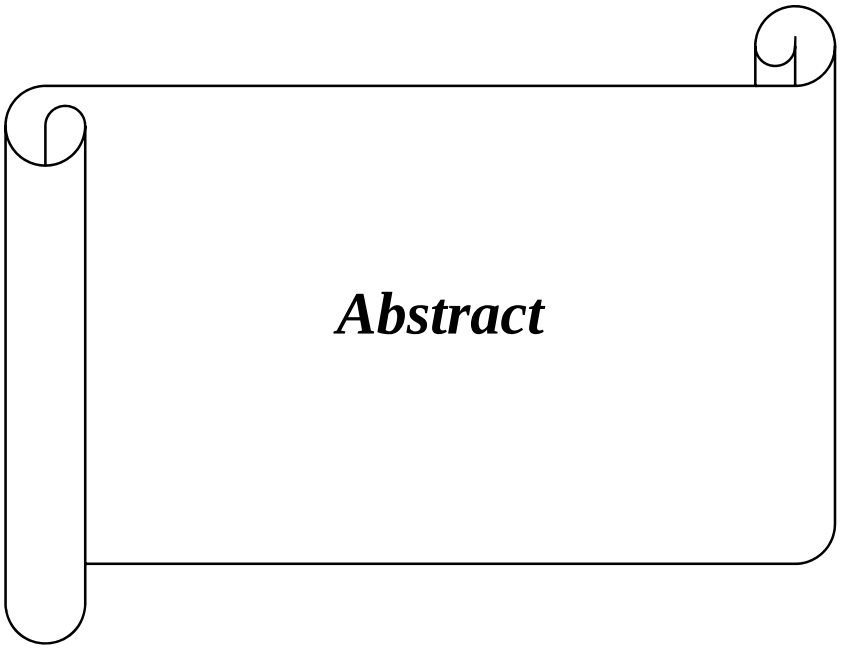
Abstract

Malting of Paddy: Mechanism, Characterization and Development of Weaning Formula Based on Malted Rice Flour

ABSTARCT

The thesis primarily focuses on the malting of two paddies with different amylose amylopectin ratio i.e. low amylose rice (LAR) and intermediate amylose rice (IAR) at four different germinating temperature (25, 30, 35 and 40°C) for 120 h. Germination was observed only at the germinating temperature of 30 and 35°C whereas at 20 and 40°C no embryo development was detected. A high germination capacity and rate was observed in IAR at 30- 35°C when compared to LAR leading to higher decrease in malting yield. Moreover, the enzyme activity of IAR malted rice was significantly higher than LAR in both germination temperature. The hydrolytic enzymes caused higher starch degradation in the IAR malted rice in comparison to LAR. The morphology of the malted flour from SEM revealed pin holes and eroded surface due to the action of hydrolytic enzymes. The structural study (XRD and FTIR) of both malted LAR and IAR revealed faster degradation of amylose as compared to amylopectin under all germination conditions which may be due to the complex nature of amylopectin. IAR paddy was found more suitable at both 30 and 35°C for malting based on outcome of present study. Germination being a complex process, a simultaneous production of enzymes and consumption of substrate was observed, and this made the determination of reaction rate by traditional Michaelis-Menten equation unsuitable. Thereby, to determine the reaction rate for both the paddies during germination a different approach was used which involved Boltzmann function. The enzyme reaction obtained from the Boltzmann function was rate for both the paddy during the process, was determined by and this was employed in Michaelis-Menten equation. However, the statistical parameter (Km and Vmax) was not in the acceptable range. Thereafter, stochastic model was also developed to modify the enzyme reaction kinetics and observed that the change in enzyme followed zero order reaction while change in substrate concentration for LAR and IAR showed second and first order respectively. Artificial neural network (ANN) was later employed to develop process modelling of starch hydrolysis during germination of the paddies and the model was found to be acceptable. The starch hydrolysis mechanism was proposed based on structural changes obtained from the vibrational spectroscopy (FTIR and Raman spectroscopy). The changes in spectra obtained from FTIR and Raman showed that amylases enzyme was synthesized with the onset of germination as amide I and amide

III regions were identified, and these enzymes might be present in α-helix or β-sheet form. The enzymes thereafter act on the skeletal mode of pyranose ring structure of glucose as units followed by the cleavage of the glycosidic linkage. This was evident from the decrease in the Raman band at 948 cm^{-1} and 938 cm^{-1} which corresponds to α-1→4 glycosidic linkage. This action of enzymes on starch led to production of open chains of α-D-glucose and β-D-glucose as FTIR peaks at 1200 and 1342 cm^{-1} were observed. Multivariate calibration analysis (PCA and PLS) was employed to correlate Raman spectral data with biochemical changes during germination and to develop a calibration model. The model showed a high prediction ability with low root mean square error of prediction. The pasting properties and thermal behaviour of both malted paddies exhibited significant changes during the process of germination. Two pasting peaks were observed in case of LAR at both germination temperatures which might be due to the formation of amylose-lipid complex. Higher decrease in pasting property was observed for IAR as compared to LAR. The values of T_O, T_P and T_C increased for the malted rice with germination time which again may be due to the amylose-lipid complex. The kinetic study for pasting properties showed a second-order kinetic while the change in the thermal behaviour followed a rational function with respect to germination time. Further, the prepared malted rice was utilized in development of a weaning formulation along with other cereals and fruit (Bhim kol) and then optimized based on physico-chemical and nutritional content. The optimized formulation showed high energy and protein content which may be beneficial for the malnourished children. The minerals present in the formulation were calcium, phosphorous, chlorine, magnesium, iron and zinc. The amino acid analysis showed presence of six essential amino acid i.e. histidine, lysine, methionine, phenylalanine, threonine and valine while the non-essential amino acid present were alanine, arginine, glutamic acid and cysteine. The optimum solid water ratio for the developed weaning formula was 50:50 based on the viscosity which was observed to be 2 Pa.s. The *in vitro* starch digestibility of the formulation with different particle size (75 and 105 μm) was also observed to be high as it moved from mouth to the intestine. The smaller particle size showed higher digestibility compared to larger one which was due to the larger surface area. The flow behaviour of the formulation in the simulated human system showed a shear thinning behaviour. The rheological model employed for fitting the shear stress-shear rate data were power law model and Herschel-Bulkley model where the Power law model was taken as the best-fitted model. The developed formula also showed absence of any cytotoxicity. The moisture sorption isotherm was studied at three different temperatures (20, 30 and 40°C) and fitted to five different models. The Peleg and the GAB

model was observed to be the best fitted model. The values of net isosteric heat of sorption and sorption entropy were found to be slightly higher based on Peleg model parameters when compare to GAB model parameters. Moreover, with increase in EMC there was a decrease in the Gibb's free energy (ΔG) for both GAB and Peleg model. The sensory attributes evaluated on 9-point hedonic chart showed higher acceptability of the developed weaning formulation as compare to the commercialized formulation. The quality attributes such as peroxide value and free fatty acid of the weaning formulation during storage at 40°C was observed to be under the acceptable range.