

DEVELOPMENT OF INNOVATIVE TECHNOLOGIES FOR A HIGHER LEVEL OF BERRY FRUITS PROCESSING IN SERBIA

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ABSTRACT: In accordance with the national strategy for sustainable development, the objective of our investigation is to develop innovative technology for a higher level of raspberries processing and to obtain products for the food and confectionery industries, as well as the active ingredients for the functional foods and dietary supplements. The concept of food engineering is applied in the development and scale up of processes from laboratory to semi-industrial level. Key entities of the product quality for medical application are verified by antioxidant capacity, anti-microbial and anti-cancer effects. Incremental innovation is achieved in the process development and additive innovation in the design of technical solutions. A preliminary economic feasibility shows positive effects in relation to the raspberries costs for the higher level of processing, domestic market capacity and sales prices of competitive products. The current level of innovative technology and estimated economic indicators provide the basis for the development of industrial technology, competitive production and international technology transfer through a business model based on partnership relations with the use of development funds, loans and grants.

Key words: *berry fruits, higher level processing, food engineering, innovation, economic indicators*

INTRODUCTION

Serbia has a large quantity of natural and acquired raw material resources available in agriculture and in food industry. The natural raw material resources are exported or used for lower phase of preparation. The acquired resources are mostly used as waste material. The existing, available technological equipment capacities of chemical, food and pharmaceutical industries (Hranisavljević, 2007), would be used for manufacturing bulk products for food and confectionery industries and the medical substances for functional foods and dietary supplements.

The fruit processing chain is at a low level within the current development and a food product range. Serbia exports fruit as frozen products, processed at the lowest level (Hranisavljević, 2010). In the case of the berry fruits (raspberries, blackberries, etc...) the products of a higher processing level are mostly imported.

On a global scale, raspberries are very important in many different fields, from food and confectionery to pharmaceutical and cosmetics products. Raspberries are a significant source of anthocyanins and quercetin, the powerful antioxidants. These decelerate the effects of aging, prevent cancer and may reduce the risk of heart disease. Quercetin also reduces the release of histamines, which may minimize allergic reaction. In addition, raspberries are a significant source of ellagic acid, a phenolic compound known to have potential anti-carcinogenic features (www.bremnerfoods.com). Raspberry seed oil has very important application. Red raspberry seed oil is a superb antioxidant. It contains 83% essential fatty acids, especially high levels of Omega-3 and Omega-6 acids, and exceptionally high levels of alpha and gamma tocopherols, Vitamin E. Thus, the red raspberry oil is known especially for the prevention of gingivitis rashes, eczema and other skin lesion and sun protection. It is useful in skin creams, bath oils and tooth paste (www.man-gmbh.com).

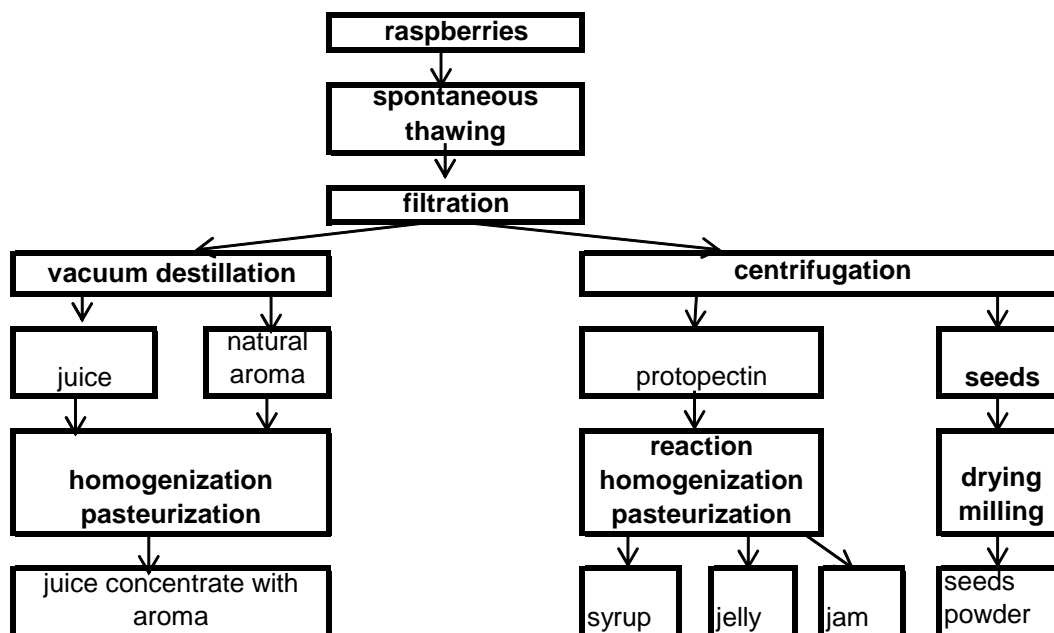


Figure 1. Flow diagram for the higher level of raspberries processing

Spontaneous thawing of raspberry as a critical process is performed at the temperature of $t=20-30^{\circ}\text{C}$ with the absence of oxygen and light. During this step the tanning reactions (enzymatic and non enzymatic) are carried out at the temperature of $t = 20-25^{\circ}\text{C}$ resulting in a greater concentration of coloring substances (flavonoides), increased antioxidant capacity and biological activities of the products obtained.

The protopectin is reactant in the hidrolisis to the pectin production The reaction was carried out at the temperature $t = 85^{\circ}\text{C}$ and pH 3,2-3,5. At the same time the homogenization and pasteurization are performed. The native ingredients in raspberries obtain a higher viscosity and degree of gelling depend on the pectin concentration.

In all technological stages the temperature is lower than $t = 85^{\circ}\text{C}$, thus reducing the denaturation of biologically active substances in raspberries. Short retention time of material flows at the target temperatures creates conditions for the energy efficient technologies.

A technical solution for condensation the aroma is designed. The 2-stage vacuum distillation of aroma-water mixture evaporation is applied. The distillation was carried out at vaccum of 740 mmHg and temperature $t = 20-25^{\circ}\text{C}$. The technical solution being easier to use, more favorable in terms of energy efficiency and more acceptable in terms of investment, compared to the traditional process of rectification.

The concept of modular technology is applied. The modules are formed with standard processing equipment in accordance with the technology for obtaining a target final product. (Figure1). The concept allows for the efficient use of available production capacity in the domestic food and pharmaceutical industries, and the contents of modules can also be applied in processing other types of berries.

A preliminary economic feasibility shows positive effects in the application of the concept of integrated obtaining the products (Table 1, Figure 1). Based on the achieved material balance for the amount of final products and semi-products from 1kg of raspberries and the selling prices for the same amount of imported final products, the share of the raspberries purchase price in the aggregate selling price of the product is 1-3%.

Domestic production of raspberry's products is poorly represented and is carried out according to traditional methods and with small production capacities. During 2010, Serbia exported about 80% of frozen and fresh raspberry, while the remaining stock was used for the production of jams, concentrates, juices, etc... Over the years, the production of jams, marmalades, purees and pastes has been increasing. Serbia exported about 53 tones of them in 2010 (www.trademap.org).

In accordance with the National strategy for sustainable development, the aim of the case study presented in this paper is a part of our investigation (Hranisavljević, 2011) to develop innovative technologies for a higher level of raspberries processing and to obtain bulk products for the food and confectionery industries (juice concentrate, natural aroma, natural colors), as well as active ingredients for functional foods and dietary supplements (seeds, pectin).

MATERIAL AND METHODS

The process engineering concept (Kolomejcová, 2001; Mahoney, 2006) is applied in the innovative development for higher level of raspberries preparation.

Incremental innovation is achieved in the key process development and additive innovation in the design of technical solutions.

Key entities of the product quality were dry material content and pectin concentration. In the case of medical application, the products quality will be verified by antioxidant capacity, anti-microbial and anti-cancer effects analysis (Hranisavljević, 2011-2015).

A preliminary economic effect was defined in relation to the raspberries costs for the higher level of processing, domestic market capacity and sales prices of competitive products.

The business model based on partnership between the research Institutes and the University is applied.

RESULTS AND DISCUSSION

The technologies are developed for a higher level of the raspberry processing with the aim of obtaining products of various profiles (Table 1)

Table 1. Product profiles of raspberries at the higher processing level

Product name	Product Category	Use of product
aroma concentrate	final semi-product	natural aroma juice concentrate with aroma
juice concentrate	final semi-product	natural colors no aroma juice concentrate with aroma
juice concentrate with Aroma	final semi-product	natural colors with aroma syrup
protopectin	semi-product	syrup, jam, jelly
seeds powder	final	dietary supplement

The eco-friendly technologies are developed. Thus, seeds and aroma are obtained as products and not treated as waste. Processes and technical solutions enable utilization of all the active ingredients from the raspberry fruit and integrated outcome of a several final products of processing (Figure 1).

CONCLUSIONS

Incremental innovation was achieved for the higher level of raspberries processing by using the integral concept at semi-industrial scale.

The modular technological concept was applied and additive innovation for existing technological equipment was achieved.

Non-waste and energy efficient technologies were developed, thus maintaining active ingredients of raspberries.

It is possible to develop a pilot-sample product at a higher level of the raspberry processing for investigating the domestic market with the aim of substituting the product import.

The final product for the food and confectionery industries (juice concentrate, natural aroma, natural colors), as well as the active substances for dietary supplements and functional food (seeds, pectine) were obtained.

Under the conditions of integrated output of the final products, the material balance achieved shows economically efficient participation of the raspberry price in the selling prices of imported products.

The achieved level of innovative technology and the preliminary economic indicators establish a basis for the industrial development of technologies and for competitive production.

Valorization of own knowledge could be possible via the development of technology export through the mechanisms of international technology transfers.

The innovation of a business model is possible through the strategic alliance and the cluster-based networking of the raspberry producers, small and medium-sized enterprises, as well as through the use of government and regional development funds, loans, and grants.

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