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MOISTURE ANALYSIS OF WHOLE MUNG BEAN AND RED LENTIL BY DOMESTIC MICROWAVE OVEN

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This paper presents the moisture analysis of selected pulses (whole Mung Bean and Red lentil) through the Domestic microwave oven. Moisture content is the main and critical parameter to analyze the food grain health. Most of the grains are spoiled and get infected due to access of moisture. Due to that there are several kinds of insects and funguses get introduced in the grain kernel and spoiled the grains at a large level. Different types of moisture analyzing techniques are used to avoid the spoilage, fungus and insects into the grains, but in our research we focused on domestic microwave oven based microwave drying method. In which 2.45 GHz frequency based domestic microwave is used to analyze the % moisture contents in the whole Mung Bean and red lentil, which further compared with the standard moisture meter. Initially whole Mung Bean and Red lentil have 7.8% and 9.4% moisture level and then treated with the domestic microwave oven at different power levels 900 W, 720 W, 450 W, 270 W and 90 W for 30 Sec, 60 Sec and 90 Sec exposure times to measure the moisture loss in pulses. The acquired results from the dry basis method (microwave oven heat treatment) also have been validated through the standard moisture meter DMM8 and in comparison minimum 0.017% and maximum 0.123% difference found in case of whole Mung Bean and in case of red lentil (Masoor dal) minimum 0.013% and maximum 0.11% of difference found between the standard moisture meter and microwave drying method.

Keywords: Domestic microwave oven; whole Mung Bean; red lentil; moisture content; Dry basis moisture analysis

INTRODUCTION

In India most of the stored food grains/pulses are get infected through the insects and funguses and get spoiled. But these insects and funguses are developed due to the excess of moisture level or moisture content in the food grains/pulses w.r.t. time.

Moisture level of the food grains like cereals, millets and pulses should be maintained in between 11.5% to 16% (Chandy; Vadivambal *et al.*, 2007). Most of the heat treatment researches were done on the wheat samples (Chandy; Walde *et al.*, 2002; Kaasova *et al.*, 2002; Vadivambal *et al.*, 2007; Rajagopal, 2009; Yadav *et al.*, 2012; and Ashraf *et al.*, 2012). Studies were earlier reported microwave heat treatment on wheat, ray and barley at different moisture levels for disinfestations and moisture control (Walde *et al.*, 2002; Vadivambal *et al.*, 2007; Rajagopal, 2009; and Yadav *et al.*, 2012;). Microwave treatment with and without conventional methods on different food grains were continuously studied (Kaasova *et al.*, 2002; and Ashraf *et al.*, 2012) and hence nutritional effects determined in terms of chemical and biological

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changes (Kaasova *et al.*, 2002; and Ashraf *et al.*, 2012). The heat treatment time span was analyzed by the literature from 28s to 300s (Vadivambal *et al.*, 2007; Rajagopal, 2009; Yadav *et al.*, 2012; and Ashraf *et al.*, 2012). According to the survey comparison of microwave heat treatment and conventional method, heating time duration on samples were small with effective power levels as compared to high temperature ranges for long time and it affects the quality of the food grains and also affects the moisture contents (Vadivambal and Jayas, 2007).

Most of the food grains get infected due to the lower or excess of moisture in grains. So Time to time moisture analysis of food grains is the important factor for monitoring and maintaining the quality (Rajagopal, 2009; Vadivambal and Jayas, 2007; and Zhao *et al.*, 2007 and 2007). Microwave heat treatment increase the shelf life of the food grains, disinfestated the grains and maintaining the nutritional level (Zhao *et al.*, 2007; and Rajagopal, 2009).

The moisture content measurements on dry weight basis were determined by the microwave method described by AOAC (1960) standards.

From the literature survey it is well defined that development and growth of insects depends upon the moisture present in the food grains (Vadivambal *et al.*, 2007; Zhao *et al.*, 2007; and Rajagopal, 2009). So to keep away insects from the food grains it is necessary to maintain the moisture level. Even though there are several kind of evaporation devices available like convection and forced draft ovens, Vacuum oven, Microwave oven and Infrared lamp drying, etc. (McClements). But for our application we have chosen the microwave oven drying method (Reeb and Milota, 1999; and Owens *et al.*, 2006) for better moisture analysis as well as disinfestations of food grains.

MATERIAL AND METHODS

Evaporation Method (Microwave Oven Drying Method)

Principle: Evaporation method is based on the measurement of the mass of water in the known mass of samples. And the moisture contents are defined by the following formula (Boone and Wengert, 1998; and Owens *et al.*, 2006) on Dry basis:

$$\%\ Moisture\ of\ foodgrains = \left(\left(M_I - M_D \right) \Big/ M_1 \right) \times 100 \quad ...(1)$$

M_I: Initial (before drying) mass/weight of grain sample

M_D: Dried (after drying) mass/weight of grain sample

In the evaporation method when heat is applied on the samples then the water molecules present in the sample get evaporate because of having a lower boiling point than the total solids like proteins, lipids, carbohydrates and minerals etc. So the loss of water molecules in the food grain samples determines the change in the moisture level in the food grain sample before and after heat treatment. This method is also called the dry basis moisture analysis.

Statistical Analysis

All the data obtained from the experiment, their graphical presentation and statistical parameters R^2 values and standard error values are calculated by the Origin 6.1 software. These statistical values are defined as follows:

$$Standard\ Error = \left(S \Big/ \sqrt{n} \right) \quad ...(2)$$

S: sample standard deviation

n: size of the sample

The value of R^2 lies between 0 d" R^2 d" 1, denotes the strength of the linear relationship between experimental time (X) and experimental data values (Y):

$$Correlation\ Coefficient\ (r) = \frac{\left(N \times \Sigma XY - \Sigma X \Sigma Y \right)}{\left(\sqrt{N} \times \left(\Sigma X^2 - (\Sigma X)^2 \right) \sqrt{N} \times \left(\Sigma Y^2 - (\Sigma Y)^2 \right) \right)} \quad ...(3)$$

$$Coefficient\ of\ determination\ (r^2) = r \times r \quad ...(4)$$

METHODOLOGY

System Description

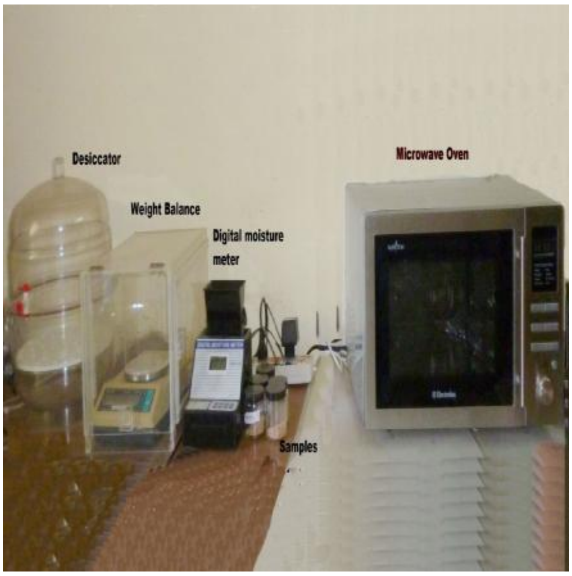
Moisture analysis of whole Mung Bean and red lentil (Masoor dal) through domestic microwave model Electrolux 26L Convection EJ26CSL4, Desiccator with rotary pump, Borosil plates, Weight balance machine and Digital Moisture Meter model no. DMM8.

Samples: Whole Mung Bean, Red lentil (Masoor dal)

Sample Size: 20 gm each

To calculate the moisture loss in the food grains first of all 5-5 batches (each batch is having 3 samples) are prepared with the 20 gm each whole Mung Bean and red lentil samples, having initial moisture 7.8% and 9.4%. Now from the first batch of Whole Mung Bean samples, first sample was placed in the microwave by applying power level 900 W at different time interval 30 Sec for treatment and then the remaining 2 Whole Mung Bean samples were also treated with the microwaves same power level 900 W at different time interval 60 Sec and 90 Sec.

Figure 1: Pictorial View of Whole Moisture Analysis System (Including Standard Moisture Meter and Microwave Oven Based Technique)



Note: Figure 3 Trend curve of % moisture of Red lentil (masor dal) w.r.t. time for standard moisture meter data and microwave oven heat treatment analysis data.

After the treatment the sample was placed in the desiccator for at least 30 minutes to keep them away from the external moisture mixing (like moisture from the atmosphere). Then the sample's weight/mass loss measurement was done using the standard analytical weight balance machine and simultaneously the same sample was placed into the standard moisture meter to measure the moisture level of the sample. Figure 1 is showing the pictorial view of whole moisture analysis system. Now in the other 4 batches of Whole Mung Bean samples, each batch was picked and treated at different time interval 30 Sec, 60 Sec and 90 Sec for different power levels 720 W, 450 W, 270 W and 90 W. The treated samples were placed into the desiccator and measure weight to calculate weight/mass loss during heat treatment. The same process was repeated for Masoor Dal samples.

RESULTS AND DISCUSSION

Experimental results of whole Mung Bean samples obtained from the microwave treatment and standard moisture meter are shown in the tabular form (Table 1). Table 1 shows the comparison of treated Whole Mung Bean samples moisture level in between the standard meter readings and microwave oven drying techniques (method based on Dry basis) readings. The experimental results show that microwave oven dry moisture analysis closely matches with the standard moisture meter DMM8 readings. On the other hand the experimental results of Red Lentil samples are shown in Table 2. In Table 2, the samples readings are more closely related to each other in microwave oven dry moisture analysis and standard moisture meter DMM8.

It can be inferred from the displayed tables (Tables 1 and 2) that the microwave heat treatment based moisture percentage are in good agreement with the standard moisture

Table 1: Experimental Results of Whole Mung Bean Moisture Analysis from Standard Moisture Meter versus Microwave Oven Drying Technique at Different Time and Different Powers

Time/Power Level	Standard Moisture Meter			Microwave Oven Drying Technique		
	30 Sec	60 Sec	90 Sec	30 Sec	60 Sec	90 Sec
Initially % moisture contents	7.80%	7.80%	7.80%	7.80%	7.80%	7.80%
900W	7.60%	7.40%	7.20%	7.56%	7.39%	7.22%
720W	7.70%	7.60%	7.50%	7.66%	7.56%	7.48%
450W	7.70%	7.70%	7.60%	7.67%	7.65%	7.58%
270W	7.70%	7.70%	7.60%	7.68%	7.65%	7.57%
90W	7.80%	7.80%	7.70%	7.78%	7.76%	7.72%

Table 2: Experimental Results of Red Lentil (Masoor Dal) Moisture Analysis from Standard Moisture Meter versus Microwave Oven Drying Technique at Different Time and Different Powers

Time/Power Level	Standard Moisture Meter			Microwave Oven Drying Technique		
	30 Sec	60 Sec	90 Sec	30 Sec	60 Sec	90 Sec
Initially % moisture contents	9.40%	9.40%	9.40%	9.40%	9.40%	9.40%
900W	9.20%	9.10%	8.90%	9.22%,	9.02%,	8.89%
720W	9.30%	9.20%	9.10%	9.29%	9.18%	9.08%
450W	9.30%	9.30%	9.20%	9.29%	9.25%	9.18%
270W	9.30%	9.30%	9.20%	9.29%	9.26%	9.18%
90W	9.40%	9.40%	9.30%	9.39%	9.37%	9.34%

meter DMM8 based reading when the high power level is used for lower time span or low power level is used for higher time span. Minimum variations in moisture level were observed at 450W and 270W in the whole Mung Bean and in red lentil.

The initial moisture level of the whole Mung Bean samples was determined as 7.8% (dry basis) by the standard moisture meter. From Figure 2, During the experiments, the moisture level of the whole Mung Bean samples of values 7.8%, reduced to 7.22% in 90 Sec at 900W by using microwave heat treatment. Further the same experiment was conducted using red lentil, then we found that the moisture level of the red lentil samples of values 9.4%, reduced to 8.89% in 90sec at 900W by using microwave heat treatment.

From the Figure 2, it is found that the standard errors of 0.123%, 0.069%, 0.046%, 0.047% and 0.017% observed between the standard moisture meter reading and microwave oven dry moisture analysis of whole Mung Bean at different power levels 900 W, 720 W, 450 W, 270 W and 90 W. Further, Figure 3 shows the standard error of the order of 0.112%, 0.069%, 0.046%, 0.046% and 0.013% between the standard moisture meter reading and microwave oven dry moisture analysis of red lentil (Masoor dal) at different power levels 900 W, 720 W, 450 W, 270 W and 90 W.

Figure 2: Trend Curve of % Moisture of Whole Mung Bean (Dal) w.r.t. Time for Standard Moisture Meter Data and Microwave Oven Heat Treatment Analysis Data

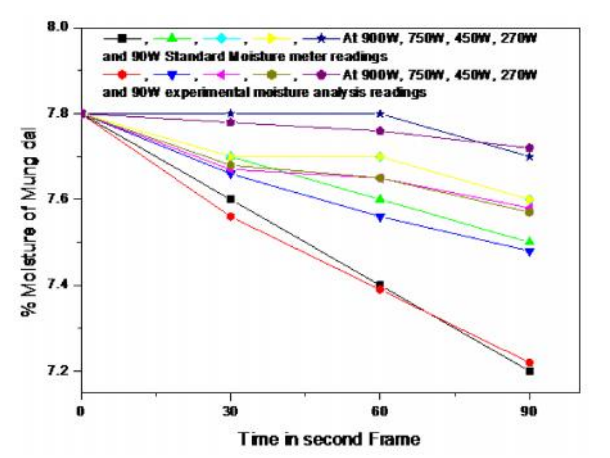


Figure 3: Trend Curve of % Moisture of Red Lentil (Masor Dal) w.r.t. Time for Standard Moisture Meter Data and Microwave Oven Heat Treatment Analysis Data

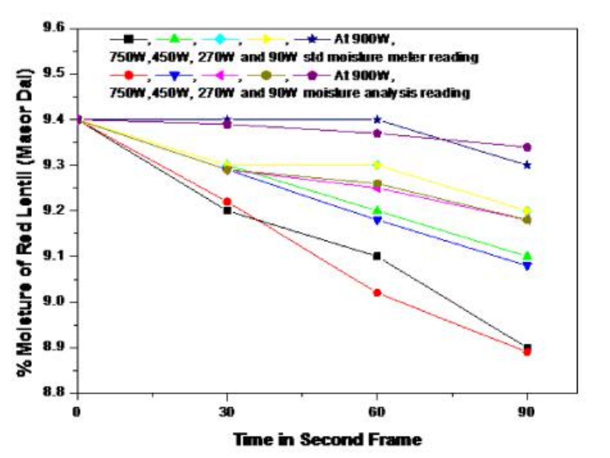


Table 3: Statistical Data Results of Microwave Treated Red Lentil (Masoor Dal) and Whole Mung Bean

SD	SE	Variance	R	R^2	Kurtosis	Skewness	Regression Equation
Microwave Treated Red Lentil (Masoor Dal)							
0.22411	0.11205	0.05023	-0.99658	0.993164	-1.87516	0.24443	y=9.392 - 0.00576666667*x
0.13817	0.06909	0.01909	-0.99974	0.999476	-1.32626	0.08558	y=9.398- 0.00356666667*x
0.09201	0.04601	0.00847	-0.98212	0.964567	0.8304	0.60073	y=9.385- 0.00233333333*x
0.09106	0.04553	0.00829	-0.97826	0.956985	1.10585	0.47184	y = 9.386 - 0.0023*x
0.02646	0.01323	7.00E-04	-0.9759	0.952381	-0.28571	-0.86392	y=9.405- 0.000666666667*x
Microwave Treated Whole Mung Bean							
0.24757	0.12379	0.06129	-0.996	0.99201	-0.55767	0.35463	y=7.779-0.00636666667*x
0.13796	0.06898	0.01903	-0.9919	0.98389	-0.62469	0.52783	y=7.784- 0.00353333333*x
0.09183	0.04592	0.00843	-0.9559	0.91383	1.77828	0.92968	y=7.777- 0.00226666667*x
0.09539	0.0477	0.0091	-0.9744	0.94945	1.23584	0.59902	y = 7.783 - 0.0024*x
0.09539	0.0477	0.0091	-0.9744	0.94945	1.23584	0.59902	y = 7.783 - 0.0024*x

All the stastical data results shown in Table 3, in which the other most important factor value of R^2 is playing the major role in microwave heat treatment experiments. So for microwave heat treatment value of R^2 are respectively 0.99201, 0.98389, 0.91383, 0.94945, 0.96571 for Whole Mung Bean and 0.99316, 0.99948, 0.96457, 0.95698, 0.95238 for red lentil with respect to 900 W, 720 W, 450 W, 270 W and 90 W.

CONCLUSION

The value of R^2 shows the strength of the linear correlation between experimental time and data. From the statistical analysis, R^2 values show the success rate of experimental data values around 94% to 99% in whole Mung Bean and in case of red lentil the success rate varies from 95% to 99% for various power levels 900 W, 720 W, 450 W, 270 W and 90 W. It validates the microwave heat treatment method for moisture analysis. From the Table 3, the experimental moisture analysis shows the standard error $\leq$ 0.2% in whole Mung Bean and red lentil in both the cases. These errors are acceptable for the experimental microwave heat treatment, so the microwave heat treatment has justified for moisture analysis. With the comparison of standard moisture meter DMM8, the most acceptable power levels are 450 W and 270 W for linear moisture analysis of microwave heating.

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