# Development of Protein and Micronutrient Fortified Shelf-stable Sweet Nutribars for School Aged Children from Puffed Rice Processed through Supercritical Fluid Extrusion

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Malnutrition is widely prevalent in South Asia where half of the world's malnourished children are found in just 3 countries - Bangladesh, India and Pakistan. Women, infants, and school age children are the most likely to suffer from malnutrition. The Pakistani population is suffering from a variety of nutritional deficiency disorders ranging from protein-calorie malnutrition to specific micro-nutrients in certain parts of the country mainly due to poor socio-economic conditions and availability of nutritionally low standard foods. Consequently, low productivity, poverty and low standard of living are widespread. According to recent National Nutrition Survey, (2011) malnutrition contributes to almost 35% of all under-5 deaths in the country. At the moment, 43.7% children aged <5 years are stunted, 45.3% are underweight and 25.2% are wasted. Furthermore, 62.1% children are anaemic, 33.4% suffer from iron deficiency anaemia, 56% facing vitamin A deficiency, 41.1% have vitamin D deficiency and 36.5% are zinc deficient. Process-based food fortification is a cost-effective, flexible, and generally acceptable approach to improve the nutrient intake in the vulnerable. Processed foods are often fortified with certain micronutrients accessible to a large number of people, thus playing a pivotal role in prevention of deficiencies and disorders. Process based food fortification of dietary staples and conversion into shelf-stable and easy-to-eat foods has proven an effective strategy for combating micronutrient malnutrition as well as to provide emergency and humanitarian assistance in response to natural or manmade disasters. Supplementation of soy protein in rice flour fortified with proposed micronutrients would be helpful to improve the nutritional quality of food products to alleviate the micronutrient deficiencies in Pakistan. This technology offers an opportunity for sustainable business development through value addition in agricultural sector utilizing agricultural co-products.

Micro-nutrients enriched and protein fortified puffed rice were prepared using supercritical fluid extrusion and further converted into shelf stable sweet nutribars for school aged children. A low-shear, twin screw, co-rotating extruder was used to produce puffed rice using supercritical $CO_2$(SC-$CO_2$). Pre-mix comprised of four micronutrients (NaFeEDTA, zinc oxide, retinylpalmitate and ascorbic acid were used to provide recommended daily values of these nutrients in 100g of product. The extruded samples (Fig. 1) were analyzed for protein content, dietary fiber, added nutrients, physical characteristics and other quality attributes followed by conversion into sweet crispy nutribars. The end product was analyzed for chemical composition, micronutrients, water activity and sensoric attributes like color, flavor, crispiness, stickiness and overall acceptability. The data obtained for each parameter was statistically analyzed.

**Fig. 1** Proto-types of micro-nutrient, protein and rice bran fortified Supercritical Fluid Extrusion (SCFX) processed puffed rice

The soy protein fortification and addition of rice bran improved the protein amount in the final product (Fig. 2) from 6.1 to 21.5% and dietary fiber from 0.9 to 8.0%. SCFX processed puffed rice were very light in weight and expanded well. However, when 8% rice bran and 22.5% soy protein concentrate was incorporated, expansion slightly decreased ultimately increasing the hardness. Regarding added micronutrients, puffed rice samples retained all added minerals, 55-58% of vitamin A and 64-77% of vitamin C. Micronutrient fortified sweet nutribars made from 20% added sugar were more acceptable with respect to sensoric and quality attributes.

In conclusion, the consumption of 4 nutribars (weighing 25g each) provide 13g protein, 5g dietary fiber, 7mg Fe, 4mg Zn, 313µg RE vitamin A, 21mg vitamin C and 200 Calories to the school aged children. This represent a significant contribution to improve nutrition in this age group if consumed.

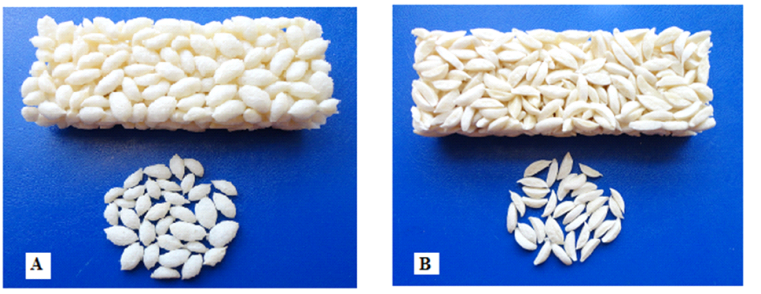


**Fig. 2** Appearance of Nutribars
A. Nutribars made from micronutrient-fortified puffed rice;
B. Nutribars made from micronutrient and soy protein fortified puffed rice