

Okara: The Hidden Treasure in Soybean By-products

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Introduction

Soybeans are one of the most versatile crops in the world, widely consumed for their high protein content and numerous health benefits. Soy-based products like tofu, soymilk, and soy protein isolates are staples in vegetarian and vegan diets and are increasingly popular for their potential to reduce cholesterol levels and improve heart health. However, the production of these soy products results in a substantial by-product known as okara.

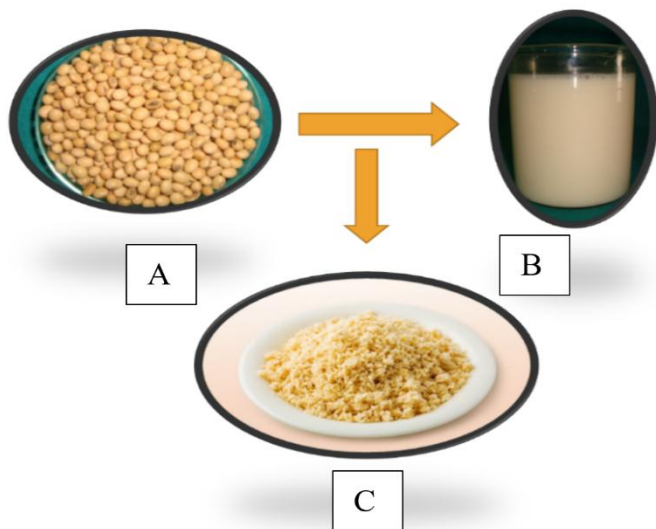


Fig. 1. A. Soyabean, B. Soya Milk and C. Wet Okara

Composition and Characteristics

Okara is the insoluble residue that remains after extracting the liquid from ground soybeans during the production of soymilk and tofu. It is characterized by its fibrous texture and high moisture content, which typically exceeds 80%. Depending on the production process, okara can be either coarse or fine, affecting its potential applications. Nutritionally, okara is a powerhouse. It contains approximately 3.5% protein, 1.5% fat, 4% carbohydrates, and 1% ash, with the remaining 90% being water. Despite its humble appearance, okara retains a significant portion of the soybean's original nutritional value, including protein, dietary fiber, and isoflavones. Isoflavones are phytoestrogens found in soy that have been linked to various health benefits, including reduced risks of heart disease and certain cancers.

Cultural Uses of Okara

Historically, okara has been used in various cultures, particularly in Japan, China, and Korea, where it is incorporated into traditional dishes. In Japan, okara is used to make unohana, a dish where the okara is sautéed with

vegetables and seasonings. In Korea, it is used in recipes like biji-jjigae, a type of stew made with okara, vegetables, and sometimes meat or seafood. These traditional uses highlight the potential of okara as a functional food ingredient, even though it is often underutilized in modern food systems.

Composition of Okara (Dry Basis)

Component	Typical Range	Remarks
Moisture (fresh okara)	75–80% (wb)	Okara is highly perishable due to high water content.
Crude Protein	15–29%	High-quality protein with good amino acid profile.
Crude Fat (Lipid)	6–11%	Contains mainly unsaturated fatty acids; some lipid loss during soymilk extraction.
Total Dietary Fibre (TDF)	50–58%	Rich source; primarily insoluble fibre.
Insoluble Dietary Fibre (IDF)	38–49%	Mainly cellulose, hemicellulose, and lignin.
Soluble Dietary Fibre (SDF)	2–9%	Very low; depends on soybean variety and processing method.
Ash (Minerals)	3–6%	Good source of calcium, iron, magnesium, and potassium.
Carbohydrates (by difference)	20–30%	Includes non-fibre carbs such as residual sugars and oligosaccharides.
Starch (residual)	1–3%	Very low; most starch remains in the soymilk fraction.
Isoflavones (Total)	300–500 mg/100g	Mostly in glucoside forms (e.g., daidzin, genistin); okara retains ~20–30% of total soybean isoflavones.
Phytate (Phytic acid)	0.5–2.0%	Antinutritional factor; chelates minerals.
Trypsin inhibitor activity	1.5–3.2 TIU/mg	Present in raw okara; reduced by heat treatment.
Calcium (Ca)	150–300 mg/100g	Mineral retention depends on soybean processing and water used.
Iron (Fe)	6–15 mg/100g	Good source, though bioavailability may be limited by phytate.
Magnesium (Mg)	100–250 mg/100g	Important for energy metabolism.
Potassium (K)	500–1000 mg/100g	Highest among the minerals; plays a role in electrolyte balance.

Environmental Impact of Okara Disposal

Challenges in Disposal

The industrial production of soy foods generates vast quantities of okara. For example, tofu production alone can generate an estimated 1.1 to 1.2 tons of okara per ton of soybeans processed. The disposal of this by-product poses significant environmental challenges. Due to its high moisture content, okara is prone to rapid microbial spoilage, leading to unpleasant odors and potential contamination if not managed properly. This spoilage also limits the time window for repurposing okara, often leading to its disposal in landfills or as low-value animal feed.

Potential as an Environmental Resource

However, if managed correctly, okara has the potential to be an environmentally friendly resource. For instance, okara can be composted, providing a nutrient-rich organic material that can enhance soil health and fertility. Its high nitrogen content makes it particularly valuable for composting, as nitrogen is a critical nutrient for plant growth. Furthermore, composting okara can help reduce greenhouse gas emissions associated with its disposal in landfills, where anaerobic decomposition would otherwise produce methane, a potent greenhouse gas.

Another environmental application of okara is in biogas production. Anaerobic digestion of okara can produce biogas, which is a renewable energy source. This process not only helps manage waste but also contributes to energy generation, offering a sustainable solution for both waste management and energy production.

Nutritional and Health Benefits of Okara

Dietary Fiber

One of the most significant nutritional components of okara is its high dietary fiber content. Dietary fiber is essential for maintaining healthy digestion, preventing constipation, and reducing the risk of chronic diseases such as heart disease, type 2 diabetes, and certain cancers. Okara is particularly rich in insoluble fiber, which aids in bowel regularity and helps prevent digestive disorders.

Moreover, research indicates that okara also contains a small amount of soluble fiber, which can help lower cholesterol levels by binding to cholesterol in the digestive system and preventing its absorption into the bloodstream. This makes okara an excellent ingredient for formulating foods aimed at improving heart health.

Protein Content and Amino Acid Profile

Okara is also a good source of plant-based protein, which is essential for the maintenance and repair of tissues, enzymes, and hormones in the body. While the protein content in okara is lower than that of whole soybeans, it still provides a substantial amount of high-quality protein. The

protein in okara contains all nine essential amino acids, making it a complete protein source, which is particularly valuable for those following vegetarian or vegan diets.

Additionally, the protein in okara is highly digestible, making it an excellent supplement in food products aimed at improving overall protein intake. The inclusion of okara in foods can enhance their protein content while also providing additional health benefits from its fiber and phytochemicals.

Phytochemicals and Antioxidants

Okara also retains a significant amount of isoflavones and other phytochemicals from soybeans. Isoflavones are known for their antioxidant properties and have been studied for their role in reducing the risk of hormone-related cancers, such as breast and prostate cancer. They may also help alleviate symptoms of menopause and improve bone health by mimicking the effects of estrogen in the body.

In addition to isoflavones, okara contains other antioxidants, such as saponins and phenolic acids, which can help protect the body against oxidative stress and inflammation. These compounds contribute to the overall health benefits of okara, making it a valuable ingredient in functional foods designed to promote well-being and prevent chronic diseases.

Food Industry Applications

Inclusion in Bakery Products

One of the most promising applications of okara in the food industry is in bakery products. Okara can be dried and ground into a flour-like consistency, which can then be used to replace a portion of wheat flour in bread, muffins, and other baked goods. This substitution not only increases the fiber and protein content of the final product but also improves its nutritional profile by adding essential amino acids and phytochemicals.

Furthermore, okara can improve the texture and moisture retention of baked goods due to its water-holding capacity. This is particularly beneficial in products like gluten-free breads, where the absence of gluten can lead to a dry and crumbly texture. Okara can help create a more desirable texture while also enhancing the nutritional value of the product.

Snack Foods and Meat Alternatives

Okara's high protein and fiber content also make it an ideal ingredient for snack foods and meat alternatives. For example, okara can be used in the production of protein bars, granola, and other healthy snacks. Its neutral flavor allows it to blend well with other ingredients, providing a nutritional boost without altering the taste of the final product.

In the realm of meat alternatives, okara can be used to create plant-based patties, sausages, and other meat-like products. When combined with other plant proteins, such as

soy protein isolate or pea protein, okara can help mimic the texture and mouthfeel of meat while adding fiber and enhancing the overall nutritional profile of the product.

Prebiotic and Gut Health Applications

Emerging research suggests that okara may have potential as a prebiotic ingredient. Prebiotics are non-digestible food components that promote the growth of beneficial bacteria in the gut, thereby supporting gut health and overall well-being. The dietary fiber in okara, particularly its oligosaccharides, can act as a prebiotic by providing a food source for gut bacteria.

Incorporating okara into foods like yogurts, smoothies, and cereals can help support a healthy gut microbiome, which is increasingly recognized as a key factor in overall health. A balanced gut microbiome is associated with improved digestion, enhanced immune function, and a reduced risk of various chronic diseases.

Agricultural and Industrial Applications

Animal Feed

One of the traditional uses of okara is as animal feed. Due to its high protein and fiber content, okara is a valuable feed supplement for livestock, including pigs, cattle, and poultry. It can be fed fresh, dried, or fermented, depending on the needs of the animals and the logistics of the farm.

Fresh okara, however, has a short shelf life and needs to be used quickly or preserved to prevent spoilage. Drying okara into a stable feed product can extend its shelf life and make it easier to store and transport. In addition, fermenting okara can improve its digestibility and nutrient availability for animals, further enhancing its value as a feed ingredient.

Soil Amendment and Fertilizer

In agriculture, okara can also be used as a soil amendment or organic fertilizer. Its high nitrogen content makes it particularly beneficial for enriching the soil, promoting plant growth, and improving crop yields. When used as a fertilizer, okara can help reduce the need for synthetic fertilizers, which are often associated with environmental issues such as water pollution and greenhouse gas emissions. Okara can be applied directly to the soil or composted with other organic materials to create a nutrient-rich compost. This compost can then be used to improve soil structure, enhance water retention, and provide a slow-release source of nutrients for plants.

Biogas Production

Another innovative application of okara is in biogas production. Okara can be used as a feedstock in anaerobic digestion processes, where it is broken down by microorganisms to produce biogas. Biogas is a renewable energy source composed primarily of methane and carbon dioxide, which can be used to generate electricity, heat, or fuel.

The use of okara in biogas production not only helps manage the waste but also contributes to sustainable energy generation. By converting okara into biogas, we can reduce reliance on fossil fuels and lower greenhouse gas emissions, contributing to a more sustainable energy system.

Challenges and Future Directions

Overcoming Spoilage and Preservation

One of the main challenges in utilizing okara is its high moisture content and rapid spoilage rate. This makes it difficult to store and transport, limiting its potential applications. To address this challenge, various preservation methods, such as drying, freezing, and fermentation, are being explored.

Drying okara reduces its moisture content, extending its shelf life and making it easier to handle. Freeze-drying is another option, which preserves the nutritional content and structure of okara while removing moisture. Fermentation, on the other hand, not only preserves okara but also enhances its nutritional profile by increasing the availability of certain nutrients and adding probiotic benefits.

Scaling Up Production and Utilization

Another challenge is scaling up the production and utilization of okara in various industries. While small-scale applications are feasible, large-scale processing and distribution require significant investment in infrastructure and technology. Developing efficient and cost-effective methods for processing okara into value-added products is crucial for its widespread adoption.

Furthermore, increasing awareness and demand for okara-based products among consumers and industries is essential for driving its utilization. This can be achieved through education, marketing, and collaboration between food manufacturers, researchers, and policymakers.

Research and Innovation

Ongoing research and innovation are key to unlocking the full potential of okara. This includes exploring new applications, improving processing techniques, and developing new products that meet the needs of consumers and industries. Research into the nutritional and functional properties of okara can also help identify additional health benefits and applications.

In addition, innovation in packaging and distribution can help overcome the challenges associated with okara's high moisture content and spoilage rate. For example, developing packaging solutions that extend the shelf life of fresh okara or create stable dried okara products can open up new markets and applications.

Sustainability and Circular Economy

Finally, the utilization of okara aligns with the principles of sustainability and the circular economy. By

transforming a waste product into valuable resources, we can reduce waste, conserve resources, and create new economic opportunities. Okara offers a model for how by-products from food production can be repurposed and reintegrated into the food system, contributing to a more sustainable and resilient food supply chain.

Conclusion

Okara, often dismissed as a waste product, is a nutritional and environmental treasure waiting to be tapped. Its potential applications in food, agriculture, and beyond highlight the need to reconsider how we treat by-products in food production. By transforming okara from waste to

resource, we can not only reduce environmental impact but also enhance our diets with its rich nutritional offerings. In a world increasingly focused on sustainability and health, okara might just be the next big thing. The future of okara lies in innovation, research, and collaboration across industries. By exploring new ways to utilize this by-product, we can unlock its full potential and contribute to a more sustainable, healthy, and efficient food system. Whether in your next loaf of bread, a plant-based burger, or as a nutrient-rich fertilizer, okara is poised to make a significant impact. As we continue to seek solutions for global challenges like food waste and sustainability, okara offers a promising path forward.
