CHAPTER V

SUMMARY AND CONCLUSIONS

The pigeon pea grain is considered as most difficult for dehulling as compared to other pulses. Pre-milling treatments are generally employed to loosen the seed coat to remove husk without losing any edible portion. There are many traditional and improved pre-milling methods for pigeon pea milling. All these methods are time consuming process for the complete milling of pigeon pea. Moreover, these pre-treatments lead to higher processing cost, longer processing time and labour consuming for pigeon pea milling. It also requires large space for milling.

Pre-milling treatments play an important role in improving dhal recovery and improving the quality. During pre-milling treatments water, oil, chemical, heating actions leads to the structural changes as well as shape deformation and therefore quality of dhal in terms of cooking time may be affected. Long cooking time results in a decrease in protein quality and a loss of vitamins and minerals. A novel pre-dehulling technique involving enzyme is prospective to reduce dehulling loss, cost, energy, time and drudgery and improve recovery and cooking quality of pigeon pea. Partial hydrolysis of the mucilaginous bonds by enzymatic reactions facilitates the easy dehulling of legumes.

The mechanism of enzymatic activity is governed by four interacting parameters viz., seed moisture content, enzyme concentration, incubation time and incubation temperature. Optimum levels of these parameters are necessary to get maximum recovery and better quality of dhal. Hence enzyme treated pigeon pea dhal requires a detailed study by optimizing the parameters to get maximum recovery with good quality of dhal and reduce the cooking time of dhal.

The experiments mainly consisted of proximate composition of pigeon pea grains, enzymatic pre-treatments on milling quality, protein content and cooking time. All the experiments were carried out in the Department of Processing and Food Engineering, College of Agricultural Engineering & Technology, Junagadh Agricultural University, Junagadh.
ICPL 87119 variety of pigeon pea was selected for the experiment and procured from ICRISAT, Hyderabad. The proximate compositions of pigeon pea grains, viz., carbohydrate, protein, fat, crude fibre and ash content were determined at 10.40 % (w.b) moisture content. Commercial food grade enzymes xylanase, pectinase and cellulase were obtained from their manufacturers. These three enzymes Xylanase : Pectinase : Cellulase as 2 : 1 : 1 (50 %: 25 %: 25 %) were used in combination for enzymatic pre-treatments. The grains were cleaned manually to remove all foreign matters. The clean grains were then graded by manually operated size grader to obtain uniform sized grains. The effect of four enzymatic hydrolysis parameters, viz., enzyme concentration (20, 27.5, 35, 42.5 and 50 mg/100 g dry matter), incubation time (4, 6, 8, 10 and 12 h), incubation temperature (35, 40, 45, 50 and 55 °C) and tempering water pH (4.0, 4.5, 5.0, 5.5 and 6.0) on hulling efficiency, protein content and cooking time of pigeon pea dhal were optimized using response surface methodology. The treated samples were dried in a tray dryer at 60 °C Temperature, 10 ± 0.5 % (d.b.) m.c. Dry milling method (oil treatment) was considered as control.

Enzymatic pre-treated and control samples of size 1 kg having about 10 ± 0.5 % moisture content (d.b.) were milled using laboratory dehusking machine/dhal mill. Samples were milled at the standard settings of the machine, i.e., 1420 rpm operating speed and 64 kg/h feed rate. After milling, all the fractions were collected in polyethylene bag. Each of the samples were milled separately. A Central Composite Rotatable Design (CCRD) of 4 variables at 5 levels each with 6 center point combinations were used for statistical analysis.

The optimum conditions obtained through response surface analysis was verified by conducting the experiment. The value of dehulling efficiency, protein content and cooking time were considered for the validation. Hulling efficiency was determined as reported by Singh et al., (2004). Protein content was estimated as suggested by Lowry et al., (1951). Cooking quality was measured as described by Singh et al., (1984).

Based on the inferences drawn from the results obtained during the study, the following conclusions could be drawn.
1. The moisture content of pigeon pea grains was found to be 10.40 % (w.b.), protein 18.17 %, carbohydrate 51.26 %, fat 1.51 %, crude fibre 7.13 %, total ash 3.74 %.

2. The value of hulling efficiency, protein content and cooking time were found to be 69.12 %, 18.89 % and 16.24 min, respectively.

3. The hulling efficiency varied from 81.21 to 84.55% obtained at different combination of variables. The minimum hulling efficiency was found in treatment number 21 having the combination of enzyme concentration of 35 mg/100g dry matter, 8 h incubation time, 55 °C incubation temperature and 5.0 tempering water pH, while the maximum hulling efficiency found in treatment number 30 having the combination of enzymatic concentration of 35 mg/100g dry matter, 8 h incubation time, 45 °C incubation temperature and 5 tempering water pH.

4. The response surface equation for hulling efficiency was obtained as given below

\[
\text{Hulling efficiency (\%) = 83.99 - 0.061X_1 - 0.14X_2 - 0.46X_3 + 0.38X_4 - 0.22X_1X_2 - 0.10X_1X_3 - 0.13 X_1 X_4 + 0.26X_2X_3 - 0.10X_2X_4 + 0.087X_3X_4 - 0.24 X_1^2 - 0.22 X_2^2 - 0.42X_3^2 - 0.33X_4^2}
\]

Where, \( X_1, X_2, X_3 \) and \( X_4 \) are the coded factors of enzyme concentration, incubation time, incubation temperature and tempering water pH, respectively.

5. The protein content of enzyme treated pigeon pea dhal varied from 19.68 to 23.50 %. The minimum protein content was found in treatment number 27, 28 having the combination of enzyme concentration of 35 mg/100g dry matter, 8 h incubation time, 45 °C incubation temperature and 5.0 tempering water pH, while the maximum protein content was found in treatment number 18 having the combination of enzymatic concentration of 20 mg/100g dry matter, 8 h incubation time, 45 °C incubation temperature and 5 tempering water pH.

6. The response surface equation for protein content was obtained as given below

\[
\text{Protein Content (\%) = 21.71 - 0.60X_1 - 0.52X_2 - 0.19X_3 + 0.26X_4 + 0.17X_1X_2 + 0.053X_1X_3 - 0.091X_1X_4 + 0.028 X_2X_3 - 0.12X_2X_4 + 0.23X_3X_4 - 0.28X_1^2 - 0.20X_2^2 + 0.016 X_3^2 + 0.016X_4^2}
\]

Where, \( X_1, X_2, X_3 \) and \( X_4 \) are the coded factors of enzyme concentration, incubation time, incubation temperature and tempering water pH, respectively.
7. The cooking time varied from 12.42 to 15.66 min. for different enzyme treated dhal samples. The minimum cooking time was found in treatment number 17 having the combination of enzyme concentration of 50 mg/100g dry matter, 8 h incubation time, 45 °C incubation temperature and 5.0 tempering water pH, while the maximum cooking time found in treatment number 4 having the combination of enzymatic concentration of 27.5 mg/100g dry matter, 6 h incubation time, 50 °C incubation temperature and 5.5 tempering water pH.

8. The response surface equation for cooking time was obtained as given below

\[
\text{Cooking time (min)} = 13.15 - 0.29X_1 - 0.34X_2 + 0.16X_3 - 0.35X_4 - 0.20X_1X_2 - 0.036X_1X_3 - 4.167E - 003X_1X_4 - 0.080 X_2X_3 - 0.27X_2X_4 + 0.21X_3X_4 + 0.46X_1^2 + 0.33X_2^2 + 0.49X_3^2 + 0.32X_4^2
\]

Where, \(X_1, X_2, X_3\) and \(X_4\) are the coded factors of enzyme concentration, incubation time, incubation temperature and tempering water pH, respectively.

9. The response surface quadratic model optimized the pre-treatment as enzyme concentration of 29.83 mg/100 g dry matter, incubation time 7.50 h, incubation temperature 42.77 °C and tempering water pH 5.41 which gave the predicted values of hulling efficiency 82.52 %, protein content 22.15 % and cooking time 13.12 min.

10. The hulling efficiency, protein content and cooking time of oil treated (control) sample was found 69.12 %, 18.89 % and 16.24 min, respectively while the observed values of hulling efficiency, protein content and cooking time at the optimum conditions of enzymatic pre-treatment variables was 84.17 %, 22.46 % and 13.56 min, respectively. Hence, there was an increase in hulling efficiency of 16.23 %, Protein content of 14.71 % and decrease in cooking time 23.78 % over oil treated sample.

11. The predicted values of hulling efficiency, protein content and cooking time obtained from equations showed 1.20, 1.40 and 3.35 % deviation from the experimental values, respectively. It could reveal that the experimental values were very close to the predicted values which confirmed the optimum conditions.

From the above study, it could be recommended that the better recovery and quality of pigeon pea dhal obtained by enzymatic pre-treatment of enzyme concentration of 29.83 mg/100 g dry matter, incubation time 7.50 h, incubation temperature 42.77 °C and tempering water pH 5.41 yielded a hulling efficiency
82.52 %, protein content 22.15 % and cooking time 13.12 min. The quantity of enzymes required has been estimated considering the 10.40 % (w.b.) moisture content of pigeon pea normally used by the pulse mills. The suggested method could save time, energy consumption and labour to a great extent and beneficial to the pulse milling industry.