Szkoła Główna Gospodarstwa Wiejskiego

w Warszawie

Instytut Nauk o Żywności

mgr inż. Patrycja Malinowska

Skład i właściwości biochemiczne fermentowanych napojów z nasion roślin strączkowych

The composition and biochemical properties of fermented legume–based beverages

Rozprawa doktorska

Doctoral thesis

Rozprawa doktorska wykonana pod kierunkiem

dr. hab. Małgorzaty Ziarno, prof. SGGW

Katedra Technologii i Oceny Żywności

Instytut Nauk o Żywności

Szkoła Główna Gospodarstwa Wiejskiego w Warszawie

Warszawa, rok 2024

Abstract

The composition and biochemical properties of fermented legume–based beverages

The presented study aimed to develop fermented bean–based and lentil–based–beverages, using selected technological processes that improve their nutritional value and content of bioactive compounds. Four research hypotheses were formulated and verified by conducting research divided into stages. The research commenced with the production of plant-based beverages utilizing white beans and brown lentils. Subsequently, optimal parameters for germination and fermentation processes were determined. The fermentation was analyzed using three industrial starter cultures (YO–MIX 207, ABY–3 and Beaugel Soja 1), containing bacteria from the genera *Lactobacillus*, *Streptococcus* and *Bifidobacterium*, assessing their effect on pH and the population of microflora in fermented beverages. Then, the nutritional value, physical properties and biochemical properties of the tested products were characterized, analyzing the effect of the germination and fermentation processes on the analyzed parameters. "The nutritional value was determined based on an analysis of protein, fat, selected carbohydrates, B vitamins, and fiber content, as well as an analysis of the profile and distribution of fatty acids in triacylglycerol molecules and the glycemic index. The physical properties were characterized by analyzing the color, stability, particle size and rheological properties. Biochemical properties were analyzed by determining the content of phenols, the ability to inhibit the DPPH radicals, the content of isoflavone aglycones and the profile of volatile compounds. The effect of germination, fermentation and flavoring on the sensory characteristics of the plant–based beverages was also analyzed.

The study showed that the fermentation using the analyzed starter cultures allowed obtaining products with a pH characteristic of fermented milk beverages (approx. 4.5) and a high number of microorganisms ($>10^7$ cfu/cm^3) throughout the storage period. This indicates that plant–based beverages from white beans and brown lentils are a suitable matrix for the fermentation process. The most beneficial was fermentation with starter cultures with the most diverse species composition of microorganisms (YO–MIX 207 and ABY–3), which results from the synergistic action of bacteria from the genera *Lactobacillus*, *Streptococcus* and *Bifidobacterium*. The

presented studies show that the germination and fermentation affect the properties of bean–based and lentil–based beverages. The microorganisms responsible for the fermentation of the investigated beverages produced selected B vitamins and initiated enzymatic transformations leading to an increase in the content of selected isoflavones, modification of the volatile compound profile, and a decrease in the content of selected oligosaccharides. The germination of bean and lentil seeds led to the activation of enzymes modifying the structure of the raw material and initiating the synthesis of new cellular components, which led to the modification of the carbohydrate profile and the profile of volatile compounds, as well as an increase in the content of protein, selected isoflavones and B vitamins in the obtained plant–based beverages. The bean–bases beverages were characterized as viscoelastic liquids with a colloidal suspension structure. Germination influenced changes in particle size, which directly determines the values of selected rheological parameters and the stability of the product. However, the physical properties of bean–based beverages was mainly shaped by the applied technological processes, especially by high–pressure homogenization, which allows obtaining a product with high stability. The base bean–based and lentil–based bevearages were characterized by a relatively low overall sensory quality. The application of the germination did not negatively affect the sensory quality, while fermentation significantly reduced it. The addition of fruit pulp proved to be the most beneficial strategy for increasing sensory quality, primarily by reducing the perceptibility of unfavorable odors and flavors (including leguminous and starchy ones). The combination of various biotechnological processes, such as fermentation and germination, is an optimal solution in the production of bean–based and lentil–based beverages. This allows for a comprehensive improvement of the nutritional properties of the obtained products, which at the same time act as a carrier of probiotic bacteria.

Key words: plant–based beverages, legumes, fermentation, germination, milk substitutes