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Biotechnology

Nutritional Value of the Product Obtained by Bioconversion of Apple Juice Production Waste

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Abstract. Nutritional value of an easily digestible product obtained at the Durmishidze Institute of Biochemistry and Biotechnology as a result of 10-day solid-state fermentation of white rot basidiomycete Sporotrichum pulverulentum G-11 on apple juice production waste was studied. Crude protein content in biomass is 17%, which corresponds to the standards of protein content in feed for both egg-laying and meat chickens (14-17%). The content of crude fat in the biomass – 6.15% exceeds the norm established for the combined feed of laying and meat chickens (2.5-2.8%). The waste conversion product contains various classes of compounds with antioxidant properties. All of the above indicates that the biomass produced by bioconversion of apple juice industry waste can be used as a functional supplement in chicken feed. *© 2025 Bull. Natl. Acad. Sci. Georg.*

Keywords: apple juice production waste, functional food, mycelial fungi, protein-rich biomass, solid-state fermentation

Introduction

Georgia possesses a significant potential for the production of high-quality fruit juices with high organoleptic quality that satisfies the local population demand and is exported along with vegetable juices (Business Formula, 2023). At present, there are several enterprises in Georgia producing high-quality natural fruit juices (Kula, Cheri, Bravo, etc.). According to the available data, thousands of tons of industrial waste are produced annually in the mentioned enterprises, which are thrown into the environment and exacerbate the ecological crisis (Nath et al., 2023).

This undesirable waste of food industry can be transformed by microbial conversion into food additives of high nutritional value and thus promote to the development of low-waste or waste-free technologies for food processing (Nagarajan, Lee & Chang 2021; Mak et.al., 2020).

Apple pomace, a residue that is generated in huge volumes during the juice production is a rich source of carbohydrates, pectin, polyphenols, and other essential nutrients (Sudha et.al., 2006).

Due to its easy availability and low cost, this by-product of apple juice industry can be considered as a promising raw material for the production of nutraceuticals. It should be noted that despite high

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interest of apple juice producing companies, this waste is not being valorized in Georgia; it is unsystematically thrown into the environment and is a source of pollution. Works on the microbial conversion of different industrial wastes is being conducted in the Laboratory of Biotechnology of the Sergi Durmishidze Institute of Biochemistry and Biotechnology, Agricultural University of Georgia. Based on the conversion of apple juice industry waste by the basidial fungus strain *Sporotrichum pulverulentum* G11, a mycoprotein-enriched, easily metabolizable biomass was obtained. The aim of the present paper is to study the nutritional value and antioxidant characteristics of the apple pomace bioconversion product and to test it for non-toxicity.

Material and Methods

Waste of the apple juice industry of Georgian company "Kula" was used as a substrate for bioconversion. Solid-state fermentation (SSF) of the selected strain *Sporotrichum pulverulentum* G11 on apple juice production residues was carried out under preliminary established optimal composition of the nutrient medium and cultivation conditions of the strain (Mkervali et al., 2023).

The non-toxicity of the strain *Sporotrichum pulverulentum* G11 was evaluated by the express-test method, using Paramecium caudatum (Guryanov et al., 2008).

The nutritional value of biomass was determined by modern standard methods: crude protein content according to ISO-5983-2: 2009/2016; crude fat – GOST 5668-68; humidity -GOST 13496 3-92; sodium – EN1551102017; magnesium – EN1551102017; zinc – EN 1551102017; phosphorus – EN 1551102017; ash by GOST 13979 6-69; and potassium – EN 1551102017. The content of soluble sugars was determined by spectrophotometric method, using 3,5-dinitrosalicylic acid (Spectrophotometer SPECOL 11, Carl Zeiss, Germany), ascorbic acid was determined by the dichlorophenolindophenol titration method (Ermakov, et al., 1987). Spectrophotometric methods were used to determine the contents of tocopherol (Fillipovich et.al., 1982), carotenoids (De Carvalho et al., 2012) and proline (Bates et.al., 1973). Total antioxidant activity was measured using 40 μM diphenyl-picryl-hydrazyl (DPPH) solution (Koleva et al., 2002).

Results and Discussion

A mycoprotein-enriched, easily digestible biomass obtained at the Sergi Durmishidze Institute of Biochemistry and Biotechnology as a result of 10-day SSF of white rot basidiomycete strain *Sporotrichum pulverulentum* G-11 on apple juice production wastes was studied (Mkervali et al., 2023). Taking into account that the mentioned biomass will be used as a functional supplement in poultry feed, its toxicity should be excluded. Although there are no data in the literature about the presence of pathogenic or toxic strains among the species *S. pulverulentum*, nevertheless, we carried out a mycotoxicity study of strain *S. pulverulentum* G-11. The express-test method used for evaluation of the toxicity is effective to determine even the smallest dose of the toxin (Guryanov & Jusupova, 2008).

The obtained negative result confirmed our assumption about the non-toxicity of the selected strain and respectively on the safety of the bioconversion product.

Further, a nutritional value of the biomass was studied for the consideration of the product as a potential feed supplement for poultry. For this purpose, the content of micro- and macro-elements, some vitamins, fats, crude protein, easily metabolizable sugars in the product, as well its antioxidant properties were studied. As is seen from Table 1, the biomass obtained by microbial conversion of the residues of apple juice industry contains macro elements: sodium, phosphorus, calcium, magnesium and zinc.

The content of raw protein in the biomass is 17%, which meets the required standards on protein content for both egg-laying and meat chickens. Crude fat content in biomass is 6.15%, which is significantly higher than the suggested norm (2.5-2.8%) for feed of laying hens and allows to regulate the content of fat in the feed ration of poultry (Todua et al., 2009). The determined high content of easily metabolizable sugars in the product increases its nutritional value (Table 1).

Table 1. Content of micro- and macroelements, crude protein and fat, metabolizable sugars in the biomass obtained by conversion of apple pomase with a strain *Sporotrichum pulverulentum* G-11 (calculated on an absolute dry weight (ADW))

N	Components	Content in biomass
1	Humidity	5.8%
2	Sodium	1.06%
3	Zink	15 mg/kg
4	Phosphorus	0.39%
5	Ashes	4.3%
6	Magnesium	0.18%
7	Potassium	0.82%
8	Easily metabolizable sugars	120 mg/g
9	Crude protein	17%
10	Crude fat	6.5%

One of the most important and integral characteristics of a potential food additive – total antioxidant activity was studied of the bioconverted product. Total antioxidant activity refers to the free radical scavenging ability of hydrophilic antioxidants present in the test material, without specifying the class of compounds (Arnao et al., 1999). A number of papers show a correlation between the amount of hydrophilic antioxidants and the total antioxidant activity (Wu et al., 2004). Currently, it is believed that antioxidants protect the body from the development of sclerosis and cardiovascular diseases, reduce the risk of developing tumors, help to slow down the aging process, and strengthen the immunity (Crozier et al., 2006). It is evident that the higher is the content of antioxidants in a product, the higher its nutritional value is. Therefore, choosing a food source/supplement rich in antioxidants is relevant. If the total antioxidant activity of the product exceeds 70%, it is considered as a product with high activity, within 60-70% as medium, and less than 60 – as low antioxidant activity (Luzia & Jorge, 2014). According to this assumption, the apple juice production residues bioconversion product is characterized by moderate total antioxidant activity (Table 2).

The contents of ascorbate, tocopherol, carotenoids and proline in the apple pomace bioconversion biomass are represented in Table 2. Tocoferol is a lipophilic antioxidant that inhibits the free radicals production. Vitamin C protects the body from damage caused by free radicals and plays an important role in a number of metabolic processes. Carotenoids are precursors of vitamin A, which is known for its photo-protective, antioxidant and immunity-boosting effects (Maoka, 2020). The biomass contains sufficient amount of proline, one of the important amino acids, which is necessary for the production of collagen and cartilage, a structural protein and a flexible connective tissue, respectively, that contributes to the elasticity and protection of joints (Wu et al., 2011). The biomass of bioconvertion of apple pomace, rich in antioxidant and protective compounds makes it a valuable product for its application as chicken feed supplement.

Table 2. Total antioxidant activity and content of ascorbate, tocopherol, carotenoids and proline in the biomass obtained by the conversion of apple pomace with a strain *Sporotrichum pulverulentum* G-11

Ascorbate, mg%	Tocopherol, mg/g	Carotenoids, mg%	Proline, μg/g	Total antioxidant activity, % of free radicals inhibition
Calculated on an absolute dry weight				
65	7	55	360	65

Conclusions

The10-days SSF of the basidiomycete strain Sporotrichum pulverulentum G-11 on apple pomace, the by-product of apple juice production industry resulted in easily digestible, non-toxic biomass, rich in mycoprotein, crude fat and microelements. The antioxidant activity was found to be 65%, which is due to the presence of several strongest reductants and radicall scavengers. These characteristics indicate that the obtained product of biotransformation of apple juice production wastes could be used as a valuable feed supplement for chickens.

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საქართველოს აგრარული უნივერსიტეტის, სერგი დურმიშიძის ბიოქიმიისა და ბიოტექნოლოგიის ინსტიტუტის ბიოტექნოლოგიის ლაბორატორიაში თანმიმდევრულად განხორციელებული ექსპერიმენტების შედეგად, ვაშლის წვენის წარმოების ნარჩენებზე მერქნის თეთრი ლპობის გამომწვევი ბაზიდიომიცეტის შერჩეული შტამის Sporotrichum pulverulentum G-11-ის 10-დღიანი მყარფაზოვანი კულტივირების პირობებში, მიღებულია ადვილად მონელებადი, არატოქსიკური ბიომასა. შესწავლილია მისი კვებითი ღირებულების მნიშვნელოვანი მახასიათებლები. ნედლი პროტეინის შემცველობა ბიომასაში 17%-ს შეადგენს, რაც შეესაბამება როგორც კვერცხისმდებელი, ასევე მეხორცული ქათმების კომბინირებულ საკვებში ცილის შემცველობის სტანდარტებს (14-17%). ნედლი ცხიმის შემცველობა (6,15%) კი აღემატება კომბინირებული საკვებისთვის დადგენილ ნორმას (2,5-2,8%). პროდუქტი შეიცავს მიკრო და მაკროელემენტებს და ანტიოქსიდანტური თვისებების სხვადასხვა კლასის ნაერთებს (ასკორბინის მჟავა, ტოკოფეროლი, კაროტინოიდები) მნიშვნელოვანი რაოდენობით. ყოველივე აღნიშნული მიუთითებს იმაზე, რომ ვაშლის ნაწნეხის ბიოკონვერსიით მიღებული პროდუქტი ფუნქციურ საკვებ დანამატს წარმოადგენს.

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