Dr inż. Barbara SIONEK
Department of Food Gastronomy and Food Hygiene, Institute of Human Nutrition Sciences
Warsaw University of Life Sciences – WULS, Nowoursynowska St. 159C, 02-776 Warsaw Poland
Katedra Technologii Gastronomicznej i Higieny Żywności
Instytut Nauk o Żywieniu Człowieka, ul. Nowoursynowska 159C, 02-776 Warszawa, Polska

THE USE OF FRUIT BIO-WASTE ON THE EXAMPLE OF APPLE POMACE®

Wykorzystanie bioodpadów owocowych na przykładzie wytłoków jabłkowych®

Key words: apple pomace, fruit pomace, waste management, fruit residues.

Apple processing generates a huge amount of bio-waste in the form of pomace, which instead of being managed, contribute to environmental pollution. Apple pomace is formed mainly at the stage of apple processing and food production. It is valuable material that can be reused in a agriculture industry according to the circular economy concept. Unprocessed or slightly processed fruit residues can be converted into animal feed or be used as biofertilizers. Apple pomace contains valuable substances and compounds that can be successfully used in food, cosmetic and pharmaceutical products. Another form of using apple pomace is the extraction of biofuels. According to the idea of sustainable development rational management of bio-waste benefits economically, reduces environmental pollution and contributes to the reduction of greenhouse gas emissions.

Słowa kluczowe: wytłoki jabłkowe, wytłoki owocowe, gospodarka odpadami, pozostałości owoców.

Przetwórstwo jabłek generuje ogromną ilość bioodpadów w postaci wytłoków, które zamiast być zagospodarowane, przyczyniają się do zanieczyszczenia środowiska. Wytłoki jabłkowe powstają głównie na etapie przetwarzania jabłek i produkcji żywności. Jest to cenny materiał, który może być ponownie wykorzystany w przemyśle rolniczym zgodnie z koncepcją gospodarki o obiegu zamkniętym. Nieprzetworzone lub lekko przetworzone pozostałości owoców mogą być przekształcane w paszę dla zwierząt lub stosowane jako bionawozy. Wytłoki jabłkowe zawierają cenne substancje i związki, które z powodzeniem mogą być stosowane w produktach spożywczych, kosmetycznych i farmaceutycznych. Inną formą wykorzystania wytłoków jabłkowych jest produkcja biopaliw. Zgodnie z ideą zrównoważonego rozwoju, racjonalne gospodarowanie bioodpadami przynosi korzyści ekonomiczne, zmniejsza zanieczyszczenie środowiska i przyczynia się do redukcji emisji gazów cieplarnianych.

INTRODUCTION

The events of recent years have changed the perception of many underestimated issues and problems related to balanced development of food production. Among the many factors, the growing adverse climate changes resulting from global warming caused by human activity, the growth of the human population, the depletion of natural resources, including drinking water, and more recently the spectre of food shortages and the growing energy and economic crisis play a fundamental role. In this context, the inefficient use of globally produced food is one of the biggest problems. It is estimated that 1/3 of the food produced in the world is wasted in the food chain. According to European Commission statistics, it is estimated that in the European Union 20% of the total food produced is lost or wasted. The result is a huge amount of waste that is a potential nutritional value, contains valuable bioactive compounds and instead of being managed, contributes to environmental pollution.

Fruits and vegetables are characterized by a high amount of waste, which is formed mainly at the stage of processing and production of food [4, 5]. Agricultural and food by-products are a valuable source of fiber and antioxidants. They contain a number of bioactive substances such as phenolic compounds, carotenoids, vitamins, polyunsaturated fatty acids, minerals and pigments. Plant by-products **include husks, seeds, pods, stems, roots, pulp and peel residues, and** under-ripe, over-ripe fruits that, **despite their nutritional value, are still rejected by the** food industry [12]**.** As **part of** the circular economy framework, bio-waste can be composted, used in the production of animal feed, used in food and pharmaceutical products, used in the production of cosmetics, packaging, bioenergy production [10, 11]. The increase in environmental awareness in modern societies promotes the use of natural, nutritionally valuable substances contained in bio-waste for food production. This idea meets the expectations of consumers regarding healthy food. According to the data of the Statistics Poland in 2020, total production of cereals in

Corresponding author - Adres do korespondencji: Barbara Sionek, Department of Food Gastronomy and Food Hygiene, Institute of Human Nutrition Sciences, Warsaw University of Life Sciences – WULS, Nowoursynowska St. 159C, 02-776 Warsaw, Poland, e-mail: barbara_sionek@sggw.edu.pl

Poland was 35.5 million t, rapeseed – 3.1 million t, potatoes – 7.8 million t, sugar beet 14.9 million t, fruit trees production in orchards – 3.9 million t, including the largest share apples – over 3.5 million t, field vegetables production – 3.9 million t, fruit production from berry plantations and fruit bushes in orchards – 0,6 mln t (Table 1).

Table 1. Production of main crops in 2020 in Poland

Tabela 1. Zbiory głównych ziemiopłodów w 2020 r. w Polsce

Specification	in million tones
Cereals total	35,5
Rapeseed and turnip rape	3,1
Potatoes	7,8
Sugar beet	14,9
Field vegetables	3,9
Tree fruit	3,9 (**Apple 3,5**)
Berries	0,6

Source: The own study based on Statistics Poland data [29]

Źródło: Opracowanie własne na podstawie danych GUS [29]

According to estimates**,** in Poland, from 20 to 30% of the harvest was wasted, which is from 13.94 to 20.91 million tons of bio-waste. A key challenge is to use natural resources while reducing environmental pollution. The circular economy concept is an interesting proposal to support the reuse of resources in the agricultural industry [8]. In the near future, it is expected that, due to increasing nutritional needs, the proper management and use of food waste will be carried out on a large scale. The European Commission has defined food waste as a priority area and has established mandatory monitoring and reporting on food waste by Member States and has committed to achieving the Sustainable Development Goal (Directive (EU) 2018/851) [13]. In 2021, as part of the reduction of food waste, the European Commission has developed a "Farm-to-Fork Strategy" that will comprehensively cover the issues of the food chain and the value of food [9]. The proper management of food by-products, especially fruit residues is beneficial for the environment and brings measurable economic benefits. The aim of the study, based on data from the literature, was to describe on the basis of the apple pomace issues related to bio-waste management.

APPLE POMACE CHARACTERISTICS

With a production of 3.5 million tons per year, Poland is the fourth largest apple producer in the world, after China, USA and Turkey. Taking into account that about 50% of apples are subject to processing, the amount of bio-waste generated in 2020 in Poland, based on Statistics Poland data, can be estimated at about 0.5 million tons [29]. The main by-product of apple processing is pomace formed in the production of juice and cider, which contain potentially valuable components. The pomace consists of peel, core, seeds, calyx, stems and pulp [26]. Apple pomace represents 20–35% of the fresh weight. The main component of apple pomace is the pulp and peel, which account for 94.5%. The other ingredients are seeds – 4.1% and fruit stalks – 1% [7]. The potentially valuable components, which are phenolic compounds are concentrated in the seed and peel. Dietary fiber in apple pomace consists of soluble and insoluble fibers [19]. Apple dietary fiber consists of cellulose, hemicellulose and pectin. It is estimated that pectin from apple pomace may have a prebiotic effect. Undigested pectin reaches the large intestine where it is a fermentation substrate for commensal bacteria. The use of dietary fiber can have beneficial health-promoting effects [6]. In addition to undigested dietary fiber, apple pomace contains a significant amount of starch and sugar, which also promotes fermentation processes carried out by microorganisms. The composition of sugars in pomace depends on the variety of apples. According to Queji (2010), the average content of apples is 23% fructose, 14.4% sucrose, and 6.7% glucose, respectively [25]. Apple pomace also contain phosphorous, calcium, magnesium and iron [31].

Other components of apple include oil, the main ingredients of which are unsaturated fatty acids, mainly linoleic and oleic acid [16]. Apple bio-waste contains organic acids like oxalic acid, malic acid, and citric acid [22]. Apple seeds contain a cyanogenic glycoside, amygdalin. The degradation of amygdalin in the human intestine can lead to cyanide formation. However, the probability of poisoning is negligible because this would require the consumption of 800 g of apple pomace [21]. A potential problem may be the content of pesticides, because apple plants are intensively sprayed with pesticides, so before processing it is necessary to carry out a toxicological analysis [2]. Apple pomace can be considered as a safe product that can be successfully used in the food chain as part of the **circular** economy framework.

USE OF APPLE POMACE

Apple pomace, like other fruits and vegetables, has a high water content (>70 %), which makes it susceptible to rapid rotting. Hence the requirement to immediately process the pomace after it has been obtained, e.g.drying, so as to prevent rotting processes. To obtain potentially valuable components contained in apple pomace, techniques such as extraction, chemical or biological conversion or synthesis should be used [6]. Processing apple residues requires a professional approach and additional investments that should be economically justified. One of the forms of apple biomass management is the extraction of nutritionally valuable substances from it, e.g. for the production of nutrafarmaceuticals or cosmetics [15]. The second is the use of unprocessed or slightly processed waste, e.g. as an additive to various food products or for the production of feed or bio-fuels [21].

The addition of fruit and vegetable to food products can change their characteristics and affect sensory properties. In order to enrich food products with valuable substances and compounds derived from apple pomace, a small addition (from 3% to 20%) is usually enough. This amount of additive makes it possible to maintain the characteristics of food products and their quality parameters, such as taste, color, texture at a level acceptable to consumers. This is crucial, when making purchasing decisions [24]. The use of apple pomace in bakery products containing fiber, polyphenolic compounds,

flavonoids contributes to the increase in antioxidation activity, which results in a potential, beneficial pro-health effect and the possibility of classifying these products as functional foods. Reis et al. (2014) applied the addition of 20% apple pomace to scones, achieving a fourfold increase in polyphenol content, a 3.3-fold increase in flavonoids and a 3.1-fold increase in proanthocyanidins [28]. Additional benefits result from a decrease in caloric value and glycemic index, which is particularly important in the case of confectionery bakery products [1]. For example, the addition of apple pomace (5%, 10%, or 15%) in cake making can avoid the addition of other flavoring ingredients, as cakes prepared with apple pomace had a pleasant fruity flavor [30].

An interesting issue is the addition of apple pomace to various meat products, including mutton, beef pâtés, poultry sausages and mutton nuggets. Apple pomace is usually used in an amount of about 10%, which does not have a significant impact on the culinary quality and properties of meat products, and is an important source of dietary fiber [18, 27, 32, 33].

Apple pomace due to its high content of phenolic compounds and antioxidants has great potential for cosmetic applications [2]. Due to the fact that they are products of natural origin, the interest in them is more motivating for the cosmetics industry [14]. Thanks to the antibacterial and anti-inflammatory properties of phenolic compounds derived from apple pomace, they can also be used in dermatology [15].

Apple pomace can also be used to produce non-toxic and environmentally friendly biopolymers [31]. In innovative experimental studies, biodegradable film, packaging materials cups, plates and objects 3D were produced from apple pomace [17, 20]. The use of fruit and vegetable bio-waste for the production of films and packaging brings a number of additional benefits resulting from their antioxidant and antibacterial properties. In addition, these packages are a barrier to gases and volatile compounds, they are also characterized by tensile strength [3]. Due to pollution and progressive degradation of the natural environment, increased greenhouse gas emission and lack of water, the management of bio-waste for the production of biodegradable packaging is a particularly desirable trend. However, the production of biopolymers from apple pomace on an industrial scale requires further work.

A promising strategy for the apple industry is to obtain bioenergy from bio-waste. The bioenergies obtained this way (ethanol, methane, hydrogen, electricity and heat) are characterized by low greenhouse gas emissions and lead to a reduction in the use of fossil fuels. In addition to biofuels, biorefineries can source value-added products such as biofertilizers, organic acids, antioxidants, enzymes, dietary fiber, emulsifiers and other natural bio-based materials used both in the food industry and in other fields [23]. Developing a biorefinery using bio-waste requires environmentally friendly technology to economically exploit it on a commercial scale.

CONCLUSIONS

In the food industry, reducing the generation, reuse and recycling of bio-waste are key to the circular economy transformation strategy. For this reason, the basic issue at present is the valorisation of organic waste. By-products of fruit and vegetables should be considered as a raw material that can be converted into an edible or useful form and as a source of valuable ingredients for use in food and other production in industries. Apple bio-waste can be used directly or after minimal processing. Pomace is used as animal feed and as agricultural fertilizer. Apple pomace can be successfully added to food products, including bakery, meat, increasing the fiber content and antioxidant properties, giving them health-promoting properties and functional food characteristics. Information from scientific research indicating the possibility of a wide use of apple pomace is important for the agri-food industry. The use of properly developed technologies and their implementation can bring economical benefits and will have a positive impact on the natural environment.

PODSUMOWANIE

W przemyśle spożywczym ograniczenie wytwarzania, ponowne wykorzystywanie i recykling bioodpadów mają kluczowe znaczenie dla strategii transformacji gospodarki o obiegu zamkniętym. Z tego względu obecnie podstawowym zagadnieniem jest waloryzacja odpadów organicznych. Produkty uboczne owoców i warzyw powinny być traktowane jako surowiec, który może być przekształcany do formy jadalnej lub użytecznej oraz jako źródło cennych składników do wykorzystania w produkcji żywności i innych gałęziach przemysłu. Bioodpady jabłkowe mogą być stosowane bezpośrednio lub po minimalnym ich przetworzeniu. Wytłoki mogą być wykorzystane jako karma dla zwierząt i jako nawóz rolniczy. Wytłoki jabłkowe mogą być dodawane z powodzeniem do produktów spożywczych, w tym piekarniczych, mięsnych, zwiększając zawartość błonnika i właściwości przeciwutleniające, nadając im właściwości prozdrowotne i cechy żywności funkcjonalnej. Informacje z badań naukowych wskazujące na możliwość szerokiego zastosowania wytłoków jabłkowych są ważne dla przemysłu rolno-spożywczego. Zastosowanie odpowiednio opracowanych technologii i ich wdrożenie może przynosić korzyści materialne i będzie miało pozytywny wpływ na środowisko naturalne.

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