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Determination of Chemical Properties of Desi Chickpea Flour (Besan) Using Near Infrared Spectroscopy and Chemometrics

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ABSTRACT: *A method was developed to determine the protein, carbohydrate, fat and moisture content of desi chickpea flour (besan) using Near Infrared Spectrometer [NIRS] and multivariate regression namely, Principal Component Regression and Partial Least Square Regression Analysis . Spectra of the samples was collected in reflectance mode using lab built pre dispersive filter based NIRS in the wavelength range of 700-2500 nm. Reference analysis was collected using the Association of official Analytical Chemists (AOAC) methods. NIR spectral data and reference data was used to develop regression models using Partial Least Square Regression and Principal Component Regression. Prediction performance of the models was compared on the basis of the coefficient of correlation [R^2] and Root Mean Square Error [RMSE] for calibration and validation sets. The R^2_c values for prediction of moisture, fat, protein and carbohydrate content from PLSR model were 0.9858, 0.9863, 0.9888, 0.9915 respectively. PCR model resulted in R^2_c 0.9739 for protein, 0.9833 for carbohydrate, 0.9795 for fat and 0.9655 for moisture content. PLSR and PCR models results were accurate enough for prediction of the parameters. This study showed that NIR can be used to determine the chemical parameters of food material.*

Keywords**:** *Desi chickpea flour (besan), Near Infrared Spectroscopy, Partial Least Square Regression, Principal Component Regression.*

INTRODUCTION

Chickpea [Cicer arietinum L.] is a legume plant of the family Fabaceae It is an important staple food in South Asia. Desi chickpeas, bengal gram, yellow gram or gram. is an Indian variety of chickpeas which is slightly smaller and rounder. Desi chickpeas are dark brown in color with a thick seed coat. The desi chickpeas are grounded into flour called besan [Bengal gram flour].. The chickpea seed is an excellent source of protein and healthy carbohydrate known as dietary fiber [1,2]. It is widely used in batters, soups, desserts, pancakes, snacks. It isalso an excellent source of folic and minerals such as iron, copper, zinc and magnesium, as well as phenol compounds [3]. Chickpea [Cicer arietinum] is an important source of proteins, carbohydrates and certain minerals. The chickpea seed contain 21.1% protein, 3.1% fat, 53.4% carbohydrate, 11.1% fiber, and 5.9% ash [4,5]. Chickpea [Cicer arientum L.] is considered the 5th valuable legume in terms of worldwide economical standpoint. Several studies are done on the theincorporation of chickpea flours to the basic recipe of various bakery products such as cakes [6], cookies [7] pasta [8; 9], bread [10,11]. The quality bakery product dependson its chemical quality hence there is a need to device a method that can determine the chemical parameters accurately. Methods like dye binding method, biuret method and kjeldahl methods have been used for estimation of its protein content [12]. Variation was observed in assessment of nutritional and compositional properties of different varieties of Desi chickpea. [13]. Apart from accurate measurement it is also required that the determination of parameters should be fast also. NIRS provides a nondestructive and fast analytical method to determine total protein content of chickpeas, lentil and pea seeds [14].

In this work application of NIRS and chemometrics have been addressed for development

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of predictive models for determination of chemical properties namely protein, carbohydrate, moisture and fat content of besan samples.

MATERIAL AND METHODS

Sample Collection

Desi Chickpea flour [besan] samples were collected from the local market. Samples included with and withut brand. The flour was packed in zip lock polythene bags and kept at ambient temperature for further analysis.

Proximate Analysis

Moisture, crude fat, protein and ash content were estimated using Association of official Analytical Chemists [AOAC] methods. Carbohydrates for all the samples were calculated using the anthrone method [15]. All the analysis was done in triplicate.

NIR Spectra

Near Infrared Spectra of all the samples were collected using a lab built filter based pre dispersive spectrometer. Light from Philips Tungsten Halogen Lamp 50W/12V was made to pass through the filters using a collimating lens. Filters of wavelength range 700-2580 nm were fitted on the filter wheel. Dispersed light passing from a bifurcated cable was reflected by the grounded sample to the PbS detector [Thorlabs PDA30G-EC] and the data was collected using Oscilloscope [Key sight]. Each spectrum was collected in triplicate and average of the scan was used to calculate the absorbance using Lambert Beer law. The sample undergoes overtone and combinational molecular vibration depending upon the type of bonds [C-H, N-H, O-H, S-H] present in the sample, when NIR light is incident on them. This leads to complex spectra where each peak does not identify a single bond. Thus there is need of chemometrics to analyze the spectra and determine the chemical parameters of the besan samples.

Statistical Analysis

Reference and the NIR spectral data was analyzed using chemometrics software Unscrambler Camo version X 10.3. Data set was divided into calibration and validation set. Calibration data was used to develop a regression model and sample in validation set were used to check the validity of the model. Data was preprocessed prior to regression analysis to remove noise. Principal component Regression [PCR] and Partial Least Square Regression [PLSR] analysis were used to build prediction model using the calibration data set for the chemical properties. Coefficient of correlation [R^2] and Root Mean Square Error [RMSE] were used to know the performance of the models.

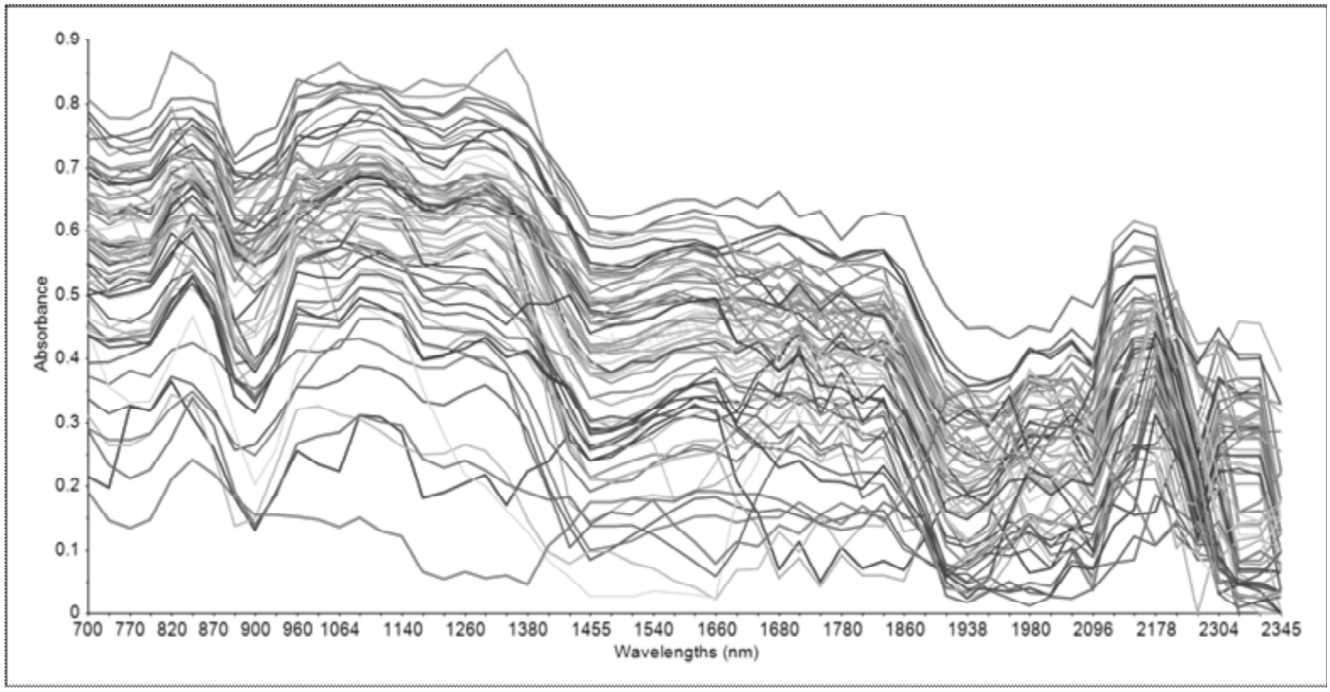

Figure 1: NIR absorption spectra of desi chickpea flour samples

RESULTS AND DISCUSSION

Descriptive Statistics of the chemical properties of besan samples are listed in Table 1. The properties show variation in the collected samples so the sample set can be used to develop a prediction model for future prediction of protein, carbohydrate, fat and moisture content of besan samples.

Table 1
Descriptive statistics of chemical data of samples

	Max	*Min*	*Mean*
Moisture	12.67817	8.775429	10.05012
Protein	29.26836	15.23261	20.66093
Carbohydrate	69.85414	40.29942	55.82413
Fat	9.4	2.316	6.197048

NIR absorbance spectra of all the besan samples are shown in Figure 1. The peaks in the spectra correspond to overtones and combination vibrational bonds of C-H, O-H, N-H bonds present in the besan samples.

PLS analysis was run using Non Linear Partial Least Square Algorithm [NIPLAS] algorithm cross validation techniques by dividing the data set into 10 segments. Preprocessing of the data was used to normalize the data, remove scattering and noise from the spectral data. Four factors of PLSR model were sufficient to develop the model. The results of the PLS model are listed in Table 1. It was observed from R_V^2 and RMSEV values that PLS model was validated with good accuracy and can be used for future prediction as a fast, robust and non destructive technique to determine the chemical properties of besan.

Table 2
PLS regression results for chemical parameter prediction of samples

Parameter	*Factors*	R_C^2	*RMSEC*	R_V^2	*RMSEV*
Moisture	4	0.9858	0.0150	0.9728	0.0212
Fat	4	0.9863	0.0163	0.9818	0.0199
Protein	4	0.9888	0.0150	0.9741	0.023
Carbohydrate	4	0.9915	0.0141	0.9831	0.0214

PCR analysis was performed using Singular Value Decomposition [SVD] algorithm cross validation techniques by dividing the data into 10 segments. The results of the regression analysis and number of factors responsible for determination for each parameter are listed in Table 3.

It was observed that overall PLSR could determine the chemical parameters of the sample with good accuracy and less number of factors.

Table 3
R^2 and RMSE values for calibration and validation set for PCR regression analysis for all the chemical parameters

Parameter	*Factors*	R^2_C	*RMSEC*	R_V^2	*RMSEV*
Moisture	2	0.9655	0.0435	0.9620	0.0451
Fat	6	0.9795	0.0281	0.9665	0.0353
Protein	4	0.9739	0.0331	0.9679	0.0385
Carbohydrate	2	0.9883	0.0322	0.9848	0.0339

CONCLUSION

An application of Near Infrared Spectroscopy along with PLSR and PCR regression techniques was used in this study to determine the protein, moisture, carbohydrate and fat content of the desi chickpea flour. The spectral data were analyzed using the multivariate statistical analysis. The results show that the PLSR and PCR models show accurate method for the prediction of chemical parameters. This suggests that a fast, non destructive and accurate technique can be used to develop a prediction model to determine the chemical properties of desi chickpea flour.

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REFERENCES

Angela Sotelo, Fernando Flores, Miguel Hernández, "Chemical composition and nutritional value of Mexican varieties of chickpea (Cicer arietinum L.)", Plant Food for Human Nutrition, (1987), **37**, 299-306.

Saleh A. Alajaji, Tarek A. El-Adawy, "Nutritional composition of chickpea (Cicer arietinum L.) as affected by microwave cooking and other traditional cooking methods", Journal of Food Composition Analysis, (2006), **19**, 806-812.

Aharon Segev, Hana Badani, Yoram Kapulnik, Ilan Shomer, Michal Oren-Shamir and Shmuel Galili, "Determination of Polyphenols, Flavonoids, and Antioxidant Capacity in Colored Chickpea (*Cicer arietinum*L.)", Journal of Food Sciences, (2010), **75**, S115-119.

Singh, U., P. Williams, and D. Petterson. "Processing and grain quality of cool season food legumes tomeet the market demands". In Proceedings, International Food Legume Research Conference, (1997), 26-30 September, Adelaide, Australia.

Dimitrios, S., M. Eleousa, and D. Georgios, "Effect of durum flour enrichment with chickpea flour on the characteristics of dough and lasagna". Journal of the Science of Food and Agriculture, (2006), **86**, 1938-1944.

Gómez M, Oliete B, Rosell CM, Pando V, Fernández M, "Studies on cake quality made of wheat–chickpea flour blends", LWT-Food Sci. Technol., (2008), **41**, 1701-1709.

Faheid, S.M.M. and Hegazi, N.A., "Effect of adding some legume flours on the nutritive values of cookies", Egyptian Journal of Food Science, (1991), **19**, 147-159.

Goñi I, Valentín-Gamazo C, "Chickpea flour ingredient slows glycemic response to pasta in healthy volunteers", Food Chem., (2003), **81**, 511-515.

Wood JA, "Texture, processing and organoleptic properties of chickpea-fortified spaghetti with insights to the underlying mechanisms of traditional durum pasta quality", J. Cereal Sci., (2009), **49**, 128-133.

Abdel-Aal EM, Youssef MM, Shehata AA, El-Mahdy AR, "Some legume protein as bread fortifier and meat extender. Alexandria J. Agric. Res., (1987), **32**, 179-189.

Coda R, Rizzello, CG, Gobbetti M, "Use of sourdough fermentation and pseudo-cereals and leguminous flours for the making of a functional bread enriched of γ-aminobutyric acid (GABA)", Inter. J. Food Microbiol., (2010), **137**, 236-245.

Umaid Singh and Ramamurthi Jambunathan, "Evaluation of rapid Methods for the Estimation of Protein in Chickpea [Cicer arietinum L.]", J. Sci. Food. Agric, (1980), **31**, 247-254.

Muhammad Zia-Ul-Haq, Shahid Iqbal , Shakeel Ahmad , Muhammad Imran, Abdul Niaz , M.I. Bhanger, "Nutritional and compositional study of Desi chickpea [Cicer arietinum L.] cultivars grown in Punjab, Pakistan," Food Chemistry, (2007), **105**, 1357–1363

Lazzeri, L., Leoni, O., Palmieri, S. "Near infrared reflectance analysis for determining the total protein content of chick-pea, lentil and pea seeds", Journal Agricoltura Mediterranea, (1990), **120**, 103-109.

Hedge, J.E. and Hofreiter, B.T. In: Carbohydrate Chemistry, 17 (Eds. Whistler R.L. and Be Miller, J.N.), Academic Press, 1962 New York.

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