acidic whey in the production of KLP offers a cost-effective solution compared to high-intensity technological methods for addressing the acidic whey issue, such as bioutilization (Panesar *et al.*, 2007), nanofiltration and nanodiafiltration (Chandrapala *et al.*, 2017), membrane filtration (Buchanan *et al.*, 2023) and enzymatic hydrolysis (Wail-Alomari *et al.*, 2011). By utilizing acidic whey, this method capitalizes on the health benefits associated with its prebiotics and bioactive compounds (Rocha-Mendoza *et al.*, 2021). Furthermore, exploring the potential to produce kishk-like products, such as rabdi, which uses pearl millet instead of wheat bulgur-could be advantageous, particularly given its low glycemic index, making it more suitable for individuals with diabetes (Sarkar *et al.*, 2015; Sathe and Mandal, 2016). This not only enhances the product's marketability but also aligns with the increasing consumer demand for diverse, healthy food options and the industry's need to reduce its environmental footprint.

CONCLUSION

The findings of this preliminary study highlight the significant potential of the Kishk-Like product as an effective and straightforward solution for the disposal of acidic whey, a byproduct generated during the processing of milk. This potential is particularly noteworthy due to the product's sensory resemblance to a well-established item in the market. Additionally, it may serve as a revenue-generating opportunity for the dairy industry by enabling the production of a shelf-stable product, thanks to its low water activity and acidic properties. Future research should prioritize the characterization and standardization of the KLP product using acidic whey resulting from processing of diverse milk types, specifically caprine, ovine and bovine, alongside bulgur manufactured from various grains such as wheat, soy, millet. Comprehensive sensory evaluations should also be conducted. Once the product value chain is established, it will be essential to analyze the production process for constraints and opportunities. Finally, further investigation into the economic viability of producing and utilizing KLP is recommended.

Conflict of interest

The author declare that there are no conflicts of interest regarding the publication of this manuscript.

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