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Utilization of Food Industry Byproducts in Producing High Added Value Foods: A Review

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ABSTRACT

Industrialized production demanded higher production volumes and the traditional by -products were replaced by commercial products of low cost and high efficiency. The new production methods, along with the increase in the number of food industry fac-to-ries and the increase in production volume, resulted in an exponential increase in waste. As legal, environmental and economic issues have been reconsidered in the past two decades, it has become more and more obvious that disposal and landfilling of those wastes present environmental and social drawbacks. At the same time, advances in mod-ern chemistry and biotechnology, academic awareness and industrial interest are helping the study of these wastes. The objective of this article is to present the utilisation of some food industry by-products that have a high environmental load and cause disposal problems for food factories when producing high-added-value foods from these wastes with high nutritional values and economic impact.

1. Introduction

Food production and processing in developing countries result in the generation of substantial amounts of waste and byproducts, which have a detrimental impact on the environment and lead to significant expenses. However, these biomaterials possess great potential for producing food additives that can effectively address malnutrition and hunger in the countries where they are produced. Many of these biomaterials contain valuable compounds such as proteins, lipids, starch, micronutrients, bioactive compounds, and dietary fibres. Moreover, biotechnological processes can be employed to reduce antinutritional factors found in some byproducts, enabling their utilisation as food additives or in the formulation of balanced foods. The diagram presented in Figure 1. shows the conceptual use of food waste and byproducts in the minimization of hunger (Torres et al., 2018).

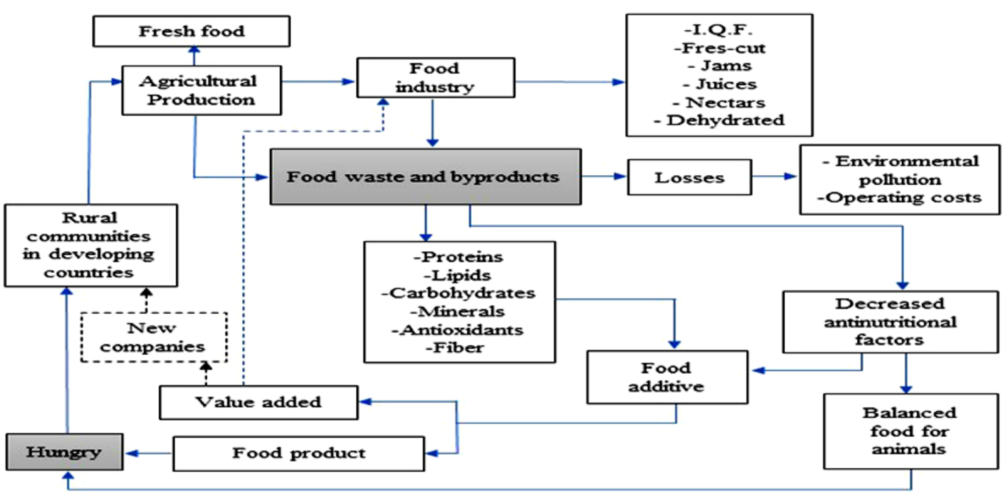

Figure 1. The Conceptual use of food wastes and byproducts in the minimization of hunger

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Food waste is a widespread, complicated, and frequently debated issue in many facets of society. Around 2.6 trillion dollars are lost annually due to food waste worldwide. Food waste can be reduced in part by identifying its sources. The end of the production cycle (meal preparation and delivery) is where food waste typically occurs. The cost of wasted raw materials, the use of cleaning supplies, energy use, salaries of food handlers, water footprint, amount of rest-intake, production waste, energy density waste, use of organic food, and food donation are just a few of the factors that have been identified as having an impact on the social, economic, and environmental dimensions of the sustainability of food waste. Finding these factors can help reduce food waste (Lins et al., 2021).

Food loss can happen during the value chain stages of production, storage, transport, and processing, which have the lowest returns. Source separation, animal feeding, rendering, composting, co-digestion, anaerobic digestion, incineration, and landfilling are the most important food waste management tech-niques. (Sun et al., 2021).

The development of innovative procedures to recycle, reuse and recover food industry by-products is consistent with the growing demand of green mate-rials and renewable resources of nutrients and bioactive compounds for the feed, food, pharmaceutical and cosmetic sectors, which will allow a reduced dependence on the current manufacturing activity with the starting raw materials. In this sense, the valorization of these wastes will provide further alternatives to reduce the environmental impact of the food industry (Brito et al., 2007).

Today, food industry by-products can be used for compost; vermicompost; animal feed and supplements; food and nutritional supplement functional foods and nutraceuticals; color and tannin extracts; inks and pigments; antibacterial agents, skin, hair and healthcare products; filtration and structural materials; biofuel and fuel additives, as well as the production of other forms of bioenergy (Bisson et al**.**, 2002).

Environmental concerns, together with the results of water resource pollution, gave rise to studies regarding waste minimization and by-product disposal in many countries. The objective of this article is to present the utilization of some food industry by-products with a high load on the environment, which causes disposal problems for food factories in producing high added value foods from these wastes with high nutritional values and economic impact.

Food industry by-products utilization

Tomato seeds

The tomato is the second most important cultivated vegetable crop worldwide and is consumed mostly as fresh fruit or processed into various products such as tomato juice, paste, sauce, puree, and ketchup (Lenucci et al., 2013). On the other hand, tomato processing by-products are available at no additional raw material cost and their utilisation can contribute to the creation of value-added products and their commercial valorization, which is the latest trend in the development of functional foods of vegetable origin (Sarkar and Kaul, 2014). Tomato processing wastes (skins and seeds) comprise 10% to 30% of raw fruit weight and tomato seeds represent 50% to 55% of the wastes. The high lysine content of tomato seed protein makes it suitable for supplementing proteins in cereal products. Also, tomato seeds lack anti-nutritional factors or toxic substances often found in other non-conventional protein sources and have a high fiber content (Cantarelli et al., 1989).

Tomato seed protein isolate was added to wheat flour at levels of 2.5%, 5%, 7.5% and 10%, respectively for preparing biscuit samples. Crude protein content in biscuit samples ranged from 14.64% to 18.75%, while total essential amino acid content ranged from 25.92% to 27.14%. A biscuit sample containing 95% wheat flour and 5% tomato seed protein isolate was the best according to its high protein content and acceptable sensory properties, with 87.85% in-vitro protein digestibility, 96.78% biological value, 91.48% true digestibility and 83.46% apparent digestibility (Nematalla, 2002). The cherry tomatoes were divided into three parts: juice, pomace (peels and skins), and seeds. To determine if protein recovery could be increased, the peels and skins, as well as the seeds, were separately treated with carbohydrates.

The seeds had the highest protein content at 27.4%, while the peels and skins contained 7.6% protein. By using Filta 02L (cellulase, xylanase, and β-glucanase), the protein recovery from the seeds in-creased by a small margin of 10%. Similarly, by em-ploying Tail 157 (pectinase and hemicellulase), the protein recovery from the peels and skins increased significantly by 210%. To separate the seeds into two fractions, a strategy was employed, revealing that the hull fraction had a higher fiber proportion (65%) compared to the original seeds (47%). Lignin consti-tuted a significant portion of the fiber in this fraction, while the protein content between both fractions was similar, ranging from 27.4% to 29.9%. (Baker et al., 2022).

2. Red radish peels

Radish, scientifically known as Raphanus sativus L., is a plant species that belongs to the Rapa/ Oleacera lineage within the Brassicaceae family, based on phy-logenetic studies. Radish is considered a root vegeta-ble because its specialised structure, called hypocot-yls, grows either partially or fully un-derground. It has a shape similar to true roots and can store starch and other compounds that contribute to its nutritional val-ue and flavor. Radish has gained scientific attention due to its high potential in terms of nutrition and phy-tochemical content. Studies have shown that radish contains various beneficial com-pounds, such as flavo-noids, particularly anthocya-nins, which have been associated with health benefits. The leaves and sprouts of radish have been found to have the highest concentrations of nutrients and phy-tochemicals. Therefore, incorporating radish leaves and sprouts into a healthy diet is recommended (Radovich, 2018). There is a significant demand for natural food color-ants as alternatives to synthetic dyes. Acylated antho-cyanins, which have increased stability, have been found to possess desirable color and stability for com-mercial food products. Red rad-ish peels have emerged as a potential alternative to FD & C Red No. 40 (allura red). Extracts from red radish peels closely mimic the color characteristics of allura red in model juices. Additionally, acylated an-thocyanins, including those from red radish peels, may find other applica-tions in challenging systems such as dairy products (Giusti and Wrolstad, 2003). Six novel acylated an-thocyanins were extracted from the fresh peels of red radishes. These compounds were then utilised to add vibrant colors to various food products like yoghurt and juices (Tamura et al., 2010). Red radish roots are abundant in non-flavonoid polyphenols, terpenes, de-rivatives, and glucosinolates, with the latter being highly concen-trated in the seeds. Raphanus sativus, the scientific name for red radishes, serves as a valua-ble source of nutrients and phytochemicals. Not only the leaves and sprouts can be considered part of a healthy diet, but the roots as well. Therefore, explor-ing the potential of red radish roots, leaves, and sprouts as raw materi-als for developing nutraceuticals is worth considering. (Gamba et al., 2021).

3. Pumpkin peels

Waste generated from the pumpkin processing indus-try presents an intriguing opportunity to con-vert in-dustrial waste into renewable energy, simulta-neously addressing environmental concerns and pro-moting sustainable development. The diverse applica-tions of pumpkin waste make it a valuable resource. One of the valuable components that can be extracted from pumpkin by-products is fiber fraction. These fractions have multiple uses as food, cosmetic, and pharmaceu-tical ingredients, offering nutritional and technologi-cal benefits while enhancing the utiliza-tion of pump-kin waste. Pumpkin waste is an excel-lent source of carotenoid pigments and contains a sig-nificant amount of starch, constituting 60% of the dry matter (Pająk et al., 2019). Pumpkin waste has also been used as a substrate and support for Lactobacillus casei (ATCC-393), demonstrating its potential in var-ious applications. (Genevois et al., 2016). Pumpkin peel powder included 7.29 mg/100 g of ß-carotene, 3.74% protein, 1.34% fat, 2.9% fiber, and 2.9% fiber. It gelatinized at 90°C and was added to bread prod-ucts as a source of ß-carotene and a source of yellow color. Pongjanta et al., (2004) showed that in confec-tions, pumpkin peel powder could be used in place of wheat flour (10–20%), improving the desserts' yellow color and beta-carotene content while also pleasing con-sumers. In sandwich bread, sweet bread, butter cake, chiffon cake and cookies, five levels of peel powder (10%, 20%, 30%, 40%, and 50%) were used in place of wheat flour. Results showed that a 10% substitution level was suitable for sandwich bread, sweet bread, and cookies, while a 20% substitution level was ideal for butter cake and chiffon cake. Butter cake, sandwich bread, cookies, and sweet bread were the next most popular desserts, with chiffon cake supplemented with powdered pumpkin peels coming in third. The replacement pumpkin products contained 15 to 103.30 g of vitamin A in the form of retinol (Jirapa et al., 2006).

The study conducted by (Norfezah et al., 2011) aimed to evaluate the potential use of waste pumpkin material in extruded snack foods. The researchers used Crown pumpkin (Cucurbita maxima) and processed the fractions of the fruit that are typically considered waste stream products, including the peel, flesh, and seeds. They incorporated the flour obtained from these three fractions into an extruded snack product formulation, along with corn grit, at different levels (10%, 30%, and 50% w/w). The mixture was processed in a twin-screw extruder to produce 10 expanded snack products. A proximate analysis was conducted to determine the nutritional value of the raw pumpkin and pumpkin flour. Additionally, a physical analysis of the product was performed to assess its color, expansion ratio, bulk density, and texture. The study found that incorporating waste stream material, such as peel and seed, at 10% result-ed in extruded products with similar expansion and density characteristics to the control sample. Howev-er, the inclusion of a greater percentage led to chal-lenges in product quality, particularly increased hardness.

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4. Tomato pulp

Waste tomato pomace, which includes seeds, pulp, and skins, is produced along with the industrial processing of tomatoes and makes up between 1 and 5 % (w/w) of the total tomatoes processed into tomato products. (Albanese et al., 2014). Tomato pulp, which is the primary waste product of the tomato processing industry, was utilised in powdered form as a thicken-ing agent in the production of commercial tomato ketchup at various concentrations (1%, 2%, 5%, 7%, and 10% w/w). The inclusion of tomato pulp powder led to a significant increase in the color parameters of the ketchup samples. Even at lower levels, tomato pulp powder demonstrated the potential to compete with other hydrocolloids in enhancing the consistency of tomato ketchup. As the concentration of tomato pulp powder increased, the apparent viscosity of the ketchup samples also increased significantly (Farahnaky et al., 2008).

Tomato pulp waste, which is a byproduct obtained during the processing of tomato juice, has been found to contain abundant lycopene, along with other bioactive compounds such as antioxidants, soluble dietary fibers, and vitamins. Recent research has suggested the possibility of repurposing tomato pulp as an inexpensive source of these bioactive compounds.

How-ever, the high initial moisture content of fresh tomato pulp and the presence of substantial nutrients make it vulnerable to microbial degradation. To address this issue, researchers preserved the fresh pulp of three tomato varieties using two different methods. They then analysed the preserved samples for total phenolic content, flavonoids, lycopene, and antioxidant activity. The results of the analysis showed that all samples contained considerable amounts of phenolic compounds and exhibited good antioxidant proper-ties. The dehydrated samples had a higher lycopene content, indicating that heat pro-cessing can break down the cellular walls and chro-moplast membranes, leading to a better release of ly-copene. These find-ings highlight the potential of re-using tomato pro-cessing waste as a source of bioac-tive compounds and encourage the implementation of a sustainable valorization plan (Trombino et al., 2021).

5. Orange peels

Natural antioxidants are in great demand due to their numerous health benefits. There are recommen-da-tions directing the use of various antioxidants de-rived from plants as natural sources applicable in the food industry. Natural antioxidants were extracted from three different waste sources, i.e., orange peels, cu-cumber peels and potato peels. These extracts were added to sunflower oil at concentration of 600 ppm before subjecting the tested oil to heat at 180°C for varied periods (4, 8, 12, 16 and 20 hrs.) and the effect of treatments on oil stability was examined. Orange peel extracts have a better effect on oil stabil-ity than both cucumber and potato peel extracts. The addition of orange peel extract as a natural antioxi-dant to sun-flower oil resulted in maintaining oil sta-bility after heat treatment at 180°C for time intervals up to 20 hrs, based on the results of peroxide value, anisidine number and thiobarbituric acid value (Hussein, 2010).

Polyphenols and their sources have been broadly studied due to their results on human fitness and are considered to be a top-notch capability component for the composition of meal formulations and dietary supplements consisting of orange pomace and orange peels, which are used within the production of gluten-unfastened bread (O'Shea et al., 2015). The yield of citrus juice represents 1/2 the load of the fruit that is meditated in a massive quantity of waste (in particu-lar peel) that is produced each 12 months globally. In conventional agriculture and product processing, those residues have very little or no value, and a small percent of this waste is being recycled to pro-duce vital oils that may be used inside the cosmetic, food, and pharmaceutical industries (Dominguez, 2016). We developed eco-friendly composite films using chitosan and polyvinyl alcohol (PVA) enriched with orange peel through the solvent casting technique.

We investigated the effects of different orange peel contents (0.25–1.25% w/w) on various properties of the chitosan/PVA films, including barrier properties, bioactivity, color, microstructure, mechanical strength, optical properties, physical characteristics, structural properties, and wettability. The addition of orange peel increased the thickness, flexibility, ther-mal stability, and water vapor permeability of the films. It also improved the films' ability to block ul-traviolet-visible light by reducing transparency. Moreover, the presence of orange peel reduced the films' hydrophobicity and oxygen transmission rate. Interestingly, the orange peel significantly enhanced the antioxidant activity of the films (Terzioglu et al., 2021).

Citrus is a widely cultivated fruit crop and holds the position of being the largest fruit crop worldwide. However, despite its significant production, the po-tential of utilising the byproducts from global citrus fruit processing has not been fully realised until now. An interesting development in this regard is the utili-sation of citrus peels, which contain valuable biopol-ymers and bioactive substances, for the production of food packaging films. Recent research has focused on preparing active packaging films using citrus peels in their powder form. These films were pro-duced from the peel powder of four different citrus fruits: orange, lemon, pomelo, and mandarin. A com-parison of the structural and functional properties of these films re-vealed some interesting findings. Ac-cording to the research, these citrus fruits' peel pow-der contained a variety of substances, including pec-tin (16.36%–23.80%), protein (5.68%–82.3%), fat (3.17%–7.65%), crude fibre (2.88%–6.27%), and polyphenols (11.45–15.47 mg GAE/g). The films made from the four different types of citrus peel powder had a trans-verse look, a yellow or flesh col-our, and a rough sur-face. These films had a thickness ranging from 0.124 to 0.157 mm and a moisture con-tent ranging from 18.16% to 25.25%. Importantly, these films demonstrat-ed strong antioxidant and anti-microbial activity, which effectively hindered the oxi-dation of corn oil. (Yun et

6. Corn silk

Corn silk fiber refers to the collection of stigmas from the maize woman's flowers. The corn silk threads are generally discarded at some point in the processing of child corn as a vegetable. The proximate composition, bodily trends and sensory residences of pork and chicken patties integrated with diverse tiers of dried corn silk were studied. The red meat and fowl patties have been formulated with either 2%, 4%, or 6% corn silk powder. Both cooked pork and bird patties in-cluded with 6% corn silk recorded the best protein attention of 33.30% and 38.42%, respectively. Beef and bird patties formulated with 6% corn silk record-ed the highest cooking yields of 80.13% and eighty-three.03%, respectively, as compared to different remedies. The inclusion of corn silk did not change patron acceptance of corn silk-based red meat and bird patties. Corn silk fibers have been powerful in enhancing the cooking yield, moisture and fat reten-tion of pork and hen patties (Wan Rosli et al., 2013).

Statistical information on baby corn production is limited because many producing countries either do not report baby corn production or include it within the sweet corn category. To date, numerous commercially viable traditional products prepared from corn silk are available (El-Ghorab et al., 2007). In addition to producing unique natural antioxidants and flavoring agents for a variety of food products, including cakes, cookies, muffins, chicken patties, and beef patties, corn silk can also be used. (Rosli et al., 2011). Wheat flour (72% extraction) was substituted with different levels of corn silk powder, i.e., 5%, 10%, 15% and 20%, for making cake samples and their nutritional value, oxidative stability during storage, physical and sensory parameters were evaluated.

Crude protein, ether extract, crude and dietary fiber and phenolic compounds were increased with increasing corn silk powder substitution levels. Cake samples substituted with 15% and 20% corn silk powder were considered excellent sources of dietary fibre and % protein increment was 18.14% and 24.18%, respectively, compared with the control cake sample. Both peroxide and acid values decreased gradually with the increase in corn silk powder levels in cake samples after storage. A cake sample containing 15% corn silk powder recorded the highest overall accepta-bility score, followed by 10% and 5% samples. Cake samples substituted with corn silk powder are considered healthy bakery products with high nutritional value (Arafa et al**.**, 2012).

7. Eggplant peels

The skin of eggplant includes unique styles of antho-cyanins and the foremost anthocyanin in eggplant is delphinidin-3-rutinoside. Anthocyanins have the ca-pability to behave as natural pink, blue and red color-ants that may be used in meals and drinks as alterna-tives to the use of synthetic dyes. Acylated anthocya-nins, along with those observed in red eggplant, have a greater balance and can be included in tough struc-tures such as dairy merchandise (Turker et al., 2004 and Jung et al., 2011). Eggplant fruits, scientifically known as Solanum melongena L., are highly con-sumed worldwide due to their abundant nutraceutical content. They contain a diverse range of phenolics, similar to other fruits and vegetables.

The pulp of the eggplant is particularly rich in phenolic acids compared to other vegetables belonging to the Solanaceae family. Furthermore, the leaves of the eggplant serve as a good source of kaempferol, while the peels contain various compounds, with anthocyanins being the most significant. It is the glycosides of delphinidin present in the eggplant peels that give them their characteristic purple color. Eggplant peels have been found to be a valuable source of anthocyanins, which possess biological activity. Different extraction methods have been explored to obtain extracts with high anthocyanin content, such as solid-liquid extraction (SLE) and ultrasound-assisted extraction (UAE) (Gurbuz et al., 2018).

To determine the ideal level of anthocyanin-rich extract addition for producing the best yoghurt sample from the standpoint of colour and consumer acceptance, yoghurt was chosen to be coloured with anthocyanin-rich extract from aubergine peels at different levels, i.e., 0.95 mL, 1.9 mL, and 3.8 mL, respectively. It was noticed that increasing the levels of anthocyanin-rich extract caused a significant increase in all sensory attributes. With 3.8 mL of eggplant peels, anthocyanin-rich extract achieved the highest increase, and there was the control yoghurt sample and samples containing anthocyanin-rich ex-tract from eggplant peels. So, eggplant peels anthocy-anin-rich extract could be used for coloring dairy products such as yoghurt and other foods (Nematalla, 2013).

8. Rice bran

Rice bran, the secondary product of rice milling en-terprises, which contained a germ and an outer layer, might be taken into consideration as a wealthy supply of nutritional components inclusive of nutri-tional fi-bers, phytic acids, vitamins B and E, gamma oryzanol and gamma amino butyric acid in compari-son to ordi-nary rice grains. Stabilised rice bran has excellent ca-pacity for practical uses, including en-hancing and sta-bilising meat emulsions and coarse floor meats, in-cluding burgers and red meat patties. As an aside, be aware, a relatively excessive percent of protein about 15% is found in rice bran, which may be remoted to a protein content of as much as 90% with a well bal-anced amino acid composition.

As such, rice protein could be very appropriate for producing fitness foods that include formulated meat analogues. Emulsified meat products that might be formulated with a low amount of lean meat content, i.e., much less than 30%, normally require inclusion degrees of three to 4% rice bran. Sausages with even lower lean meat content can be formulated using soy protein isolate to enhance gelation and stabilised rice bran to immobilise water and protect organoleptical properties, which include texture. For low meat emul-sified sausage, an inclusion level of 2% soy protein isolate and 3% stabilised rice bran is normally an amazing starting point (Jiamyangyuen ***et al*.,** 2005 and Henk, 2008).

Rice bran will be used as a source of dietary fiber. Wheat flours (82% and 72% extractions) have been substituted with exceptional tiers of rice bran, i.E., 5%, 10%, and 15%, to provide pan bread and salted biscuits. The outcomes indicated that rice bran might be considered an amazing supply of total dietary fi-ber, which extended via 1.1, 1.4, and 1.6 folds for pan bread samples substituted with rice bran, and the in-crement percentages ranged from 50.31% to a hun-dred thirty five.49% for salted biscuit samples as compared with manage samples. Chemical composi-tion, bodily properties, and sensory assessment of both pan bread and salted biscuit samples showed that the extent of 10% rice bran was observed to be the high-quality alternative degree to wheat flour, with no unfavourable results on bodily and sensory attributes of bakery merchandise. One serving of pan bread and salted biscuits equal to 100g containing 10% rice bran can be considered nutritious in terms of overall die-tary fiber, calorific value, phenolic con-tents and a confirmed antioxidant hobby. Amino acid ratings, protein performance ratio and organic value of bakery merchandise had been additionally stepped forward by way of substitution with rice bran (Arafa ***et al*.,** 2014).

9. Grape pomace

The industrial processing of grapes generates a high quantity of a by-product called pomace, which in-cludes skin, seeds, and rachis and corresponds to about 20% of the grapes used in processing. The solid residues generated in this process are usually trans-formed into animal feed and fertilisers, or they are often discarded incorrectly on the land. Grape pom-ace can be used as a food ingredient because it has a high content of fiber and antioxidant compounds. The dried organic Bordeaux grape pomace, which is com-posed of skin and partially deffated seeds, was ground and sieved, and then wheat flour was substi-tuted with grape pomace, i.e., 20%, 25%, and 30%, for making cookie samples. Sensory, physicochemi-cal, and functional properties of cookies were studied and revealed that, the addition of organic grape pom-ace to wheat flour decreased the water activity and significantly increased the content of fibers, hardness, brittleness, antioxidant activity, and total phenolic content of the cookies. The sensory evaluation results revealed that no significant differences were observed for cookie samples, implying that the addition of grape pomace to wheat flour did not negatively affect the preference of cookies (Sant'Anna et al**.,** 2014; Kar-nopp et al**.,** 2015).

Grape skin was dried for six days at room tempera-ture, reducing the moisture content to 7.14 percent. In order to make cookies, wheat flour was substituted for the powdered dried grape skin at levels of 5%, 10%, and 15%.

According to the findings, grape skin can be used as a partial replacement for up to 15% of composite flour in cookies without impairing their sensory quality (Kuchtova et al., 2016). In place of wheat flour, grape seed flour was used in bread for-mation at amounts of 2.5%, 5%, 7.5%, and 10%. It was found that grape seed flour may replace wheat flour up to 5% (w/w) in bread samples while still maintaining customer ac-ceptance. Higher grape seed flour content resulted in a decrease (Hoye and Rossy, 2011).

Grape seed extract mainly contains 15 phenolic compounds, such as (+)-catechin, (−)-epicatechin, proanthocyanidin, gallate, flavonols and others. Several studies on grape seed extract and its components indicated that it has pharmacological attributes, such as antioxidation, anti-inflammation, anticancer, neuroprotection, lipid lowering, bacteriostatic activity, and reduced blood pressure. The seeds of grapes are valorized to obtain grape seed oil, grape seed flour or powder, and grape seed extract, which are used to improve several properties of diverse food products. Grape seed oil is mostly used for cooking and to make emulsions, while grape seed flour, powder, and extract are used to produce food coatings, films, and food preservatives (Yan Chen et al**.,** 2020).

10. Oat bran

Oat bran is a valuable by-product of the grain milling process and is known for its high dietary fiber con-tent, making it an excellent addition to food products. It contains a substantial amount of protein, minerals, vitamins, and soluble β-glucan, which are beneficial for human health. Research suggests that incorporat-ing oat bran into fermentation processes can lead to several positive effects. A study indicated that the addition of 30% oat bran (w/w) during the fermenta-tion period resulted in a 39% increase in protein con-tent. Furthermore, there was a significant 5-fold in-crease in β-glucan content from 1.3 to 1.6, while un-desirable lignin content decreased by 24% (Eliopoulos et al., 2022). The addition of oat products such as flour, flakes, and bran to wheat flour affects water absorption and the rheological properties of the dough. According to (Gambus et al., 2003), oat bran, which is a by-product of oat milling, is a more valuable supplement to wheat flour than oat flour and its optimal addition amounts up to 5%. The usage of oat grains and their fractions as components in a variety of meals, such as breakfast cereals, drinks, breads, and baby foods, has expanded in the food industry (Sang and Chu, 2017). Oat products are also used in the production of various confectioneries. Oat flour may be added (20–25%) to different doughs like yeast, sponge, short, short-crust, and ginger bread. Moreover, the phenolic contents, antioxidant properties and anti-proliferative capacity of oat brans were higher than those of corresponding whole oat varieties in most food systems (Li et al., 2018).

Oat bran has garnered considerable attention among cereal brans due to its higher content of dietary fibers and phytochemicals. The current study aims to investigate the nutritional and functional properties of oat bran after yeast (Saccharomyces cerevisiae)-induced fermentation. To achieve this goal, a comparative analysis was conducted on raw and fermented oat bran to investigate their nutritional profiles, antioxidant activity, and functional characteristics. The findings reveal that fermentation significantly enhances the levels of crude fat, protein, and total dietary fiber (both soluble and insoluble) in oat bran. Furthermore, the post-fermentation value of soluble dietary fiber increased from 5.01 ± 0.21% to 7.2 ± 0.1%. Fermentation also leads to improved antioxidant activity, as indicated by increased DPPH-RSA and ferric reducing antioxidant power values in the bran samples. Additionally, the anti-nutritional factor phytate was significantly reduced from 1113.3 ± 8.5 mg/100 g to 283.4 ± 3.5 mg/100 g in the bran samples after fermentation. The water-holding capacity of oat bran was also enhanced by 2.11 (5.68%) after fermentation (Mustafa et al., 2022).

4. Conclusion

Recently, much attention has been focused on the utilization of food processing by-products and wastes as well as underutilized agricultural products. Such utilization would contribute to maximizing the avail-able resources and result in the production of various new food products. At the same time, a major contribution to avoiding waste disposal problems could be made. Thus, recycling of waste and food processing by-products constitutes an opportunity for providing valuable materials to the pharmaceutical, cosmetic, nutraceutical, and food industries. Reducing costs and the environmental impact linked to the disposal of these by-products in the production areas could be achieved, which would provide additional income to food factories by producing high-value foods.

References

Albanese, D., Adiletta A., Acunto, M., Cinquanta L. and Di Matteo, M. 2014. Tomato peel drying and carotenoids stability of the extracts. Inter. J. Food Sci. Technol., 49: 2458-2463.

Arafa, S.A., Neven, M.M. and Nematalla, Kh.M. 2012. Effect of corn silk on characteristics and keeping quality of cake. J. Biol. Chem. Environ. Sci., 7(4): 371-400.

Arafa, S.A., Nematalla, Kh.M. and E.M. Khalil, 2014. Formulation and evaluation of some high fiber products. Bull. Fac. Agric. Cairo Univ., 65: 38-49.

Baker, P.W., Preskett, D., Krienke, D., K. S. Runager and Charlton, A. 2022. Pre-processing waste tomatoes into separated streams with the intention of recovering protein: Towards an integrated fruit and vegetable biorefinery approach to waste minimization. Waste and Biomass Valorization, 13:3463-3473.

Bernnan, C.S., Hardacre, A. and Md Nor, N. 2011 Comparison of waste pumpkin material and its potential use in extruded snack foods. Food Sci. Technol, Inter., 17(4): 367-373.

Bisson, L.F., Waterhouse, A.L., Ebeler, S.E., Walker M.A. and Lapsley, J.T. 2002. The present and future of the international food industry. Nature, 418: 696-699.

Brito, A.G., Peixoto, J., Oliveria, J.M., Costa, C., Rodrigues, A. and Nogueira, R. 2007. Brewery and grape wastewater treatment: Some focal points of design and operation. Springer Science Business Media Lie., New York, NY, USA, pp. 109- 131.

Cantarelli, P.R., Palma E.R. and Caruso, J.G.B. 1989. Composition and amino acid profiles of tomato seeds from canning wastes. Acta Alimen- taria, 18(1):13-18.

Dominguez, M. T., 2016. Spray drying bioactive orange peel extracts produced by soxhlet extraction: use of WPI, antioxidant activity and moisture sorption isotherms. LWT Food Sci. Technol., 72: 1-8.

Eliopoulos, C., Markou, G.N. Chorianopoulos and D. Arapoglou, 2022. Transformation of mixtures of olive mill stone waste and oat bran or *Lathyrus chymenum* pericarps into high added value products using solid state fermentation. Waste management, 149: 168-176.

El-Ghorab, A., K.F. El-Massry and Shibamoto, K. 2007. Chemical composition of the volatile extract and antioxidant activities of the volatile and nonvolatile extracts of Egyptian corn silk (*Zea mays* L.). J. Agric. Food Chem., 55(22): 9124-9127.

Farahnaky, A., Abbasi, A., Jamalian, J. and Mesbahi, G. 2008. The use of tomato pulp powder as a thickening agent in the formulation of tomato ketchup. J. Texture Stud., 39(2): 169-182.

Gamba, M., Asllanaj, E., Raguindin, P.F., Kern, H. and Muka, T. 2021. Nutritional and phytochemical characterization of radish (*Raphanus sativus*): A systematic rewiew. Trends Food Sci. Technol., 113: 205-218.

Gambus, H., Pisulewska, E. and Gambus, F. 2003. The use of products of milled naked oat in bakery bread. Biul. IHAR., 229: 283-290.

Genevois, C., Flores, S. and de Escalada Pla, M. 2016. By product from pumpkin (*Cucurbita moschata*) as a substrate and vegetable matrix to contain *Lactobacillus casei*. J. Func. Foods, 23:210-219.

Giusti, M.M. and Wrolstad, R.E. 2003. Acylated anthocyanins from edible sources and their applications in food systems. Biochem. Engineer. J., 14 (3): 217-221.

Gurbuz, N., Uluisikb, Frarya, S.A. and Doganlara, S. 2018. Health benefits and bioactive compounds of eggplant. Food Chem., 268: 602-610.

Henk, W.H. 2008. Stabilized rice bran, an innovative ingredient for meat emulsions and beyond. Poultry Proc. Magazine, 4(2):1-13.

Hoye, C. and Rossy, C. 2011. The supplementation of grape seeds flour with red grape and seeds in bread. J. Food Sci., 76: 428-436.

Hussein, S.M. 2010. The effect of adding some plants residues extracts as nutritional antioxidants on the stability of sunflower oil. 5th Arab. Mans. Con. Food Dairy Sci. Technol., 10: 219- 228.

Jiamyangyuen, S., Srijesderuk, V. and Harper, W.J. 2005. Extraction of rice bran protein concentrate and its application in bread. Songklanakarin J. Sci. Technol., 27(1): 55-64.

Jirapa, P., Angkana, N., Siriporn, K. Tippawan, M. and Thirawat, T. 2006. Utilization of pumpkin powder in bakery products. Songklanakarin J. Sci. Technol., 28(1): 71-79.

Jung, E., Bae, M. E, Jo, Y. and Lee, S. 2011. Antioxidant activity of different parts of eggplant. J. Med. Plant Res., 5(18): 4610-4615.

Karnopp, A. R., Figueroa, A.M. P.R., J.C. Los, Teles, F.T., Kubiaki, Buggio, J.G. and Gran- ato, D. 2015. Effects of whole wheat flour and Bordeaux grape pomace (*Vitis labrusca* L.) on the sensory, physicochemical and functional properties of cookies. Food Sci. Technol., 35(4): 750-756.

Kripanand, S.M. and Kurian, A.E. 2016. Nutritional composition and antioxidant activity of pumpkin wastes. Res. J. Pharmaceutical Bio. Chem. Sci., 6 (3): 336-344.

Kuchtova, V., Karovicova, J., Kohajdova, Minarovicova Z.L. and Kimlickova, V. 2016. Effects of white grape preparation on sensory quality of cookies. Acta Chimica Slovaca, 9(2): 84-88.

Lenucci, M.S., Durante, M., Anna, M.G. Dalessandro and Piro, G. 2013. Possible use of the carbohydrates present in tomato pomace and in byproducts of the supercritical carbon dioxide lycopene extraction process as biomass for bioethanol production. J. Agric. Food Chem., 61: 3683-3692.

Li, C. C., Wang, W.R., Yong, X.L., Li, L.J. and Chen L.Z., 2018. Phenolic contents, cellular antioxidant activity and antiproliferat:ive capacity of different varieties of oats. Food Chem., 239(5): 260-267.

Lins, M., Zandonadi, R.P., Raposo, A. and Ginani, V.C., 2021. Food waste on food service: An overview through the perspective of sustainable dimensions. Foods, 10(4): 1175-1179.

Mustafa, G., Arshad, M.U., Saeed, F.M., Afzaal, B. Niaz and Raza, M.A. 2022. Comparative study of raw and fermented oat bran: Nutritional composition with special reference to their structural and antioxidant profile. Fermentation, 8(9): 510-519.

Nematalla, Kh.M., 2002. Study of the relative nutritive value of some plant proteins in Egypt. Ph.D Thesis in agricultural science, Mans. Univ. Nematalla, Kh.M. 2013. Effect of anthocyanin-rich vegetables on heart disease risk markers. Bull. Fac. Agric. Cairo Univ., 64: 409-424.

O'Shea, N., Roble, Arendt, C.E. and Gallagher, E. 2015. Modelling the effect of orange pomace and peels using response surface design for gluten-free bread baking. Food Chem., 166: 223-230.

Pajak, P., Roznowska, I.P. and Leslaw, J. 2019. Development and physicochemical, thermal and mechanical properties of edible films based on pumpkin, lentil and quinoa starches. Inter. J. Biol. Macromolecules, 138: 441-449.

Pongjanta, J., Siriporn K. and Thirawat, T. 2004. Utilization of pumpkin peels powder in desserts making. J. Sci. Technol., 8: 83-89.

Radovich, T.J.K., 2018. Biology and classification of vegetables (2nd ed.) M. S. Uebrsax, Handbook of vegetables and vegetables processing. Vol: 1, John Wiley and Sons Ltd, pp. 1-23.

Rosli, W., Nurhanan, W.I., Solihah M.A. and Mohsin, A.R. 2011. Corn silk improves nutrient con- tent and physical characteristics of beef patties. Sains Malaysiana, 40(2): 155-161.

Sang, S. and Chu, Y. 2017. Whole grain oats, more than just a fiber: Role of unique phytochemicals. Mol. Nutr. Food Res., 61(7): 715-726.

Sant'Anna, V., Christiano, F.D.P., Marczak, Tessaro L.D.F.I.C. and R. C. S. Thys, 2014. The effect of the incorporation of grape marc powder in fettuccini pasta properties. LWT, Food Sci. Technol. Int., 58: 497-501.

Sarkar, A. and Kaul, P. 2014. Evaluation of tomato-processing by-products: A comparative study in a pilot scale setup. J. Food Pro. Engineer., 37: 299-307.