Low-Fat Plant-Based Bottled Katik

ECAMPUZ CAMP1 Challenge

Team 8

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Abstract:

In this report, we investigated the production of katik from soybeans. We thoroughly discuss product analysis with advanced quality assurance techniques. Soy-based katik stands out as a great alternative because of its advantages such as high protein content and environmental friendliness. Market research shows that business is possible, especially in places like Uzbekistan.The report ends by stressing the ethical, environmental, and health aspects of soy-based katik. It highlights its potential to meet market needs and promote plant-based diets with a focus on sustainable production. Yet, it also recognizes and tackles challenges in implementing soy-based katik, emphasizing the importance of overcoming obstacles for successful market integration.

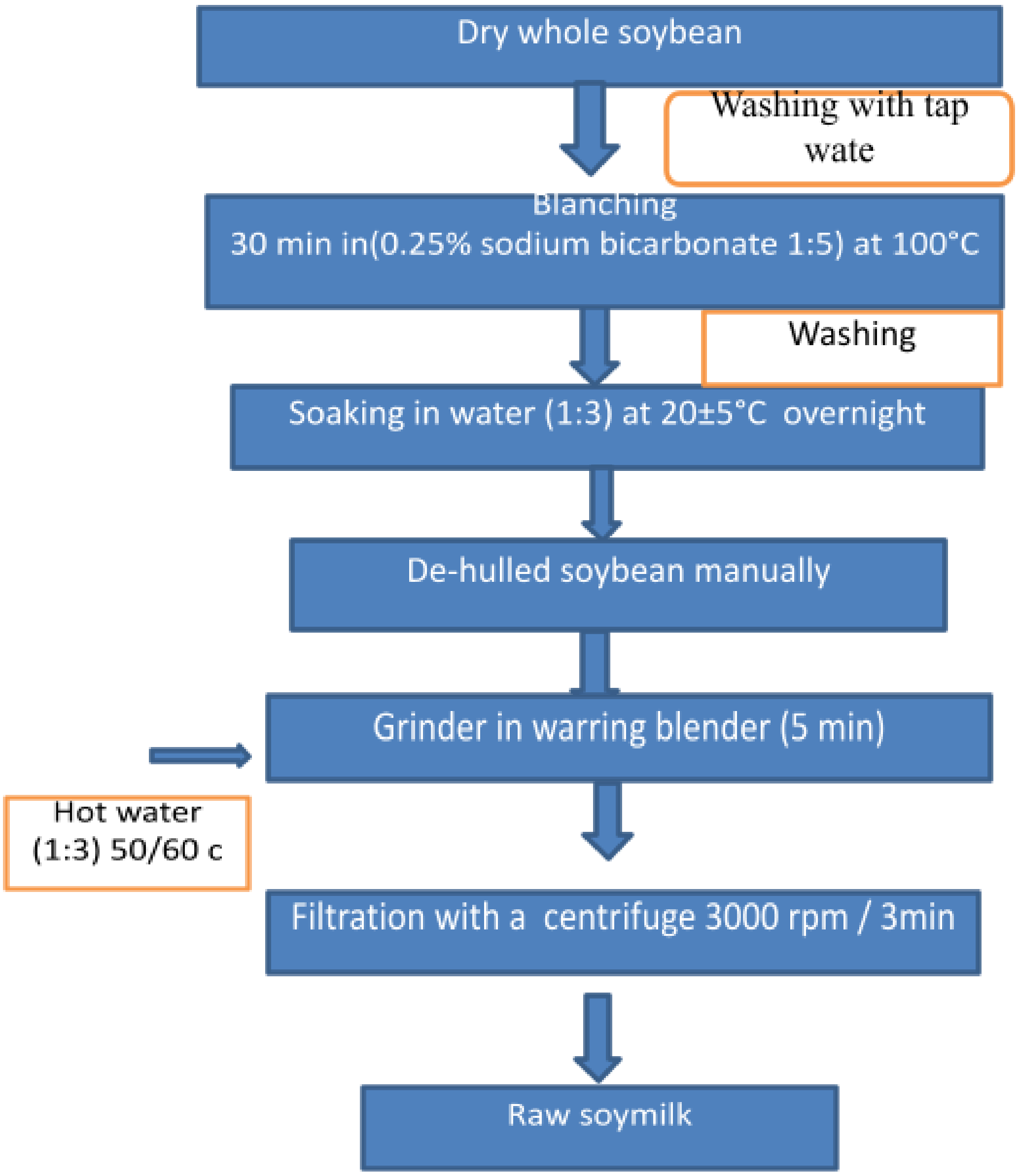
Introduction

Dairy cows and their manure contribute to climate change and harm local water and vital ecosystems. Choosing plant-based dairy products is considered a more viable option, as it avoids animal exploitation. Plant alternatives are also less environmentally damaging, require less land, water and energy, and produce fewer greenhouse gasses. When low in fat and saturated fat, they can offer health benefits, and possibly contain important nutrients. Choosing plant alternatives reduces the risk of contributing to antibiotic resistance against conventionally farmed bacteria. In addition, plant alternatives can contribute to global food security by reducing the number of components required for an efficient diet.

Soy stands out as the best choice for caustic production, with comparable protein levels, essential nutrients and allergen-free properties of cow's milk. Its neutral taste makes it viable for processing plenty, suitable for a variety of kitchen applications. Soy has a potentially lower environmental footprint than traditional dairy products, with lower carbon emissions and water use. Free of fatty acids and containing cancer-fighting phytoestrogens, soy is emerging as a healthy, versatile and environmentally friendly alternative to hot crafts.

Soy is an excellent choice for katik, closely resembling cow's milk in composition. Soy is a local and accessible option. With comparable protein content, essential nutrients, and allergen-free properties, soy's versatility and environmental benefits make it a fitting and easily accessible candidate for crafting nutritious and sustainable katik.

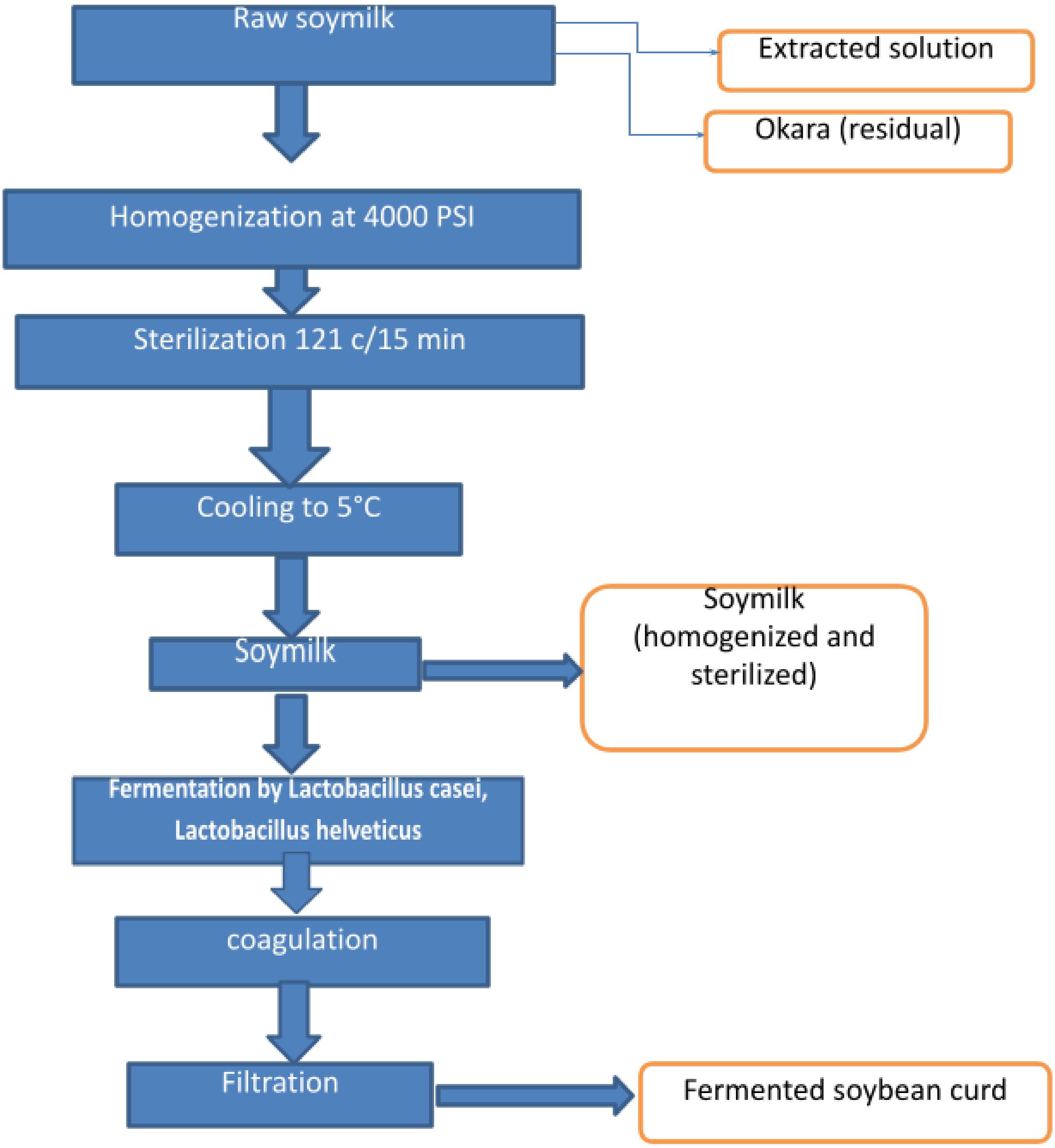
Product Development



Initially, we obtain dry soybeans from a store and soak them in a solution containing 0.25% sodium bicarbonate at a temperature of 100°C for half an hour. This aids in softening the soybeans and removing their outer skin. Then it is washed to eliminate any remaining sodium bicarbonate and impurities. Afterwards, the soybeans soak in water overnight at a ratio of 1:3 (soybeans to water), contributing to further softening in preparation for subsequent steps.

After soaking, the outer skins of the soybeans are manually removed, and the soybeans are ground using a Waring blender until a smooth mixture is achieved. This grinding process facilitates the extraction of liquid from the soybeans.

The blended mixture undergoes filtration with a centrifuge, separating the liquid portion (soy milk) from the solid components, resulting in a smoother and purer soy milk. Ultimately, the end product is raw soy milk, retaining the natural flavors and nutrients of the soybeans.



Homogenization is initiated at 4000 PSI to break down fat globules and attain a uniform texture. Subsequently, sterilization is conducted at 121°C for 15 minutes, ensuring the elimination of potential microorganisms for enhanced safety and shelf-stability.

The soy milk is then cooled to 5°C to arrest enzymatic activity and contribute to longer preservation. After cooling, soy milk is fermented using Lactobacillus casei and Lactobacillus helveticus.

Coagulation follows fermentation. It transforms soy milk into a semi-solid state. The fermentation process, guided by beneficial bacteria, contributes to the development of a thicker and more textured product.

Filtration step refines the coagulated mixture, separating solid components from the liquid. Katik, as the final result, develops its texture, flavor, and nutritional attributes through fermentation and coagulation.

To sum up, the steps explained demonstrate how soy milk becomes katik through careful adjustments of different factors for the desired taste and nutrition. shelf life of katik is approximately 5 days under standard refrigeration conditions(2-8 degrees, less than 70% humidity).we recommend the use of oriented polyester film (OPET) as the preferred packaging material for the optimal preservation of katik composition, given its demonstrated effectiveness in retaining fermentation activity and microbial composition(Witthuhn et al., 2005).

Product Analysis

In the production of katik, it is necessary to measure fat, protein, and carbohydrate concentrations to ensure compliance with government standards (Table 1). It is also important to note that real-time monitoring of microbial count and sugar concentration might be required to ensure consistency in the final product.

Traditionally, the Kjeldahl Method has been used to assess protein content, the Gerber Method for fat content, and Gravimetric Analysis for overall product composition. However, modern analytical techniques have introduced a broader array of methods. In addition to the mentioned traditional methods, contemporary approaches include near-infrared spectroscopy (NIR), high-performance liquid chromatography, and enzyme-linked immunosorbent assay (ELISA). Recent technological advances, including gas chromatography, mass spectrometry, and nuclear magnetic resonance, have expanded our analytical toolkit, allowing for a more thorough and precise analysis of product composition.

Table 1. Nutritional and energy value of katik (based on 100 gr product)

Name of the product	Fat g	Protein g	Carbs g
Mass fraction of fat			
3.5%	3.5	2.7	3.6
3%	3.0	2.8	3.6
2%	2.0	2.9	3.8
1%	1.0	3.0	3.8
low fat	0,05	3,0	3,8

Analysis of Nutritional Components (Fat, Protein, Carbohydrates) using NIR Spectrometer

Among instrumental techniques, the NIR spectrometry holds greater promise as it can be used for quantitative and qualitative analysis of dairy products. This method employs light to analyze the chemical composition of the product. It is fast, non-destructive, and can measure multiple components simultaneously, making it ideal for real-time analysis during production.

In one study, researchers used advanced PLS regression to analyze dairy products with different protein and fat content, achieving outstanding performance with R2 greater than 0.94 (Pu et al., 2020).

In a separate investigation conducted on a farm in Germany, scientists employed an inline NIR instrument to predict fat (%), protein (%), and lactose (%). The results showed promising accuracy, with R2 values of 0.99, 0.98, and 0.92 for fat, protein, and lactose content, respectively, along with low standard errors (0.09, 0.05, and 0.06) (Melfsen et al., 2012).

Another study focused on quantitative analysis, using a training set from laboratory-scale milk samples. The resulting R2 values for sucrose and lactose predictions were 0.9749 and 0.9987, demonstrating high accuracy in the analysis (Thanavanich et al., 2022).

While using an NIR spectrometer in production is user-friendly, building an accurate prediction model involves specific steps. As shown in Figure 2, firstly, samples with known reference values are created, divided into calibration and validation sets. The calibration set is for data analysis, and the validation set tests the model's performance. Poor performance may signal problems like inaccurate reference values or insufficient samples. Conversely, a well-performing calibration model allows confident and accurate content predictions for use in production.

Fig. 1. Common NIR spectra from three distinct dairy powders, namely whole milk powder (WMP), skim milk powder (SMP), and whey protein concentrate (WPC)(Pu et al., 2020).

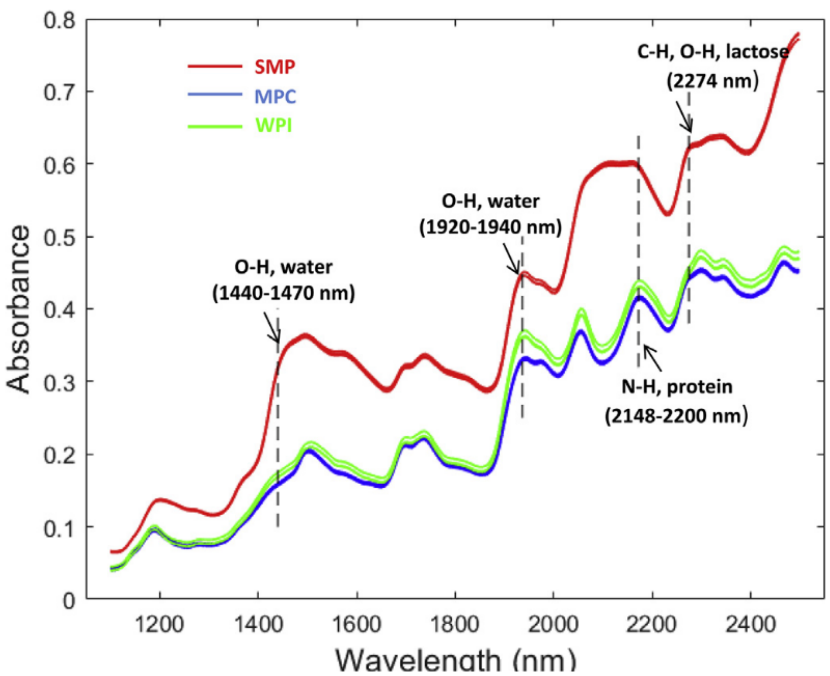
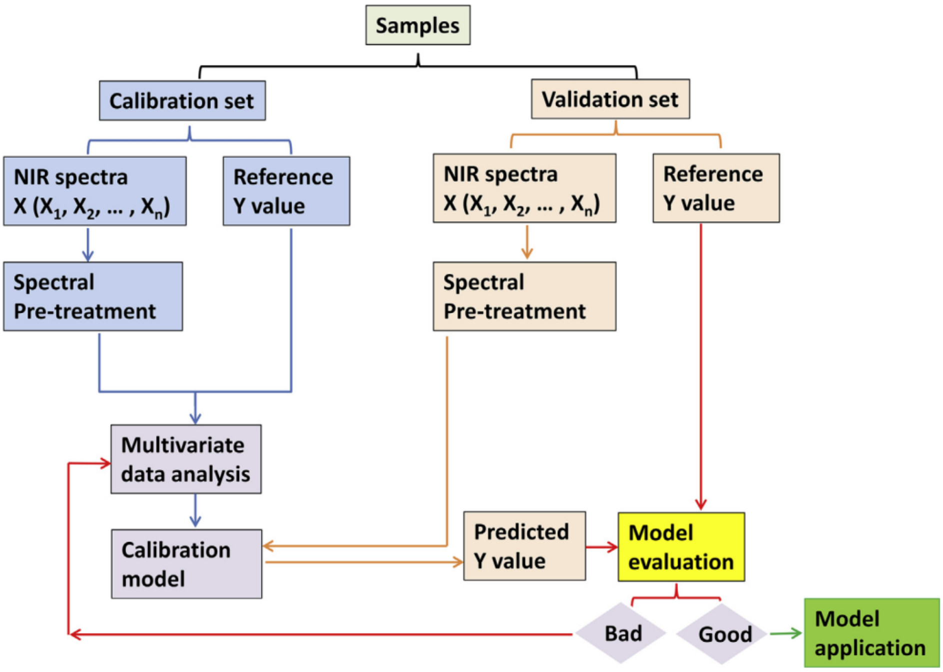


Fig. 2. Calibration model training and evaluation workflow(Pu et al., 2020).



Investigating Secondary Attributes of katik

For evaluating soy milk quality, spectrophotometers are utilized to measure color, refractometers assess viscosity, and digital pH meters check acidity levels.

During fermentation monitoring, dedicated fermentation vessels equipped with temperature control systems maintain specific temperature ranges. pH meters and NIR spectrometers are used to monitor acidity levels, and calibrated pipettes measure inoculation ratios.

To maintain hygiene, autoclaves sterilize equipment, UV sterilization chambers decontaminate air and surfaces, and hygrometers monitor humidity levels.

Quality checks involve high-performance liquid chromatography (HPLC) for chemical composition analysis, petri dishes and incubators for microbiological testing, and sensory panels in specialized booths for taste, aroma, and texture assessment.

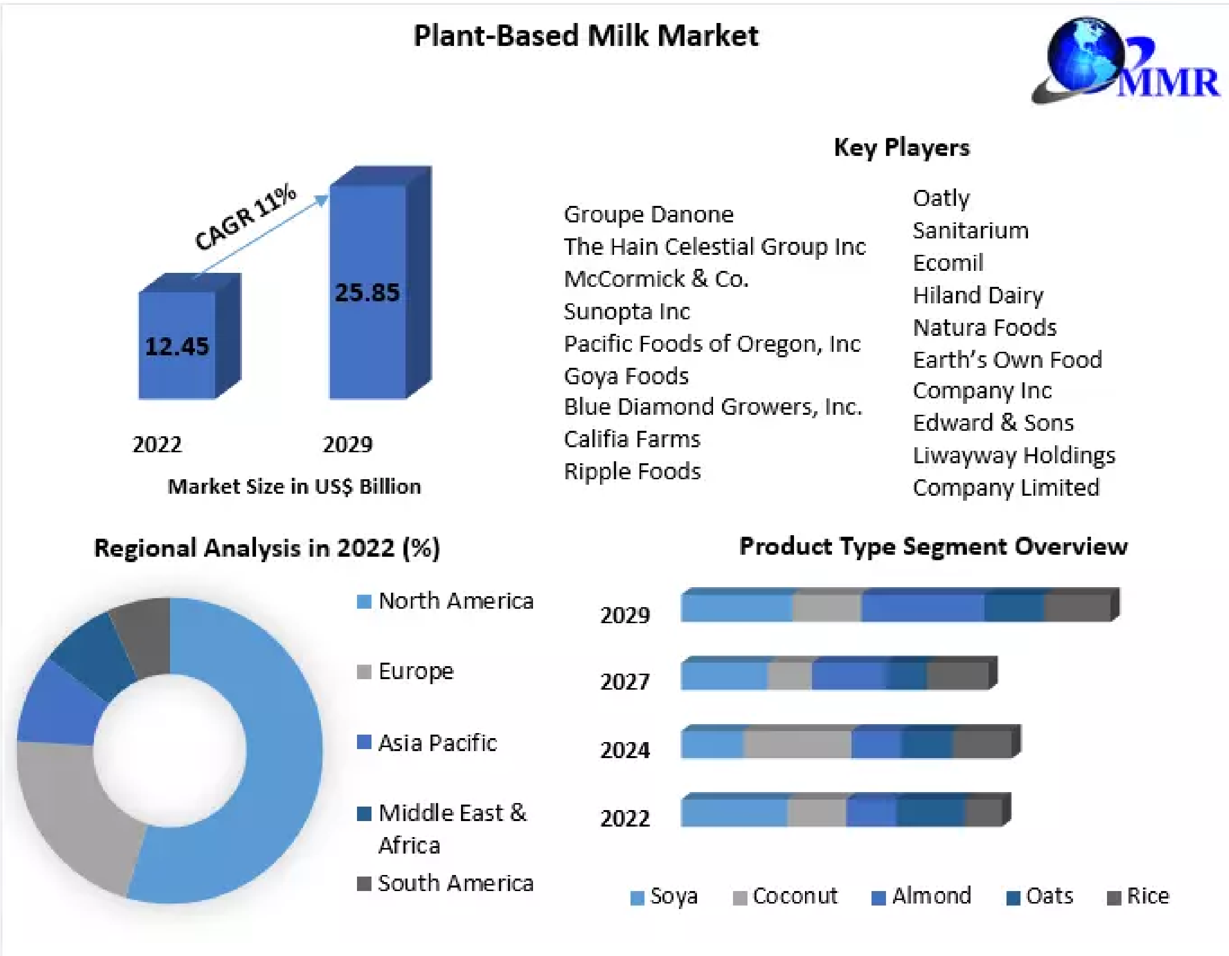
Analytical techniques employ advanced spectrometers such as Fourier-transform infrared (FTIR) and nuclear magnetic resonance (NMR) for molecular analysis. Gas chromatography-mass spectrometry (GC-MS) identifies volatile compounds.

According to UzDSt 1223:2009(“1223:2009-сон 31.07.2015. Катык из коровьего молока,” n.d.) toxic elements like zinc, mercury, arseniy and lead need to be checked. They are determined using classical methods of analysis(non instrumental analytical techniques).

Market Analysis, Innovation, Reproducibility, and Commercial Viability

The study of the market shows an increasing want for dairy products made from plants("Plant-Based Milk Market," n.d.), especially among those who can't eat milk sugar and animal-free diet lovers. Right now, people like eating food that's good for their health and doesn't harm the environment. The possible sales for soy-made katik seem good. The new way to make katik from soybeans is by using machines for product checking. Setting up a NIR spectrometer that can quickly and in real-time check important details. NIR tests have many benefits over old ways, making them the best pick for checking quality and improving processes in soybean katik craft.

Fig. 3. Plant based milk market analysis("Plant-Based Milk Market," n.d.).



In Uzbekistan, where they grow a lot of soybeans, making katik from these beans is very money-saving because there's lots of cheap workers and the raw materials are in their country. In 2022, soybeans were grown as a main and secondary crop on 80.4 thousand hectares("Uzbekistan expands the area under soybeans, increasing soybean oil and meal production," 2023). This means that getting the raw materials needed for these crops is done really well. The cost benefits linked to the job market in Uzbekistan show that large-scale production is possible on a big scale without lowering quality. Deals with big local food makers and selling through stores like Korzinka, Makro and Havas make the katik product more business-friendly.

The product aligns seamlessly with current consumer trends and preferences, catering to the increasing demand for plant-based and nutritious options. Potential partnerships with health food stores, supermarkets, and specialty retailers enhance the commercial relevance of katik from soymilk, aligning it with existing marketing strategies and distribution networks.

A preliminary financial analysis shows the potential profitability and positive return on investment, further supporting its feasibility.

Conclusion

In short, it's important all over the world to consume plant based dairy milk instead of animal based dairy products. This will help protect nature and animals, and is better for our bodies too. This change is important in Uzbekistan as well, where they grow a lot of soybeans. But, taking these items to the market in Uzbekistan requires consideration of special flavors and financial issues. Economy of the country should be considered too.

The study has limitations. Firstly, due to seasonal changes, raw product composition changes. NIR spectrometry is good for quick checks, but it has problems like keeping the instrument steady and calibration model transferability. These issues need continuous attention and validation for reliable use at an industrial scale. Checking soybean quality, affected by season change, is important to maintain good product quality.

Next, signals from spectroscopy work well for both fat and protein. But there are still problems when it comes to carbohydrates in soy milk because of light scattering(Riu et al., 2020).

Finally, to create a calibration model for NIR spectroscopy analysis, we need reference measurements from HPLC(High-Performance Liquid Chromatography), and assembling these datasets is a time-consuming and costly process.

To conclude, moving towards plant-based dairy replacements in Uzbekistan looks good but we need to think about taste choices, financial and technological problems.

Continued research and development, along with addressing these challenges, are crucial for realizing the potential of plant-based dairy products for Uzbek consumers, promoting sustainability and health awareness.

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