BIOCHEMICAL STUDIES ON BY-PRODUCTS OF SOYA INDUSTRIALIZATION

By

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B.Sc. Agric. Sci. (Biochemistry), Fac. Agric., Cairo Univ., 1996
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APPROVAL SHEET

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ABSTRACT

Okara, the soybean residue from soy milk production, contains nutrients and functional components. The proximate analysis was found to be 33.64% crude protein , 21.08% total lipid and 45.03% total dietary fiber in okara . The risk of development of diabetes type 2 is increasing worldwide in which the lifestyle and diet preference are primary responsible. In the current study, okara (rich source of fiber) has been manufactured into okara crackers which can be used to investigate its dietary role in controlling diabetes in STZ diabetic rats with and without high fat diet. 48 male albino rats were divided into eight groups (six rats in each group). G1, G2, G3 and G4 were healthy rats and fed on basal diet, basal diet with 30% okara crackers , high fat diet, and high fat diet with 30% okara crackers respectively. G5, G6, G7 and G8 were diabetic groups which fed on similar diets respectively as previous groups for 60 days. Blood glucose, liver function, kidneys function and lipid pattern of experimental animals in addition to pancreas and liver histopathology and insulin immunohistochemistry were carried out. Okara crackers diet has decreased the serum glucose level. The activity of AST, ALT and ALP were inhibited in diabetic rats fed on diets containing okara crackers. Uric acid , urea and creatinine content of diabetic rats which were significantly decreased after feeding on okara crackers compared with diabetic control. Total cholesterol ,triglycerides , HDL and LDL were improved when diabetic rats fed on okara crackers. There were cellular changes, a decrease in the number of β cells, a number of islands, and the pancreatic change in the pancreas of the diabetic group, as well as degeneration of liver cells, necrosis and central vein congestion. But rats feeding on the okara crackers have improved tissue and restored parts of the islands. In conclusion, the use of 30% okara crackers in diet has improved the hyperglycemia and hyperlipidemia associated with diabetes.

Key words: okara, diabetes, fiber diet, proximate analysis, crackers.

DEDICATION

I dedicate this work to whom my heartfelt thanks; my family, my mother, my husband for their patience and help, as well as to my friends for all the support they lovely offered along the period of my post-graduation.

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INTRODUCTION

Agro industries are focused in the transformation and processing of raw materials from agricultural source (plant or animal) and contribute to the generation of large amounts of organic residues. These are solid or liquid materials, which are not used in the production chain, and constitute a serious problem because, apparently without viable application, they are discarded directly into the environment and, if not properly treated, can cause pollution in soil, surface water and groundwater (Mareti *et al*., 2010).

Increasing the biological value and assignment of functional profile is one of the priority areas in the design of a new-generation dietary products that can be achieved through: the use of raw materials and ingredients rich in biologically active and physiologically useful substances; the modification of carbohydrate, fatty acid and amino acid compositions of raw materials and ingredients that will ensure achieving the optimal balance between physiologically useful components; the use of food additives of natural origin, which have a positive impact on the human body in metabolism and meet the modern requirements of adequate nutrition. The mentioned additives must be safe; therefore, when developing them, it is necessary to define their assignment, useful properties, functionality and safety. The issue of providing of production with regional raw material resources is especially relevant (Silagadze *et al*., 2017).

Okara is a by-product generated during tofu or soymilk production processes. It contains about 50% dietary fiber, 25% protein,

10% lipid, and other nutrients. Due to its high fiber content and low production costs, okara is a good raw material and rich source for preparing fiber and could also be used as a dietary supplement to prevent diabetes, obesity, and hyperlipidemia (Li *et al*.,2012$_b$).

The main components of okara, dietary fiber and protein, could be related with the total lipids and cholesterol decreasing in the plasma and liver, as well as with the fecal output increase in high-fat fed hamsters. So okara might play an important role in the prevention of hyperlipidemia and could be used as a natural ingredient or supplement for functional food (Villanueva *et al*., 2011).It is a suitable dietary additive in biscuits and snacks because it reduces calorie intake and increases dietary fiber. The high-quality protein fraction has good water holding and emulsifying qualities and contains a peptide with anti-hypertension effects (O'Tool, 1999).

The importance of food fibers has led to the development of a large and potential market for fiber-rich products and ingredients and nowadays there is a trend to find new sources of dietary fiber, such as agronomic by-products that have traditionally been undervalued. Although there have been great achievements in this research field, further investigations are needed for designing 'new food systems' that consider the precise functionality of dietary fiber from both technological and physiological points of view (Rodríguez *et al*., 2006).

In present work, the main aim was to study the hypoglycemic and hypolipidemic effect of okara, the soybean residue from soy milk production and nutritional evaluation through an animal experiment.

REVIEW OF LITERATUR

1. Soy milk processing and okara production

Okara is a by-product obtained during the processing of soybeans for the production of soy milk. It is yellowish white with a neutral, smooth flavor. It consists of an insoluble fraction obtained from the hydrothermal treatment of the crushed soybean. This residue is generally discarded causing a significant environmental problem because it is susceptible to putrefaction due to its high moisture content (80%). This by-product still contains many beneficial components, which has attracted the increasing current interest in functional foods. Furthermore, the development of techniques for value-addition generates not only great nutritional interest but also environmental significance. Besides its soft taste, colorless appearance, and easily digestible carbohydrates, okara is suitable for gluten-free product formulations (Aguado, 2010).

Grizotto *et al*. (2010) estimated that from each ton of processed soybeans around seven tons of soymilk are produced and two tons of okara. The latter contains 85 g.100 g–1 moisture (wwb, wet weight basis). For every 1 kg of soybeans used in manufacturing soybean curd, about 1.1to1.2 kg of okara is obtained (Vong and Liu, 2016). Therefore, large amounts of okara are produced annually, especially in Asian countries with high soybean consumption.

Rashad *et al.* (2011) evaluated the potential use and improve the health beneficial properties of the waste of soybean manufacturing products by solid-state fermentation. In comparison with non-

fermented okara (control), some levels of value addition occurred as a result of the fermentation. The protein contents increased by 20.10-54.40%, while the crude fiber decreased by 7.38- 45.50% with different strains. With all the organisms used, the ash content increased while the carbohydrate and lipid contents were reduced. Total phenolic content and all parameters of antioxidative activities were increased in fermented substrate.

The dumping of soybean curd residue (SCR) has become a problem to be solved due to its contamination to the environment. SCR is rich in fiber, fat, protein, vitamins, and trace elements. It has potential for value added processing and utilization; options that simultaneously hold the promise of increased economic benefit and decreased pollution potential for the environment (Li *et al*., 2013).

Park *et al*. (2015) reported that incorporating fresh okara into bakery products increases the protein and fiber content and contribute to a more nutritious product for consumers and may reduction of environmental waste.

Although okara has high moisture content of 70%-80%, most of the water is bound to the fiber, resulting in a clumpy appearance and structure that resemble wet sawdust. Fiber, mainly insoluble fiber (in the form of cellulose and hemicellulose), makes up the bulk of the dry matter content at 40-60% (Vong and Liu, 2016).

Tavares *et al*. (2016) studied the stability of gluten-free sweet biscuits developed with soybean okara, rice bran and broken rice. The formulations were elaborated with increasing percentages of these

ingredients and compared with the standard (commercial sweet biscuit) for ten months. The experimental sweet biscuits had characteristics of color, weight, volume and diameters (internal and external) very similar to the commercial, whereas texture, lipids and energy value decreased, and moisture and protein increased during storage. The sweet biscuits showed the same stability when compared to the standard.

2. Chemical composition of okara

Okara, a Japanese word meaning “honorable hull” or soy pulp, is a byproduct of soymilk and tofu manufacturing. Okara is rich in dietary fiber (50–60%), protein, and fat. It has a nut taste and low solubility in water. The protein content of okara is approximately 30%, with a good essential amino acid profile and *in vitro* digestibility, making it a low-cost protein. The fat of okara is approximately 10% with high polyunsaturated fatty acid content. small amounts of starch, sugars, potassium, and significant levels of B group vitamins (thiamin, riboflavin and nicotinic acid) are also recovered in okara (Van Der Riet *et al*., 1989).

Young (1991) showed that well-processed soy-protein isolates and soy-protein concentrates can serve as the major, or even sole, source of protein intake and that their protein value is essentially equivalent to that of food proteins of animal origin. These proteins contain all amino acids essential to human nutrition, which makes soy products almost equivalent to animal sources in protein quality but with less saturated fat and no cholesterol. The importance of the sulfur