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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(9): 2648-2650

www.thepharmajournal.com
Received: 18-06-2023
Accepted: 22-07-2023

HC Yadav
Farm Machinery and Power Workshop, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India

Vandana
Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India

Corresponding Author:
HC Yadav
Farm Machinery and Power Workshop, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India

Functional and nutritional qualities of okara and food industry applications

HC Yadav and Vandana

Abstract
Okara is a significant residue created during the processing of soybeans and has a strong nutritional profile. The nutritional makeup of okara is affected by the processing circumstances, variety, pre-treatment, post-production treatments, and processing techniques. It is used as a crucial industrial ingredient in a number of food preparation businesses because of its high quantity of fibres, lipids, proteins, and bioactive components. A number of techniques, such as fermentation, enzymatic processing, chemical processing, biotransformation, and high-pressure microfludization, can be used to enhance the prebiotic potential and nutritional profile. Due to its prebiotic potential, okara is a promising therapeutic option to prevent a range of metabolic diseases as diabetes, obesity, hypercholesterolemia, and hyperlipidemia. The functional, therapeutic, and industrial applications of okara are discussed in the current review along with how processing, especially drying, affects okara quality.

Keywords: Microwave, drying, antioxidant, value-addition

Introduction

Okara is the residue left over after the water-extractable fraction of the ground soybeans is removed and used to produce tofu or soymilk. Japanese speakers refer to it as "honourable hull" or "soy pulp". In Chinese, it is also known as douzha or tofuzha, bean curd residue, and soybean residue. Its beige hue and light, crumbly, fine-grained texture give it the appearance of wet sawdust or shredded coconut and it tastes like nuts (almond and coconut). It is a by-product produced during the production of soymilk that has little economic value but might be a healthy food with lots of fiber, protein, carbs, vitamins, minerals, and fat as well as outstanding functional qualities. Currently, it is either disposed of in landfills or utilized as fertilizer and stock feed. The majority of the okara, particularly in Japan, is burned, producing carbon dioxide. However, because okara is extremely prone to putrefaction, disposing it as garbage might pose environmental issues. Its high moisture content (between 70% and 80%) makes it tough to handle and has a high propensity to deteriorate (Asghar *et al*., 2023) [3]. To extend its shelf life and prevent spoiling, it must be dried fast. There has been a lot of focus on drying okara because of the environmental issues caused by the huge creation of leftovers and its high moisture content. The sensory characteristics and practical characteristics of okara are significantly influenced by the drying process. Okara that has been freeze dried performs best in terms of its ability to hold onto water, to swell, and to bind lipids, followed by okara that has been vacuum or hot-air dried. One of the most important considerations to make during drying is the preservation of the protein quality, which can be affected by the drying conditions. The water-holding capacity, fat-binding capacity, emulsifying and foaming properties, and anti-hypertension actions are all attributed to the high quality protein fraction. These non-nutritional characteristics have an effect on how a certain food product is made and how good it is. While protein solubility rose with larger amounts of deamination, particularly in acidic and alkaline conditions, water holding capacity decreased with acid alteration. It's also crucial to remember that denatured proteins and fibres in okara reduced the solubility of the proteins and their ability to hold water. When it comes to the nutritional-nonnutritional composition and shelf-life characteristics of okara, vacuum tray drying outperforms microwave drying.

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Functional and nutritional composition of okara

The fibres created from dried okara are very good at holding water. Oven drying of raw okara appeared to alter the fibre structure and decrease the water-holding capacities (WHC) as compared to flash drying (Mahanti *et al*., 2021) [6]. Lower water holding capacity (WHC) values of okara were discovered after drying (80 °C) (Ahlawat *et al*., 2018) [2]. They claimed that the purification process, which entailed subjecting the wet okara to proteolysis before extracting the fat using a soxhlet, resulted in a total yield of dietry fibres of 75%, which had the best water holding capacity (WHC). They arrived to the conclusion that high temperature drying of extracted fibres should be avoided since it can alter isoflavones, change the microstructure of the fibres, and reduce overall water holding capacity (WHC).

Okara flour made from decorticated soybean seeds had a water holding capacity of 28.33, 19.74, and 22.8 g/g protein and a protein solubility of 29.98, 25.17, and 41.29 g/100 g material at pH levels of 3, 5, and 7, respectively. Similar to this, okara flour made from whole soybean seeds had 25.55, 21.15, and 29.81 g of soluble protein per 100 g of material at pH levels of 3, 5, and 7, respectively, and 22.03, 19.84, and 17.10 g of water/g of protein water retention capacity. Okara dried at 260°C using a flash dryer had a water holding capacity of 22.23, 18.65, and 24.96 g/g protein and a protein solubility of 14.36%, 12.44%, and 14.74% at pH 3, 5, and 7, respectively. In contrast, when dried using a tray dryer, the water holding capacity was 20.55, 17.10, and 21.41 g/g protein and the protein solubility was 18.32%, 15.14%, and 16.

On a dry matter basis, okara has 52.8–58.2% fiber, 9.3–10.9% fat, and 25.4–28.4% protein. On a wet basis, okara had 0.4% ash, 1.5% crude fiber, 1.5% fat, 4.7% protein, and 85.5% moisture. Okara had a dry matter content of 5.89% total ash, 27.53% crude fat, 11.38% crude fiber, and 30.10% crude protein. Its fresh base composition was 80.50% moisture, 5.87% crude protein, 5.37% fat, 2.22% fiber, and 1.15% ash. On a fresh basis, the calcium and iron contents were 62.49 and 1.48 mg/100g and 320.46 and 7.58 mg/100g, respectively. Iron was 24.99 percent available, and calcium availability was 42.53 percent. They discovered that okara has an in vitro protein digestibility of 80.06% and 611.80 mg of phytic acid per 100g. In contrast to controls, we discovered that in vivo colonic fermentation of okara led to increased total short chain fatty acid production, larger faecal weight, and lower pH in okara-fed rats. Only 0.55% of the total dietary fibre, which was made up of 49% okara, was soluble. There were no statistically significant differences between the two groups in any of the tests, with the exception of lower body weight and more faecal fermentation in the okara-fed group. As a result, it can be claimed that okara has the potential to be an effective prebiotic dietary supplement for weight loss.

Effect of processing on Okara

Okara's high moisture content and water activity provide considerable challenges when it comes to handling since it is quite bulky or "messy" and contains roughly 80% water. Yeasts have the ability to quickly obliterate fresh okara. Therefore, it's crucial to maintain okara before using it. These are the two best methods for keeping okara. Using lactic acid bacteria to ferment it, is one way to stop microbial degradation. Drying okara immediately after manufacture is another method of preservation. The most practical method of preserving this waste is drying, which enables significant cost savings in handling, storage, and transportation. They observed that higher inlet air temperature and velocity expedited drying and that the change in protein content was minimal with just slight colour changes after drying the okara to about 13% moisture. The sensory characteristics and useful characteristics of okara are significantly influenced by the drying techniques. Okara that has been freeze dried performs the best in terms of its ability to hold onto water, to swell, and to bind lipids, followed by okara that has been vacuum or hot-air dried. On the other hand, hot-air-dried okara is superior in terms of cation-exchange capability, followed by vacuum drying and freeze drying. The final product quality of okara flour is shown in Figure 1.

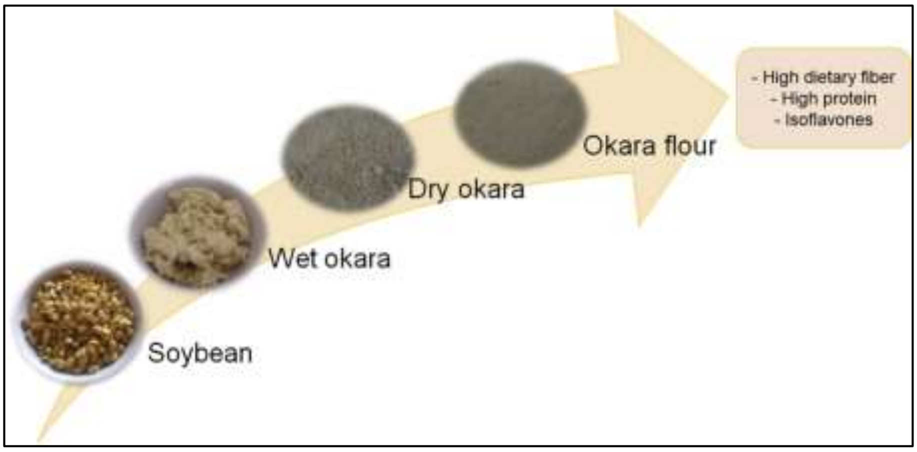

Fig 1: End product quality of okara flour

Microwave-vaccum drying would be a promising and competitive option for drying okara due to its short drying time and small volume. This combined drying strategy can cut drying time by more than 90% while retaining a product quality that is almost equal to lyopholization, as opposed to hot-air drying and lyopholization. Okara was tested for its response to vacuum and microwave drying, and it was shown that okara dried in vacuum trays provides the best sensory evaluation in terms of colour, flavour, and general acceptance. It was also discovered that the vacuum trays dried method is safe for health because okara is dried in this process at a low temperature (45 to 50 °C) for a significant amount of time. They came to the conclusion that the vacuum tray drier method is superior to the microwave procedure for producing okara of high grade.

After drying at 100 °C, the nutritional composition of okara was studied, and it was found that either the process used to create the soymilk—particularly the grinding step—or the quality of the raw material (seed variety and quality) had an effect on the nutritional composition of okara. Additionally, it was found that dried okara had a dry matter protein content of 37.5% and a fat content of 20%. The conservation of okara by drying in a flash dryer found that the process was technically feasible, and the flour made from the okara had protein concentrations between 36.71 and 41.39 percent, lipid concentrations between 13.19 and 16.45 percent, fibre from 21.43 to 43.74 percent, and ash concentrations between 3.61 and 4.59 percent. The primary by-product of the production of soymilk and tofu was freeze-dried okara, which comprised 40.3% of the total sugar (dry weight basis) as nonstarch polysaccharides (NSP). Raw okara also had significant amounts of ash 3.5%, fat 9.8-19.8%, and protein 28.5-33.4%. Effect of tray drying decorticated soybean okara for 8 hours at 68°C on its immediate composition. The amount of moisture, protein, fat, fiber, and ash in the tray-dried, decorticated soybean okara was reported to be 19.69%, along with 43.68%, 16.23%, and 19.17%. Due to its higher protein, carbohydrate, and fat content, dried okara has a higher calorific value than wet okara. Additionally, it has been found that hoover drying food for an extended amount of time at a temperature of 45 to 50 °C is secure, healthy, and offers a superior sensory evaluation in terms of colour, flavour, and overall acceptance. In legume flours (chickpea, lentil, and bean), the influence of dehydration treatments on antinutrient factors and also on protein digestibility was discovered, and it was revealed that phytic acid decreased in the case of lentil (44%), followed by white beans and pink-mottled cream beans. The concentration of polyphenolic chemicals in flours did not decrease as a result of the dehydration. However, all legumes showed a higher rise in in vitro protein digestibility (IVPD) from 12% to 15% (Martín-Cabrejas *et al*., 2009) [5].

Value-addition

Cookies can have up to 30% more dried okara powder added to them without having a negative impact on the cookies' sensory qualities (Ostermann-Porcel *et al*., 2017) [4]. A rice cake machine was used to puff soy/rice cakes from a combination of okara pellets and parboiled rice. The predominant ratios were 90/10, 70/30, 40/60, and 0/100 (w/w) for okara pellets and parboiled rice. Specific volume (SPV), texture, color, flavor, fragrance, and integrity of the cakes were all assessed. Customers favoured the 70% okara rice cakes that did not considerably differ in beany flavour or aroma. In the range of 5 ("liked slightly") to 7 ("liked a lot"), the biscuit made with 30% decorticated soybean okara flour received scores from almost 80% of the assessors. This demonstrated the potential for its use in confectionery items and showed that the use of 30% (w/w) of decorticated soybean okara flour in the formulation of biscuits was regarded appropriate. The panellists unanimously approved the sausage formulations containing 1.5% and 4% of okara flours from decorticated (A) and non-decorticated (B) soybeans, placing special emphasis on the formulation containing 1.5% okara flour A, which received the highest frequencies of scores in the acceptance range (92%) for the parameters of colour, odour, and taste.

Conclusion and perspectives

Okara offers promising functional and nutritional qualities that can be harnessed for various food industry applications. Continued research and innovation are essential to fully unlock its potential and contribute to the development of sustainable and nutritious food products. Further research is needed to comprehensively analyze the nutritional content and bioactive compounds present in okara from different soybean varieties and processing methods. Research into efficient and cost-effective methods of processing okara to retain its nutritional and functional properties is important for its widespread application. Investigating how okara can improve the texture, shelf life, and sensory attributes of different food products is essential for determining its feasibility as an ingredient. Understanding the bioavailability of nutrients from okara-based products and their impact on human health is crucial. Clinical studies are needed to establish the potential health benefits of incorporating okara into diets, including its effects on gut health, oxidative stress, and chronic disease risk. Assessing consumer perception and acceptance of food products containing okara is important to ensure market success.

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