Developing appropriate storage technology for sweet potato

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DETERMINATION OF THE DRY MATTER CONTENT OF CASSAVA (*Manihot esculenta*, Crantz) TUBERS USING SPECIFIC GRAVITY METHOD

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ABSTRACT

The determination of the dry matter content of cassava tubers using oven dry method is a major constraint in tropical developing countries where the source of electricity is unreliable. In this study a prediction equation was developed as an alternative approach to dry matter determination with the oven dry method. The study was conducted for two years with eleven cassava accessions (using 13 and 15 month old tubers). In the first year, the specific gravity and the dry matter content (oven dry method) of the same tubers were used to derive the prediction equation that can be used for easy and faster estimation of the dry matter content of cassava tubers. The specific gravity and dry matter content based on the oven dry method ranged from 1.0966-1.1469 and 31.45-40.74%, respectively. There was a perfect correlation (R^2 = 0.9979) between specific gravity and oven dry matter content of cassava tuber. The middle portion of the cassava tubers gave the true representation of the dry matter content. The prediction equation developed was Y = - 175.46 + 188.61 X where: X = specific gravity and Y = percentage dry matter content. The dry matter content based on the prediction equation for the various accessions was found to be between 31.88-41.53% with a mean of 38.39%. The chi-square test conducted at probability level of 0.05 shows that there was no significant difference between percentage dry matters estimated using the oven dry method and the prediction equation. Hence, the prediction equation could be used to estimate the percentage dry matter content of cassava tuber if the specific gravity is known.

Keywords: cassava accessions, dry matter, specific gravity, oven dry method, prediction equation.

INTRODUCTION

Cassava (*Manihot esculenta*, Crantz) is from the family *Euphobiaceae.* It is among the most important root crops worldwide and provides food for one billion people (Bokanga, 2001; Nuwamanya *et al*., 2009). In Africa the crop is the most important staple food crops grown and plays a major role in the effort to alleviate food crisis (Hahn and Keyser, 1985). The crop contributes significantly to the economy of most tropical countries (Amani *et al*., 2005; Kawano *et al*., 2003). The edible root supplies energy for more than 500 million people worldwide (Ceballos *et al*., 2006) and it can be processed into various products and industrial applications (Abu *et al*., 2006; Ceballos e*t al*., 2006). Cassava tuber is an excellent source of carbohydrates. The economic value for cassava products for the farmer and industries is the dry matter content which is the chemical potential of the crop and reflects the true biological yield. The dry matter content which is also referred to as the dry weight is however controlled by polygenic additive factor (IITA, 1985; Kawano *et al*., 1987). According to Lian (1985) the dry matter is influenced by several factors such as the age of the plant, crop season, location and efficiency of the canopy to trap sunlight. Dry matter of cassava varies from one accession to another and ranged between 17% and 47% with the majority lying between 20% and 40% (Barima *et al*., 2000); values above 30% are considered high. The dry matter of the tuberous roots has become an important character for the acceptance of cassava by researchers and consumers who boil or process them. The conventional approach for determining dry matter of cassava tubers is by the use of the oven dry method. In this method, a fresh tuber is weighed, dried in an oven for at least 24 hours at 105°C and reweighed to determine the percentage dry matter content. The process more tedious when working with large samples and almost impossible in areas where there is no source of power or electricity. Therefore, this study seeks to address the problem by finding an alternative method for determining the dry matter content of cassava tubers other than the use of oven dry method.

MATERIALS AND METHODS

Study area

The study was conducted at the School of Agriculture laboratory, University of Cape Coast, Cape Coast from March 2008 to November 2009. The area has a temperature and relative humidity of 30-36°C and 60-70%, respectively.

Plant material

The cassava tubers were obtained from the Asuansi Research Farm in Abura-Asebu-Kwamankese District in the Central Region of Ghana. In all, eleven accessions were collected. The accessions were UCC 003, UCC 007, UCC 42, UCC 64, UCC 153, UCC 421, UCC 504, UCC 505, UCC 506, UCC 514, and a local variety called Afisiafi. Three healthy tubers were collected for each accession for the experiment.

Specific gravity determination

The freshly harvested tubers were peeled and thoroughly cleaned with water to get rid of all soil particles on the tubers. The ends of the tubers were nicely trimmed to get a uniform shape. Their specific gravity was found using the formula (Luther *et al*., 2004).

$$Sg = \frac{Weight\ of\ tuber}{Loss\ of\ weight\ in\ water} \quad (1)$$

Dry matter content determination with oven dry method

After a thorough mopping of water from the individual tubers, a sizable amount (20g) was obtained from the various sections of the tuber (head, middle and tail). It was then further sliced into small sizes to facilitate oven drying at 105^{o}C for 24 hours (Asare, 2004).

After the oven dry determination, correlation analysis was used to find out how the specific gravity values correlated with the dry matter content values (using oven dry method). Regression analysis was used to derive a prediction equation for the estimation of the dry matter content of cassava tubers. The specific gravity was the independent variable (X) and percentage dry matter content was the dependent variable (Y). Analysis of variance and chi-square method were used to analyze the data.

RESULTS AND DISCUSSIONS

Table-1 shows the specific gravity values for all the accessions used. It was observed that for the same tuber specific gravity differ slightly from head to tail. Also, the specific gravity values for all the accessions were greater than 1.0 and ranges from 1.0966 to 1.1469. This shows that the various tubers used were all denser than water and the values obtained agrees with (NRI, 1996). Table-2 also shows the dry matter content for the various accessions using oven dry method. The dry matter value obtained ranged between 31.45 - 40.74%. These values conform to the findings of Braima *et al*., (2000). It was also not different from IITA cassava varieties (IITA, 1985) and varieties grown in India (Vimala *et al*., 2008).

Table-1. Specific gravity values of various sections of cassava at 13 months.

Accessions	Tuber section			Mean
	Head	Middle	Tail	
Afisiafi	1.1584	1.1492	1.1330	1.1469
UCC 64	1.1524	1.1495	1.1151	1.1390
UCC 504	1.1514	1.1334	1.1159	1.1336
UCC 003	1.1440	1.1383	1.1392	1.1405
UCC 153	1.1463	1.1377	1.1269	1.1370
UCC 007	1.1466	1.1372	1.1373	1.1404
UCC 42	1.1367	1.1338	1.1307	1.1337
UCC 505	1.1357	1.1288	1.1245	1.1297
UCC 91	1.1273	1.1138	1.1163	1.1191
UCC 506	1.1201	1.1167	1.1198	1.1189
UCC 514	1.1152	1.1009	1.0736	1.0966
Mean	1.1395	1.1308	1.1211	1.1305

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Table-2. Percentage dry matter content of various sections of cassava at 13 month.

Accessions	Tuber section			Mean
	Head	Middle	Tail	
Afisiafi	41.60	41.36	40.55	41.19
UCC 64	41.76	41.23	34.87	39.29
UCC 504	41.58	38.26	35.02	38.29
UCC 003	40.21	39.16	39.32	39.56
UCC 153	39.36	39.24	38.37	38.99
UCC 007	40.69	38.96	38.97	39.54
UCC 42	38.86	38.33	37.76	38.32
UCC 505	38.68	37.41	36.61	37.57
UCC 91	37.13	34.64	35.09	35.62
UCC 506	35.80	35.17	35.74	35.57
UCC 514	34.89	32.25	27.21	31.45
Mean	39.38	37.79	35.98	37.72

Figures 1 and 2 shows the specific gravity of cassava tubers versus the dry matter content. It revealed that the dry matter content of cassava tubers depends on the specific gravity and vice versa. This means that as the specific gravity increases the dry matter content also increases and vice versa, this trend was not different from the study conducted by Asare (2004). From the close relationship between dry matter content and specific gravity, a regression equation was derived (Y = - 175.46 + 188.61 X). This was similar to Liu *et al.*, (1985) for sweet potatoes. However for this equation there was a perfect correlation (r = 0.9979). With this equation the dry matter content of cassava tubers can be rapidly and simply be determined in tropical developing countries in laboratories which are unequipped to carry out standard analysis. Bradbury (1986); Woolfe (1992) also had a similar equation with a correlation (r = 0.998).

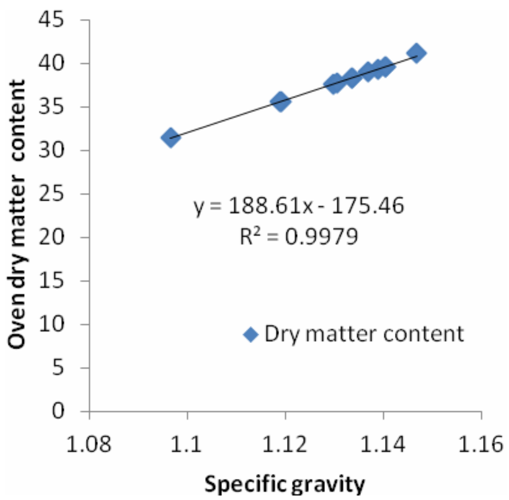

Figure-1. The linear relationship between specific gravity and oven dry matter content.

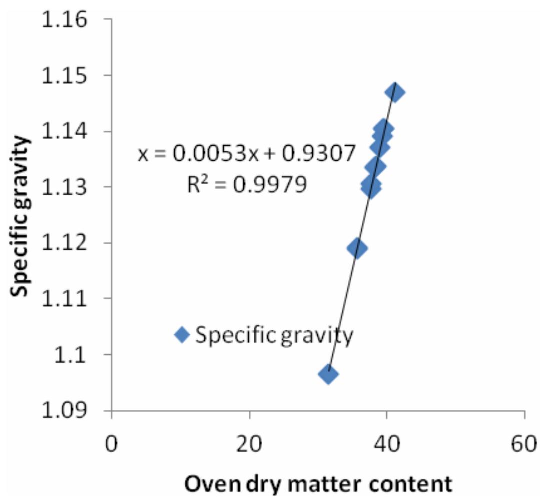

Figure-2. The linear relationship between oven dry matter content and specific gravity.

Table-3. Comparison of the percentage dry matter content based on oven dry method and the prediction equation for 15 month old cassava tubers.

Accessions	Percentage dry matter based on		Deviation of prediction equation from oven dry method
	Oven dry method	Prediction equation	
Afisiafi	39.85	40.70	0.85
UCC 64	38.68	39.11	0.43
UCC 504	35.64	37.69	2.05
UCC 003	31.81	32.55	0.74
UCC 153	38.93	39.63	0.70
UCC 007	39.54	40.28	0.74
UCC 42	38.73	39.14	0.41
UCC 505	37.58	36.40	-1.18
UCC 91	35.95	35.76	-0.19
UCC 506	31.38	31.70	0.32
UCC 514	31.80	32.55	0.75
Mean	36.45	36.94	0.49

Table-4 shows the deviation of the prediction equation method from oven dry method. It was observed that the dry matter content from the prediction equation was slightly greater than using the oven dry method with a mean deviation of 0.49. It can therefore be said that the prediction equation over predicts the dry matter content of cassava tubers slightly. This could be due to unavoidable experimental or human errors.

Tables 5 and 6 shows the verification of the prediction equation for the second year (using 13 and 15 month old tubers) to prove whether the deviations observed were statistically significant or not. It was observed that the deviation was highly insignificant. This further proves the point that the differences could only be due to unavoidable experimental errors. Thus the prediction equation may be used to predict or estimate the dry matter content of cassava tubers. Furthermore the dry matter value obtained by the use of prediction equation was not different from other researchers (Megnanou, *et al*., 2009; Nuwamanya *et al*., 2009). This is a relief when dealing with large samples or in places where electricity is unreliable.

Table-4. Verification of the prediction equation for dry matter content determination at the second year using 13 month old tubers.

Accessions	df	% Dry matter content based on		Chi-square χ^2	Probability of greater value	
		Oven dry method (ODM)	**Prediction equation** (PE)		0.05	0.001
Afisiafi	3	37.21	37.07	0.000529	7.81	11.34
UCC 64	3	34.87	34.01	0.021747	7.81	11.34
UCC 504	3	35.03	34.60	0.005344	7.81	11.34
UCC 003	3	36.00	34.89	0.035314	7.81	11.34
UCC 153	3	38.93	41.27	0.132677	7.81	11.34
UCC 007	3	39.57	39.40	0.000734	7.81	11.34
UCC 42	3	39.96	38.27	0.074630	7.81	11.34
UCC 505	3	35.77	34.63	0.037528	7.81	11.34
UCC 91	3	33.59	32.06	0.073016	7.81	11.34
UCC 506	3	32.52	33.59	0.034085	7.81	11.34
UCC 514	3	40.32	39.40	0.021482	7.81	11.34

Table-5. Verification of prediction equation for dry matter content determination at the second year using 15 month old tubers.

Accessions	df	% Dry matter content based on		Chi-square χ^2	Probability of greater value	
		Oven dry method (ODM)	**Prediction equation** (PE)		0.05	0.001
Afisiafi	3	38.99	40.90	0.089196	7.81	11.34
UCC 64	3	38.68	39.11	0.004728	7.81	11.34
UCC 504	3	35.64	38.50	0.212457	7.81	11.34
UCC 003	3	35.00	33.82	0.041171	7.81	11.34
UCC 153	3	37.33	37.41	0.000171	7.81	11.34
UCC 007	3	39.85	40.70	0.017752	7.81	11.34
UCC 42	3	38.73	39.14	0.004295	7.81	11.34
UCC 505	3	37.58	36.40	0.038253	7.81	11.34
UCC 91	3	35.95	35.76	0.001010	7.81	11.34
UCC 506	3	31.38	31.70	0.003230	7.81	11.34
UCC 514	3	31.81	32.55	0.016823	7.81	11.34

CONCLUSIONS

The specific gravity values for the tuber and the various sections used were all greater than one. This means that the samples were denser than water and that it cannot float on water. The percentage dry matter of the various accessions ranged from 31.70 - 42.85 % with the mean value of 37.72%. Using the derived prediction equation Y = - 175.46 + 188.61 X, the dry matter content of the various accessions (cassava tubers) ranged from 31.88 - 41.53% with a mean value of 38.39%.

The accumulation of dry matter within the tuber decline from head to the tail, therefore the middle portion gives a true representation of the whole tuber. This means in taking a portion for the tuber analysis, the middle portion should be selected.

Prediction equation obtained for estimating the dry matter content when specific gravity is known is

$$Y = -175.46 + 188.61\,X \quad (2)$$

Conversely, when the dry matter content is known, the prediction equation for estimating specific gravity is

$$X = 0.9307 + 0.0053Y \quad (3)$$

where

Y = dry matter content
X = specific gravity.

This prediction equation may be used to determine the dry matter content of cassava tubers in place of the oven dry method because the differences were not statistically significant. That is χ^2 was far less than χ^2_t, which means the prediction equation is relatively consistent.

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