World Academy of Science, Engineering and Technology
International Journal of Nutrition and Food Engineering
Vol:10, No:09, 2016

Development of a Rice Fortification Technique Using Vacuum Assisted Rapid Diffusion for Low Cost Encapsulation of Fe and Zn

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Abstract : To address the micronutrient deficiencies in the Asian region, the World Food Program in its current mandate highlights the requirement of employing efficient fortification of micronutrients in rice, under the program 'Scaling-up Rice Fortification in Asia'. The current industrial methods of rice fortification with micronutrients are not promising due to poor permeation or retention of fortificants. This study was carried out to develop a method to improve fortification of micronutrients in rice by removing the air barriers for diffusing micronutrients through the husk. For the purpose, soaking stage of paddy was coupled with vacuum (- 0.6 bar) for different time periods. Both long and short grain varieties of paddy (BG 352 and BG 358, respectively) initially tested for water uptake during hot soaking (70 °C) under vacuum (28.5 and 26.15%, respectively) were significantly ($P < 0.05$) higher than that of non-vacuum conditions (25.24 and 25.45% respectively), exhibiting the effectiveness of water diffusion into the rice grains through the cleared pores under negative pressure. To fortify the selected micronutrients (iron and zinc), paddy was vacuum-soaked in Fe2+ or Zn2+ solutions (500 ppm) separately for one hour, and continued soaking for another 3.5 h without vacuum. Significantly ($P<0.05$) higher amounts of Fe2+ and Zn2+ were observed throughout the soaking period, in both short and long grain varieties of rice compared to rice treated without vacuum. To achieve the recommended limits of World Food Program standards for fortified iron (40-48 mg/kg) and zinc (60-72 mg/kg) in rice, soaking was done with different concentrations of Fe2+ or Zn2+ for varying time periods. For both iron and zinc fortifications, hot soaking (70 °C) in 400 ppm solutions under vacuum (- 0.6 bar) during the first hour followed by 2.5 h under atmospheric pressure exhibited the optimum fortification (Fe2+: 46.59±0.37 ppm and Zn2+: 67.24±1.36 ppm) with a greater significance ($P < 0.05$) compared to the controls (Fe2+: 38.84±0.62 ppm and Zn2+: 52.55±0.55 ppm). This finding was further confirmed by the XRF images, clearly showing a greater fixation of Fe2+ and Zn2+ in the rice grains under vacuum treatment. Moreover, there were no significant ($P>0.05$) differences among both Fe2+ and Zn2+ contents in fortified rice even after polishing and washing, confirming their greater retention. A seven point hedonic scale showed that the overall acceptability for both iron and zinc fortified rice were significantly ($P < 0.05$) higher than the parboiled rice without fortificants. With all the drawbacks eliminated, per kilogram cost will be less than US$ 1 for both iron and zinc fortified rice. The new method of rice fortification studied and developed in this research, can be claimed as the best method in comparison to other rice fortification methods currently deployed.

Keywords : fortification, vacuum assisted diffusion, micronutrients, parboiling
Conference Title : ICNFS 2016 : International Conference on Nutrition and Food Sciences
Conference Location : Singapore, Singapore
Conference Dates : September 08-09, 2016