ABSTRACT

Rice, a major staple in India with about 107 MT of consumption per year, serves as an ideal vehicle to deliver the deficient micronutrients to a large target population. Fortified rice kernels (FRK) are prepared using rice broken and a vitamin-mineral premix (VMP) through extrusion technology, with the concentrations of iron, folic acid, and vitamin B_{12} (cyanocobalamin) in FRK maintained at 280-425 mg, 750-1250 µg, and 7.5-12.5 µg per 100g, respectively, as per FSSAI guidelines (2018). In the present study, the effect of rice varieties with varying apparent amylose content (AAC) and the addition of parboiled rice flour (PGR) on system parameters like torque (Tr) and die pressure (Dp), physicochemical properties of FRK such as length (L), lightness (L*), water absorption index (WAI), and water solubility index (WSI), as well as cooking properties such as cooking time (CT), solid loss (SL), elongation (ER), and textural properties of FRK were analysed and correlated. The FRK extrusion process conditions were optimized based on the feed AAC, and the ratio of PGR in the feed was also optimized. Protocols for the estimation of folic acid and cyanocobalamin in FRK were developed and validated. These protocols were used to study the micronutrient stability of FRK during different cooking and storage conditions. To study the effect of rice varieties, four parboiled and three raw rice types with intermediate amylose content (0–24%) were processed to manufacture FRK. Compared to raw rice, the parboiled rice showed the highest Tr, Dp, L, CT, ER, and hardness, and lesser WAI and SL in cooking FRK. The raw rice FRK showed higher lightness. The torque, die pressure, length, redness, and cooking time increased with an increase in AAC and were in the range of 12.55–22.81 Nm, 58.31–88.96 bar, 4.58–5.09 mm, 0.35–1.15, and 6.1–11.2 min, respectively. Other parameters, such as breadth, whiteness index, and cooking loss decreased with an increase in AAC. Except for cohesiveness, all other textural properties of cooked FRK increased with an increase in AAC. These correlations of the FRK properties with AAC were confirmed through multivariate analysis. Response surface methodology-based optimization showed that the optimal AAC% for FRK manufacturing was 19-20%, and the optimal moisture content of feed, die temperature, feeder screw speed, and extruder screw speed were 30-31%, 106-107 °C, 7 rpm, and 30 rpm, respectively. The addition of PGR increased improved the cooking and textural properties of the FRK. The study showed that 20% PGR could replace the sodium alginate as an additive to improve the quality of the FRK. For the estimation of FA, ultrasonication-assisted extraction for 5 minutes at 30 °C in 0.25 M phosphate buffer with 1% ascorbic acid was found to be ideal. For cyanocobalamin, digestion and heat extraction (70 °C, 30 min) of the FRK samples followed by purification and concentration by solid-phase extraction was found to be more efficient for HPLC analysis. The cooking study revealed that iron losses were significant in excess water cooking and rinsing only. Rinsing caused an 11% loss of folic acid and a 5% loss of cyanocobalamin. The retention of folic acid and cyanocobalamin was highest in pressure cooking (94-95%), followed by water-tight cooking (89-90%), excess water cooking (84-90%), and microwave cooking (76-86%). In the storage study, iron losses were under 2.1% at ambient and room temperature, rising to 4% under accelerated conditions. Folic acid losses were about 7% at ambient and room temperatures, increasing to under 12% in accelerated conditions, while vitamin B_{12} losses reached 12% in accelerated conditions but ranged from 8-9% at ambient and room temperatures. All micronutrient levels remained within FSSAI's 2018 guidelines.

Key words: Fortified rice kernels, apparent amylose content, micronutrient analysis, storage stability, cooking stability