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STUDY ON THE EFFECTS OF DRYING PROCESS ON THE COMPOSITION AND QUALITY OF WET OKARA

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Abstract: Drying of the soymilk residue Okara was investigated by the two different drying processes in order to obtain good quality Okara in respect of its composition and shelf life characteristics. In one method the drying of wet Okara was accomplished in a Vacuum tray drier, maintained at around 758 mm Hg and 50^{o}C thereby reducing moisture content by as much as 95%. In the other method drying of Okara was performed in Microwave unit that reduced the moisture content between 88% and 90%. The Vacuum tray drier method is more effective to produce Okara of good quality compared to the Microwave process. The study revealed high total viable bacteria and yeasts and molds counts of wet Okara in comparison to dried Okara. The microbiological quality of different Okara samples illustrated the importance of drying to increase the shelf life.
Keywords: Okara, Okara drying, Microwave, Vacuum tray dryer.

Introduction

The soymilk residue which is a byproduct and known as Okara is used as a food material for its high content of protein and fiber. Okara is the pulp fiber residue generated as a byproduct in large quantities from the soymilk production process. Raw Okara contains about 75% of moisture (wet basis), 25% protein, 10-15% oil and bulk amount of crude fiber [1]. According to Travaglini *et al* [2] the amino acid profile of Okara is slightly superior to that of soymilk itself and Bowles and Demiate [3] showed that approximately 1/3 of the isoflavones present in the soybean remains in the Okara indicating that the Okara protein is of extremely high quality suggesting that it is a good, low cost source of nutrients for human nutrition. The presence of 95% of the solid grain solid components in Okara makes it a very high nutritional

value [4] and may be utilized as an ingredient in a variety of processed foods [2,5,6] because it reduces calorie intake and increases dietary fiber. The high quality protein fraction is responsible for water and fat binding, emulsifying and foaming properties and anti hypertension effects [7, 8] and these non-nutritional properties influence the production and quality of a determined food. Due to high moisture content Okara possesses high capacity of deterioration. However Okara must be dried quickly to avoid spoilage to prolong the shelf life of products. During drying Okara, one of the most important aspects to be considered is the preservation of the protein quality, which can be affected by the drying conditions.

Travaglini *et al* [2] studied the drying of Okara in a tray drier with forced air circulation at 65^0C and observed that the protein quality was maintained. According to these authors, the inconvenience of this method was the low productivity, since it is a discontinuous process requiring long drying process. Grizotto and Aguirre [9] reported that the drying of Okara in a drum drier resulted in a better product than that dried in a tray drier as far as the protein quality was considered. The disadvantage of this method was the elevated cost of the equipment. Wachiraphansaku and Devahastin [10] used a spouted bed, Grizotto and Aguirre [9] used a pneumatic flash dryer using Response Surface Methodology. Camila *et al* [11] dried Okara pellets in a combined process consisting of a pneumatic tube and a rotational drum while Tatsummi *et al* [12] applied the electrohydro-dynamic technique. These techniques, however, appeared either costly or were not beneficial in terms of product quality. Hence, alternative drying methods for Okara that may result in making economically viable better quality final product need to be investigated. However, literature of Okara on drying by using Microwave and Vaccum tray dryer appear to be very meagre.

. The objective of this study was to investigate the drying of Okara in a Microwave unit and by Vacuum tray drier. The effects of drying on the physicochemical, microbiological and sensory characteristics of the dried Okara samples during storage at 4^0C were also investigated.

2. Materials and Methods

The chemicals used were purchased from MERCK, India. Soybean seeds were purchased from the local market (New Alipore Market, Kolkata West Bengal, India).

2.1 Preparation of Okara

Cleaned and uninfected soybeans were initially soaked in volume of water for overnight. After removing the hulls under running water the soaked, peeled soybeans were blended with water-soybean ratio 6:1 in a blender (KENSTAR MG-9603) for 15 min to obtain the soybean slurry. The resultant slurry was boiled to destroy trypsin inhibitor and filtered through 3 layers of cheese-cloth. When filtering slowed, the remaining liquid was squeezed from fine cheese-cloth for 1 min. and the residue thus obtained was called Okara. The Okara was kept in plastic bags in a refrigerator (4°C) for less than 5 days prior to drying.

2.2 Drying of Okara

Okara was dried using two different heating methods namely, Vacuum tray drying and Microwave drying.

2.2.1 Vacuum tray drying

A known amount of wet Okara was spread over a Petridish and placed on the rack of Vacuum tray dryer unit (Vacuum Oven 8" dia-12" deep, Temperature upto 150^0C, Model D-50). Vacuum in the dryer was set at 758 mm Hg and the temperature kept between 45^0C to 60^0C. The drying was continued for 5 hours till the product became free flowing. After cooling, the dry Okara powder was stored in a suitable food grade plastic container for further analysis.

2.2.2 Microwave drying

A known amount of wet Okara was spread over a polymer plate in Microwave (SAMSUNG MW83H/XTL) and heated for 10 minutes at 60°C. The product was then collected, powdered, cooled and stored in suitable food grade plastic container for further analysis.

The wet Okara before drying and the Okara powders after drying are classified as:

A = Wet Okara

B = Vacuum tray dried Okara

C = Microwave dried Okara

2.3 Product Analysis

2.3.1 Physicochemical analysis of Okara samples

The analysis of the samples for protein, moisture, total solids, fat, fibre and ash contents were carried out in triplicate using standard methods (AOAC, 2005) [13]. Carbohydrate was determined according to Anthrone reaction method [14]. Fats were determined by Soxhlet's method [15]. Proteins were estimated by Folin-Lowry method [16]. Energy values were obtained using the Atwater formula where by fat, protein, and carbohydrate supplied 9, 4, 3.75 Kcal/g respectively [17].

2.3.2 Fatty Acid Estimation

Pure triglyceride fraction was separated from the isolated Okara fat by thin layer chromatography on silica gel G layer, with 90 volume n-hexane and 10 volume diethyl ether mixture as the eluting solvent. The triglyceride fraction identified by exposure to iodine vapour , marking the spot and removing iodine by aeration and extracting the triglyceride spot with n-hexane several times. The hexane was evaporated off and the triglyceride fraction isolated was methylated to methyl esters by the method of Brockerhoff [18]. The conversion of triglyceride to fatty acid methyl esters suitable for Gas Liquid Chromatography analysis is accomplished by one of the simplest KOH catalyzed methanolysis method of Brockerhoff [18]. About 40 mg of triglyceride was dissolved in 0.5 ml of diethyl ether and 1ml of 0.5 (N) methanolic KOH solutions was added and shaken. After 10 minutes at room temperature 1ml of 1(N) HCl was added and shaken. The methyl esters were extracted with 3x1.0 ml of petroleum ether. The extracts were evaporated in water bath. The sides of the tube were washed with sufficient GLC grade n-hexane to redissolve the methyl esters for GLC analysis.

2.3.3 Microbiological analysis

The total microbial loads of the wet and dried Okara samples were enumerated in freshly prepared zero and 28 days of cold storage at 4^{o}C as described by APHA (2005) [19]. Microbiological quality of wet and dried Okara samples were evaluated by enumerating total viable organisms which include total aerobic count of bacteria, *E.coli*, total coliforms, yeast and molds.

Ten grams of Okara samples were homogenized using CM 101 CYCLO MIXER (REMI) vortex stirrer with 90 ml sterile saline (0.85% NaCl) to obtain a 10^{-1} dilution. Further

tenfold serial dilution was made using the same diluents till a dilution of 10^{-6} was obtained. The spread plate technique was used to assess the microbial population. Aliquot (0.1 ml) of suitable dilution was spread plated in duplicates onto prepared, sterile and dried Petri dishes of suitable media for the enumeration of different organism. Plate count agar was used for total viable count and Potato Dextrose Agar was used for the presence of yeasts and moulds. After inoculating, the plates were agitated, allowed to solidify, incubated and inverted in an incubator at 37^{o}C for 48 hrs for total viable counts and at 25^{o}C for 3-5 days for yeasts and moulds. The number of colonies counted on the plates taken into consideration the dilution factor and expressed as $\log_{10}$cfu/ml. Microbiological examinations were carried out at 1 and 28 day of intervals.

2.3.4 Sensory evaluation of Okara powder

The Okara samples were kept at 4^{0}C to 5^{0}C until evaluation. 20 members were chosen from the department of School of Community Science and Technology, BESU, Shibpur, Howrah, West Bengal**.** They were assisted in developing a consensus evaluation for flavour attributes for both wet and dried Okara. Evaluation was done at Nine Point Hedonic Scale. Characteristic evaluation included colour aroma texture and overall acceptability. The information contained on the sensory performance was indicated as 9**=**like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=neither like or dislike, 4=dislike slightly, 3= dislike, 2=dislike very much, 1=dislike extremely.

2.4 Results

2.4.1 Physicochemical analysis of Okara samples

The results of proximate analyses of wet and dried Okara samples are shown in Figure 1.

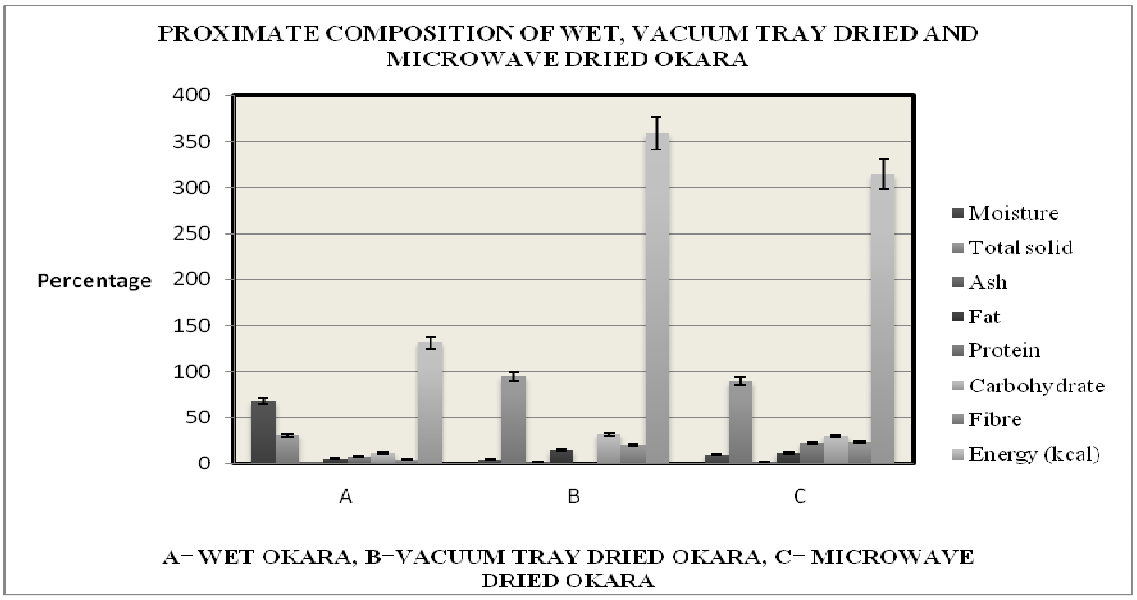

Figure 1 Physicochemical analysis of Okara samples

Figure 1 revealed that the moisture content of the wet Okara was 68.03%. On drying by Vacuum tray drier and by Microwave heating the moisture contents comes down to the region of 5.03% and 10.06% respectively. The contents of the other components, namely lipid (6.02% for wet Okara, 15.00% for Vacuum dried Okara and 12.06% for Microwave dried Okara), ash (1.00% for wet Okara, 2.05% for Vacuum dried Okara and 1.91% for Microwave dried Okara), fibre (5.00% for wet Okara, 20.33% for Vacuum dried Okara and 23.52% for Microwave dried Okara), carbohydrates (12.01% for wet Okara, 33.05% for Vacuum dried Okara and 31.06% for Microwave dried Okara), proteins (8.08% for wet Okara, 25.00% for Vacuum dried Okara and 22.33% for Microwave dried Okara), total solids (32.05% for wet Okara, 95.04% for Vacuum dried Okara and 90.07 for Microwave dried Okara) and energy (131.00% for wet Okara, 358.73 % for Vacuum dried Okara and 314.63% for Microwave dried Okara) were obtained. Both Vacuum tray dried and Microwave dried Okara powders were totally different if compared to wet Okara in respect of chemical composition.

2.4.2 Fatty Acid Estimation of Okara Samples

The fatty acid compositions of the oils extracted from wet and two dried Okara powders were presented in the Figure 2.

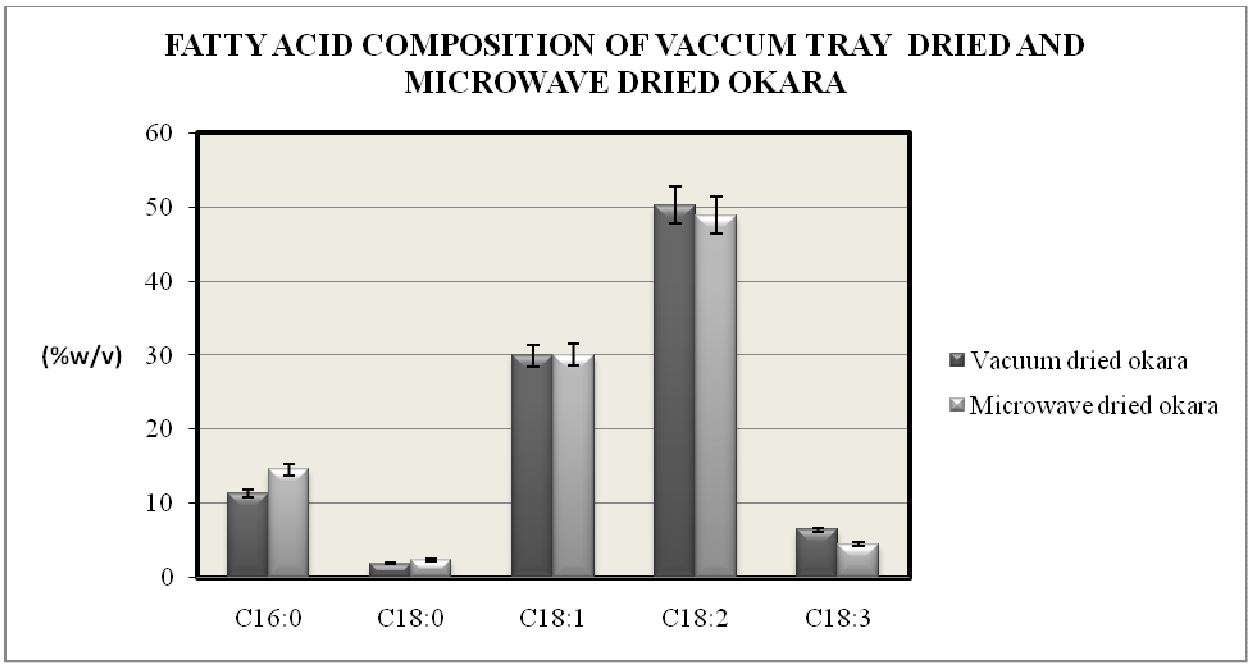

Figure 2 Fatty acid compositions of the oils extracted from Okara powders

From Figure 2 it was observed that the fatty acid composition of the isolated fat from dry Okara sample showed variation in content of saturated fatty acids. Micro wave dried Okara had highest percentage of palmitic acid (16:0), where as Vacuum tray dried Okara has lowest (11.38%). On the contrary it was also shown that linolenic acid content of Vacuum dried product was higher than micro wave dried Okara. One can expect in case of Microwave heating more of the localised heating effect that may cause directly a change in the content of polyunsaturated fatty acid (PUFA) by deterioration of the alpha-linolenic acid (ALA) by oxidation.

2.4.3 Microbiological analysis

Table 1 Microbiological analysis of Okara products

Days of Storage at 4^0 C

Types of Okara Samples		0 day	28 day
	1. Total aerobic count	5.2×10^4 cfu/ml	11×10^8 cfu/ml

A	2. Yeast and molds	6.4 x10^4 cfu/ml	5.2x10^8cfu/ml
	3. *E.coli* and Coliform	zero	zero
B	1. Total aerobic count	zero	3.2x10^4cfu/ml
	2. Yeast and molds	zero	4.1x10^7cfu/ml
	3. *E.coli* and Coliform	zero	zero
C	1. Total aerobic count	zero	4.3x10^4cfu/ml
	2. Yeast and molds	zero	4.1x10^7cfu/ml
	3. *E.coli* and Coliform	zero	zero

A= Wet Okara, B = Vacuum tray dried Okara, C=Microwave dried Okara

The microbial load of different Okara samples at zero time and after four weeks of cold storage are shown in Table 1. The total viable count of wet Okara was 5.2 x 10^4cfu/ml at zero day while that was zero for both the dried Okara samples. The total viable count of all types of okara samples were increased on the 28th day of storage. For wet Okara sample it was increased from 5.2x10^4cfu/ml to 11.0x10^8cfu/ml and from zero to 3.2x10^4cfu/ml and 4.3 x10^4cfu/ml for Vacuum dried and Microwave dried Okara samples respectively. PDA medium containing chloramphenicol was specified for yeasts and molds. Data illustrated in Table 1 indicated that no colony of yeast and mold was grown in plates for both types of dried Okara samples at zero day but wet Okara sample contained 6.4x10^4cfu/ml at zero day. Yeast and mold colonies were increased for all types of Okara samples during 28 days of storage. Coliforms and *E. coli* were not detected in all the Okara samples throughout the storage period.

2.4.4 Sensory evaluation of Okara powder

Sensory analysis of wet Okara, Vacuum Tray Dried and Microwave Dried Okara as shown in the Figure 3 which indicated categorically vast improvement in quality of Okara after drying by both processes.

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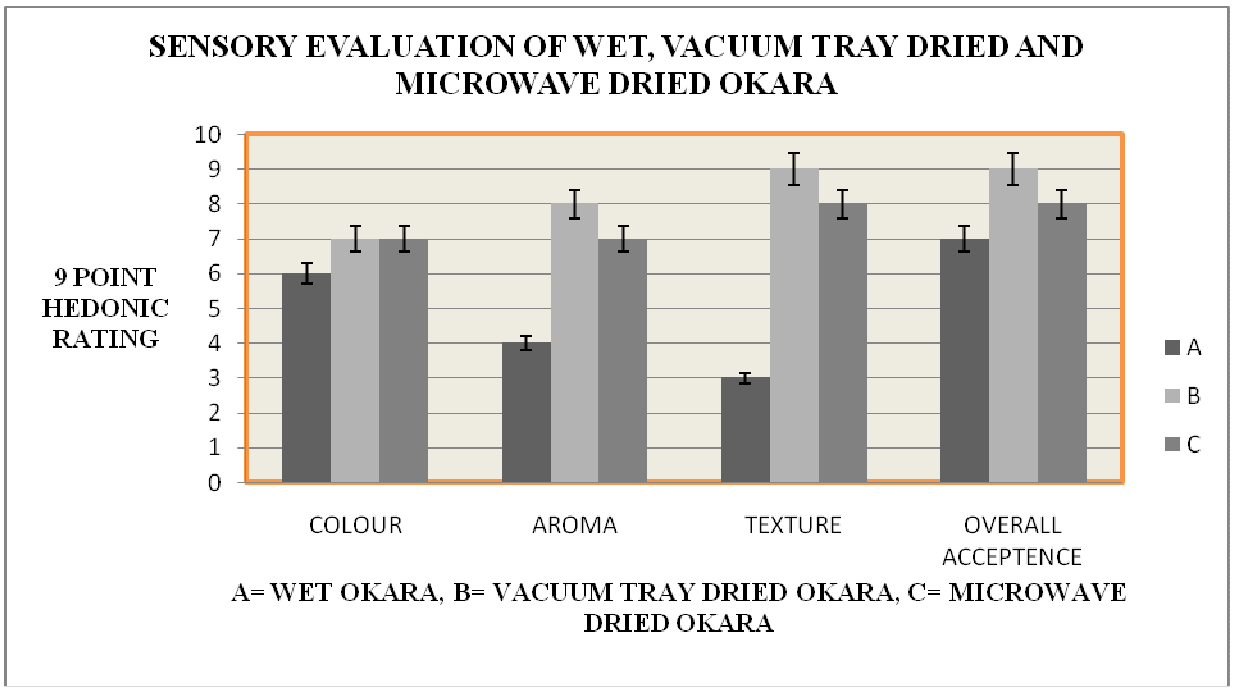

Figure 3 Sensory evaluations of Okara samples

Discussion

It is worth noting that the low moisture content in both the Vacuum tray dried and Microwave dried Okara products enable their preservation for a long period of time. In this study, the microbiological quality of different Okara samples illustrated the importance of drying to increase the shelf life. The study revealed high total viable bacteria and yeasts and molds counts of wet Okara in comparison to dried Okara. The absence of *E. coli.* signifies that all the samples were free from faecal contamination.

When Okara is properly dried, the proportion of all the constituents of dried Okara gets increased. Dried Okara has higher protein, fat, carbohydrate, with 25% of protein whereas wet Okara contains only 8% of protein. Due to its higher protein content, dried Okara can be supplemented with other protein deficient or other protein limited food product for product development. Dried Okara has higher calorific value in comparison to wet Okara because of its higher protein, carbohydrate, and fat content. In Vacuum tray drying almost 98% moisture is removed where as in case of Microwave drying only around 90% moisture is removed. The Vacuum tray dried Okara powder has considerably better storage quality than Microwave drying. Based on the observations, it can be affirmed that the physicochemical

properties, of the Okara dried by the two processes remained totally different to the mean values observed in the original wet Okara.

There is a difference in the content of palmitic acid in lipid part obtained from the dried Okara sample. Saturated acid tend to remain more in the oil of Okara dried by Microwave process. PUFAs tend to decrease with the Microwave process of drying.

Wet Okara normally cannot be stored for more than 2 days but dried Okara can be stored for 28 days without any changes of nutritional property. Both Vacuum tray dried and Microwave dried products were contaminated with microorganisms of public health concern at 28 days. The high total bacterial and fungal counts in both products may be a consequence of the low level of hygiene maintained after post processing preservation and the storage of the products. This includes the handlers, the utensils and environment. The results from the present study suggest that the dried Okara should be used in further applications as soon as possible since prolonged storage may negatively impact on their proximate composition, the feature that made them to be highly valued for food and feed formulations in the first place. This information would be valuable especially where these Okara powders are being consumed as protein supplements.

The colour, aroma, texture of wet Okara is not so much accepted like dried Okara. Dried Okara is whitish yellow in colour and has sweet aroma but wet Okara is white in colour and has little beany flavour. The texture of wet Okara is creamy soft whereas dried Okara is little hard. Apart from physico-chemical property, Okara dried in Vacuum tray drying gives better sensory evaluation in respect of colour, flavour and all over acceptance. Vacuum tray dried method is safe for health since in this process Okara is dried in minimum temperature (45^0C-50^0C) for long hour. It is a slow process but nutritional quality of the final product is not affected.

Conclusion

Wet Okara can be very effectively dried by heating in a Vacuum tray drier and also by Microwave heating. The compositions of dried Okara powders obtained by the two processes are changed remarkably and turned out to be nutritionally more significant because dried Okara contained much higher percentage of protein, carbohydrate and lipid (including its valuable PUFAs). The shelf life of the dried Okara products vastly increases after proper drying. It may be mentioned that Vacuum drying method is preferred for producing

nutritionally enriched Okara to the Microwave drying for food application since there is also minimum loss of macro and micro nutrient of dried Okara. In dried Okara the percentage of fibre is higher which is beneficial towards our health as some time Okara fibres interfere with protein starch interaction. For this reason substitution of starch material is required for developing more value added food products. Production of fibre rich food product, substitution with dried Okara flour is the best approach. High protein content of dried Okara also initiates development of protein rich ready to eat food product. The production of good quality Okara makes it a good starting material of protein and fibre supplementation.

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