Mineral losses in hot water- and microwave-blanched green and dry white beans[1]

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ABSTRACT

The effect of microwave and conventional hot-water blanching upon selected mineral (calcium, copper, iron, potassium, magnesium, manganese, sodium, zinc) losses in green and dry white beans (*Phaseolus vulgaris*) was studied. The mineral content was determined by atomic absorption spectrophotometry. Microwave blanching resulted in significantly greater losses of calcium, magnesium and potassium, but in significantly greater manganese retention in dry white beans. Neither method resulted in significant mineral changes in green white beans. In practical terms, the microwave blanching treatment did not have the expected performance in relation to mineral retention when compared to the traditional hot-water blanching, thus suggesting that it may not be a viable alternative blanching method under all circumstances.

RESUMEN

Determinación y comparación de pérdidas de ciertos minerales entre los tratamientos de escaldado con agua caliente y microonda en habichuelas blancas verdes y secas

Se estudió el efecto del escaldado con microondas y con agua caliente sobre las pérdidas de ciertos minerales (Ca, Cu, Fe, K, Mg, Mn, Na, Zn) en habichuelas (*Phaseolus vulgaris*) blancas verdes y blancas secas. El contenido de los minerales fue determinado por absorción atómica. El escaldado con microondas en habichuelas blancas secas resultó en pérdidas significativas mayores en Ca, Mg y K, pero en retención significativamente mayor en Mn. Ninguno de los dos métodos resultó en cambios significativos en el contenido de los minerales en las habichuelas blancas verdes. En términos prácticos, el escaldado con microondas, contrario a lo esperado, no resultó ser mejor que el escaldado tradicional con agua caliente en cuanto a la retención de minerales. Esto sugiere que en algunas circunstancias el escaldado con microondas puede no representar una alternativa factible al escaldado convencional.

INTRODUCTION

Microwave technology is being extensively used as a convenient method of preparing foods in our modern, time conscious society. Interest in this area is becoming more apparent as foods that have formerly

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been packaged for conventional preparation are now appearing in containers for use in both conventional and microwave ovens. In the same way that microwave technology has affected the consumer sector, surely it will have a great impact in the food processing industry. The microwave alone or in combination with other conventional energy sources makes possible the precise control of food processing that results in better product yields and quality in the shortest possible time (4, 5). There are six major unit operations in microwave food processing: blanching (to inactivate spoilage enzymes), cooking (to modify flavor and texture), dehydration (to reduce moisture content), pasteurization (to inactivate vegetative microbes), sterilization (to inactivate microbial spores) and tempering (to raise temperature below freezing) (4, 5, 7, 11, 19).

In view of the recent emphasis on nutrient content and labeling of processed foods, it becomes important to evaluate new food processes in terms of their effects on nutrient retention. Appreciable amounts of water-soluble substances are frequently lost during processing, especially during blanching (2, 3, 4, 9, 15, 16, 21). Various researchers have reported nutritional retention advantages using microwave radiation for blanching and other processes, especially in relation to water-soluble nutrients (carbohydrates, vitamins, minerals) and those easily destroyed by heat, such as vitamins (2, 4, 8, 18, 19).

With regard to the energy cost differentials, industrial microwave food processing has become more economically attractive in recent years, as costs of gas and oil have risen and use of coal and nuclear energy sources for generating electrical power has increased. Also recent advances in equipment design and research of food properties should stimulate the development of new and improved commercial food processes. In terms of advantages to steam blanching, microwave energy is faster in accomplishing enzyme inactivation (5, 19) and it is more efficient than steam, which itself is less energy efficient than water blanching (6).

The microwave energy for heating, particularly in food processing, is thus very attractive. Because nutritional information has acquired such a tremendous interest among consumers, and therefore among industrial sectors, the objective of this study was to determine and compare selected mineral losses in hot water and microwave blanching treatments in green and dry white beans.

MATERIALS AND METHODS

Dry (10 to 15% humidity) and green (50 to 60% humidity) white beans (*Phaseolus vulgaris*) of the Arroyo Loro variety were obtained from the Isabela substation of the Agricultural Experiment Station. The seeds were planted by hand in late September (1990) for harvesting in late November (1990) at the green stage. The dry stage harvest was done during December (1990) after the beans were allowed to dry in the field.

The harvested pods were transferred to the Laboratory of Food Technology, where they were mechanically shelled, cleaned and freed from foreign material.

Five aleatory 1-pound samples of each, dry and green, white beans drawn from a 140-pound shelled bean harvest were used for mineral loss determinations. Three 200-g subsamples were drawn from each of the previous 1-pound samples. One of these five sets of 200-g subsamples was used as an untreated control, while the other two sets were used either for the hot water or the microwave blanching treatments.

The water-blanch treatment was accomplished by the traditional method. The 200-g sample of the dry bean material was soaked in 1 liter distilled water at room temperature for hydration to occur. The rehydration process ended when the dry beans doubled their weight. The hydrated beans were placed in 500 ml distilled hot water (180 °F) for 3 minutes. For the microwave blanch treatment, dry beans were hydrated as before. The 200-g samples were placed in 600-ml beakers covered with a glass watch in a General Electric Microwave Oven, Model JET342G, (Louisville, KY)[3] for 1 minute. This time was chosen according to results obtained in the peroxidase test. The beans reached an average temperature of 200 °F. The microwave oven was designed to provide 700 watts output and an operational frequency of 2450 MHz.

The peroxidase activity determination was performed to test for the adequacy of blanching in the microwave treatment. A 1% solution of guaiacol in distilled water was prepared. Equal volumes were mixed with hydrogen peroxide (3%). A volume of 200 ml of the mixed solution was added to 50 g of sample and mixed. The mixed material was tipped out into a white porcelain basin and the development of a red color was observed (the first complex formed is green; later it changes to pale red and deep red). The appearance of a pinkish-orange color indicates the presence of oxidase. The extent of bubbling and coloration parallels the presence of enzymes, but is not quantitative (12, 14, 17).

The 200-g green bean samples were blanched for the same time and at the same temperature as the hydrated beans, both in the hot water and the microwave methods.

Mineral contents (Ca, Cu, Fe, K, Mg, Mn, Na, Zn) were determined by atomic absorption spectophotometry according to standard methods (1). Triplicate 1-g samples of each blanched or unblanched 200-g bean samples were used. The 200-g samples were blended in a Waring blendor (Winsted, Conn.) and oven dried. The dried samples were ground to 40

[3]Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment of materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over the equipment of materials.

mesh in a Wiley mill, model 4276 (Philadelphia, PA). These ground samples were stirred to obtain a homogeneous mixture, a 1-g sample of which was weighed. Samples were then vacuum dried in a vacuum oven, for further ashing in a muffle furnace (1). Samples were never in contact with any metal except stainless steel.

Standards were prepared by suitable dilution of the stock standard solutions. The sample solutions were diluted if necessary to bring the concentration of the element of interest into a suitable range of analysis (in the case of K and Mg, 1 ml of sample solution was diluted to 100 ml). To overcome potential anionic interferences when determining Ca, Mg and K, the final sample dilution and all standards and blanks contained 2 ml of LiCl (50,000 ppm) in 100 ml. The blank used for the determination of Na contained 50,000 ppm of KCl. The addition of this inhibitor (KCl) was not required for the final Na sample dilution because of its high content of K. Determinations were performed with a Perkin-Elmer model 2380 (Norwalk, Connecticut) atomic absorption spectrophotometer. A 10-cm (4 in.) 1-slot burner head and standard air-acetylene flame was used for elemental analyses. Single element hollow cathode lamps were used for all minerals, except for K, which was determined by atomic emission. The instrument settings and other experimental conditions were in accordance with the manufacturer's specifications. National Bureau of Standards (NBS) Citrus Leaves (Standard Reference Material #1572) were used to verify the calibration and standard solutions (2, 10, 15, 16, 21).

Data were submitted to analysis and to least significant difference (lsd) test.

RESULTS AND DISCUSSION

Table 1 gives mineral content in green and dry white beans for control and treated samples.

When compared to the control sample, the K loss in the hot-water blanched green white beans was significantly different at the 5% level. However, when compared with microwave blanching, there were no significant differences with the control. When the hot water blanching was compared to the microwave blanching, the latter resulted in better retention, although not significantly. In general, although not statisticaly significant, more Ca, Mg, Mn, and Zn were retained when the samples were treated with microwave blanching than with the traditional hot water blanching. In the case of copper, both treatments resulted in the same retention. On the contrary, a somewhat smaller amount of iron was retained in the microwave treatment than the hot water one. On the basis of the results obtained, we can conclude that the retention of the minerals in green white beans in both treatments is about the same.

TABLE 1.—*Concentration (mg/100g)*[1] *of minerals in green and dry white beans after different blanching treatments (wet weight basis).*

	Minerals	Control	Treatments Hot-water	Microwave
Green Beans	Ca	172.8a[2]	171.5a	174.8a
	Cu	2.2b	1.7b	1.7b
	Fe	11.0c	11.4c	11.0c
	K	1690.7d	1622.7e	1688.7de
	Mg	214.7f	214.7f	217.3f
	Mn	1.9g	1.9g	2.0g
	Na	9.4h	8.1h	8.6h
	Zn	4.1i	3.9i	4.0i
Dry Beans	Ca	192.8a	201.9b	194.4a
	Cu	1.5c	1.3c	1.4c
	Fe	10.9d	10.3e	10.2e
	K	1782.0f	1747.3g	1646.0h*
	Mg	242.0i	241.3i	227.3j*
	Mn	2.0k	1.5l	2.3m*
	Na	12.6n	12.4n	11.8n
	Zn	3.8o	3.9o	3.9o

[1]Measured values are the average of 15 calculations.

[2]Means within the same row with the same attached letter are not significantly different (5% level); an asterisk at the end of the row indicates that significantly different means are so at a 1% level.

The Ca loss in the microwave blanched dry white beans was significant at the 5% level when compared to the hot water-blanched samples. The microwave and the control samples were not significantly different in Ca content.

The Fe loss in the microwave and hot-water blanching treatment, when compared to that of the control, was significant at the 5% level. However, when the microwave blanching was compared to hot-water blanching, the Fe loss was not significant. These results suggest that the microwave treatment contributed to a slightly greater nutritional loss of Fe than the hot water treatment.

The K loss in the microwave blanching was significant at the 1% level when compared to the control and the hot water-blanched samples. Also, the hot water treated samples presented a significant (5% level) lower content when compared to that of the control samples. This finding suggests that the microwave blanching contributes to greater nutritional loss of K than the traditional hot water treatment.

The Mg loss in the microwave blanching treatment was significantly ($P = .01$) greater when compared to that of the hot-water blanched and control samples. Neither the control nor the hot-water blanched samples presented a significant difference in Mg content when compared. These results showed that microwave treatment contributed to greater nutritional loss of Mg than the hot water treatment. The opposite situation was observed for Mn loss. The microwave treatment showed a higher ($P = .01$) Mn content than the hot water blanched and control samples. The hot water-treated samples presented a lower ($P = .01$) Mn content than the control samples. These findings suggest that in the case of Mn, the microwave treatment contributed to less nutritional loss than the hot water treatment and that the Mn retention was significantly greater than in the control samples.

Cu retention with the microwave blanching was practically the same as with the hot water blanching. The samples blanched with hot water retained K and Fe better than the ones blanched with microwave. Finally, Zn retention was the same for both microwave and hot water blanching.

As expected, both green and dry white beans contained high levels of K, Mg, Ca and Fe (13). A 100-g serving of these white beans before and after blanching treatments supplied more than 100% of Fe 80% of K, 60% of Mg and 50% of Cu of the recommended dietary allowances (RDA) for male adults (Food and Nutrition Board, Recommended Dietary Allowances, National Academy of Sciences, Washington DC, 1989). For female adults, the same 100-g serving supplied more than 80% of K, 75% of Mg, 60% of Fe and 57% of Cu. However, this 100-g portion supplied only 2% of the Na RDA for both males and females.

Microwave blanching was significantly superior to the hot water-treatment only with respect to Mn in dry white beans. Microwave was also superior, although not significantly, in Ca, K, Mg, Mn, Na and Zn retention in green white beans and in Cu retention in dry white beans.

These results suggest that in practical terms, the emerging microwave blanching technique may not always be a better alternative to the traditional hot water blanching. This in spite of the fact that recent studies indicate that the most significant routes for the loss of water soluble nutrients (like minerals) is via extraction by food processing operations like blanching, and that leaching during blanching can be almost entirely eliminated by using microwave cookers (20). It is also known that the nature and extent of mineral loss depend on pH, temperature, ratio of water to food, agitation of the water, surface-to-volume ratio and maturity (3, 15, 20). In the present investigation, the hot water blanching treatment was administered under controlled circumstances in a laboratory environment. The bean samples were blanched in beakers with 500 ml distilled water. This ratio of water to food may not be the one found in industrial blanchers. In addition, industrial blanchers exhibit continuous flow and agitation of water providing conditions leading to greater mineral losses. This situation could have been the reason for the observed mineral losses in the hot water-blanched samples. Microwave blanching produced a liquid exudation which could have accounted for the mineral losses observed in this treatment.

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