INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
08–045/ZIP/2008/10–3–316–320
http://www.fspublishers.org

Full Length Article

Impact of Sweet Potato Cultivars on Blood Glucose Level in Diabetic and Healthy Participants

SURAYIA ZAKIR, MOHAMMAD SARWAR[1]†, JONATHAN ALLEN‡, MASOOD SADIQ BUTT¶, MEHR-UN-NISA†, UMAIR ARSHAD, ISLAM-UD-DIN¶¶ AND ASIF JAVAID†
Department of Food Science and Technology, University of Sargodha, Sargodha, Pakistan
†Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan
‡Department of Food Sciences, North Carolina State University, Raleigh, NC 27695, USA
¶ Institute of Food Technology, University of Agriculture, Faisalabad, Pakistan
¶¶Department of Mathematics and Statistics, University of Agriculture, Faisalabad-38040, Pakistan
[1]Corresponding author's e-mail: drms01@gmail.com

ABSTRACT

The incidence of diabetes mellitus (DM) all over the world is alarming, since nearly 7% of the world population and 12% of the population in Pakistan is affected by it. Although allopathic medicine has made tremendous progress, its cost is soaring, side effects are numerous and the control of DM remains unabated. The symptomatic treatment (without proper diagnose of blood glucose/insulin level & HbA_{1c}) through indiscriminate use of allopathic medicine is quite common. The objective of the present study was to show that sweet potato has an impact on blood glucose healthy and diabetic participants. White star (Pakistan) and Bearuegard (US) cultivars were analysed through bicinchoninic acid (BCA) protein assay protein assay and electophorses to determine true protien and identify protein banding pattern, respectively. In diabetic persons, the mean value of two hours postprandial blood glucose level (mg dL^{-1}) were 296 in glucose-control (T_1), which declined to 246 in white star (T_2), marginally increased to 301 in glucose + Caiapo (T_3), substantially decreased to 216.29 in white star-skim (T_4), despite fasting glucose level was at 253, and decreased to 257 in Beauregard (T_5), respectively with coefficient of variation (CV) ranged from 35% to 43%. The average value of two hours insulin varied from 5.21 to 12.85 µLU mL^{-1}. The preliminary results indicated that sweet potato has a blood glucose lowering effect on the person with diabetes and Caiapo had compatible results in normal subjects. White star and its skin showed better results than Beauregard as evident from the postprandial glucose level and insulin response. These findings present a great opportunity for the North Carolina, US and Pakistan farming community/industry to consider developing new markets for sweet potato products that offer anti-diabetic health benefits.

Key Words: Sweet potato; Blood glucose level; Diabetes mellitus; BCA

INTRODUCTION

Diabetes mellitus (DM) is one of the leading causes of death and disability all over the world. Nearly 7% of the world's population suffers from diabetes and about 3.2 million people die every year (Anthony *et al.*, 1999; WHO, 2000). Nearly 40% of people with type-2 diabetes require insulin injections. The goal of diabetes management is to keep blood glucose level closer to normal range as safely possible as described by American Diabetes Association (ADA, 1994), thus avoiding blood glucose level that are too high (hyperglycemia) or too low (hypoglycemia).

In Pakistan, diabetes prevalence is high, 12% of the population above 25 years of age has DM and 10% have impaired glucose tolerance (IGT) (Jawad, 2003). Likewise, DM is the seventh leading cause of death listed on US. The total number of Diabetics in the US is 18 million, of which 13 million are diagnosed. Each year, approximately 800,000 people are detected with diabetes (ADA, 2002).

Novel scientific endeavors are underway but so far no absolute cure is available. Current allopathic treatment has made tremendous progress in controlling this disease, yet the use of insulin and medications have led to impaired glucose level, GI system's malfunction and other physical and behavioral changes. In terms of efficacy, 40% of cases those drugs can no longer control blood sugar after three months of continued treatment at an adequate dosage (FAO, 1998). There is evidence that these drugs produce damaging long-term side effects; moreover, the cost of medical treatment is soaring (WHO, 1998). Thus, the management of diabetes through diet diversification and use of biomedicine is gaining popularity.

Sweet potato (*Ipomoea batatas*), belonging family Convolvulaceae, is gaining importance due to its usefulness in controlling blood glucose of person with diabetes. Thus, the present study was undertaken to provide additional information to current literature. This study was cross sectional, which identified protein banding pattern and

To cite this paper: Zakir, S., M. Sarwar, J. Allen, M.S. Butt, M.U. Nisa, U. Arshad, I.slam-ud-Din and A. Javaid, 2008. Impact of sweet potato cultivars on blood glucose level in diabetic and healthy participants. *Int. J. Agri. Biol.*, 10: 316–20

glycoprotein in two elite cultivars, Beauregard and White Star. It also determined physiochemical analysis and (iv) testing various forms of food (sweet potato) on diabetic and normal participants. The objective was to determine physiochemical charateristics of two sweet potato varieties namely beauragard (US) and white star (Pakistan) of skinwhole tuber. In addition, both cultivars were analysed wirh BCA (bicinchoninic acid) acid protein assay and electophorses to determine true protein and indentify acidic glycoprotein.

MATERIALS AND METHODS

The sweet potato cultivar, Beauregard, was procured from the Food Science Department, North Carolina State University, while White Star, a Pakistani cultivar, was obtained from Ayub Agricultural Research Institute, Faisalabad, Pakistan. Caiapo tablets were purchased from Expo Brazil and utilized further in the efficacy trials. The whole cultivars were cleaned, sliced, placed overnight in an oven at 40^{o}C and then packed airtight. The skin from the Pakistani cultivar, White star, was also separated and packed to use further in efficacy studies l. The cultivars were analyzed for moisture, ash, protein, fiber, fat and nitrogen free extracts (NFE) contents according to standard procedures (AOAC, 1990). Each cultivar was analyzed for total protein using a BCA kit. Bovine serum albumin (BSA) was used as protein reference to draw a standard curve and compare unknown samples. Electrophoresis was run for the identification of protein bands in the skin and flesh samples of the selected cultivar for comparison with that of caiapo using Coomassie Brilliant Blue stain. Marker proteins of known molecular weight were run in a separate lane of the gel, in order to calibrate the gel and determine the weight of unknown proteins by comparing the distance traveled relative to the marker (Rybicki & Purves, 2005). Same samples were run to determine glycoproteins. Dehydrated sweet potato and skin alone were tested for general appeal by a consumer taste panel based on various sensory attributes like color, flavor, taste, texture and over all acceptability following 9-point hedonic scale described by Larmound (1977).

The participatory rapid appraisal (PRA) was conducted on 20 each normal participants and person with diabetes from the city and the suburbs of Faisalabad. The participants were briefed about the objectives of the study and were also apprised about the process of blood sampling and intake of various treatments of sweet potato. The participants were also told about the protocol of the experiments, time involved and other attendant problems. The researcher obtained prior approval from the ethics committee of the University to conduct human research and examined the effect of consumption of sweet potato on the regulation of glucose level in healthy participants as well as diabetic persons with special reference to glucose level and insulin response.

RESULTS AND DISCUSSION

Proximate analysis. Sweet potato samples along with the skin of White Star were analyzed for dry matter, crude protein, crude fat, fiber and ash and NFE. The dry matter of Beauregard, white Star and skin of white Star was 17.54, 17.89 and 18.97%, respectively. The amount of dry matter agreed with the results of Purcell *et al*. (1989) who observed that generally sweet potatoes contain about 25% dry matter. The proximate analysis showed that crude protein was 2.54, 2.9 and 4.88%, while fat was 1.13, 1.04 and 1.23% in Beauregard, white star and white Star skin, respectively (Table I). Likewise, the fiber content was 2.26, 2.10 and 9.19%; ash was 3.91, 3.92 and 7.01% in the corresponding products. The NFE content is almost non significant (90%) in both the cultivars but different with skin (77.69%).

The means regarding protein contents agreed with the previous findings (Cooley, 1948; Whitechair *et al.,* 1949; Murthy & Swaminathan, 1954) who reported that the protein level of sweet potato ranged from 1.73 to 11.8% (dry weight basis); however, protein content varies from location to location. There are large unexplained differences in protein content due to location at which the sweet potato is grown (Purcell *et al*., 1978). Crude protein ranges from 1.3 to > 10% (dry weight basis) from which 60 to 85% of nitrogenous material and the remainder is mostly amino acids and amide nitrogen (Purcell *et al.*, 1972). Likewise, mean values for lipids and fatty acids (minor class of components) are also in line with the previous reports that ranged from 0.29 to 2.7% (Purcell *et al.*, 1989).

BCA protein assay. The mean values for total protein extracted through BCA assay was 1.75 and 2.79%, respectively in the skin and flesh of Beauregard, and the corresponding values for White Star were 3.4 and 2.10%. The results agree with the work of Purcell *et al*. (1978). Crude protein ranges from 1.3 to > 10% (dry weight basis) and varies from variety to variety, which is what the current research focused (Purcell et al., 1972).

Electrophoresis identification. The SDS-PAGE protein banding patterns of Beauregard and White Star samples were then evaluated and compared to Caiapo fractions. These results showed that all samples showed essentially the same protein banding pattern, a result suggesting homology between the test cultivars and 22 kDa was similar both in the cultivars with reference to Caiapo (indicated by arrows in Fig. 1). Also, staining patterns revealed the presence of magenta color in the skin samples showing the presence of glycoprotein in the skin (Fig. 2). The results of electrophoresis were indicative of acidic glycoprotein and consistent with Kusano *et al*. (2001), Maeshima *et al*. (1985) and Chang and Su (1986) who found protein at 30 and 25 KDa, respectively.

Sensory evaluation of test food. The servings of the test food dehydrated Beauregard, white star and white Star skin were prepared and subjected to sensory evaluation before

Table I. Chemical analysis of sweet potato cultivars

Cultivars	Crude Protein %	Fat %	Fiber %	Ash %	NFE %
Dehydrated Beauregard	2.34 (± 0.15)	1.33 (± 0.33)	2.26 (± 0.13)	3.91 (±0.10)	90.05 (±0.24)
Dehydrated White Star	2.72 (± 0.08)	1.24 (± 0.26)	2.10 (± 0.12)	3.92 (±0.08)	89.88 (±0.37)
White Star Skin	4.88 (± 0.11)	1.23 (± 0.10)	9.19 (± 0.34)	7.01 (±0.22)	77.47 (±0.55)

Table II. Descriptive statistics of blood glucose (mg dl^{-1}) and Insulin (µIU ml^{-1}) levels with Various Treatments of Normal Participants

Parameters	Glucose (Control) (T_1)	White Star (T_2)	Glucose+ Caiapo (T_3)	White Star (Skin) (T_4)	Beauregard (T_5)
Fasting Blood					
Mean	83.14	82.65	85.39	91.44	87.06
SD	9.30	11.05	12.29	15.17	12.89
CV	0.11	0.13	0.14	0.16	0.14
One Hour					
Mean	115.54	95.90	116.78	86.44	96.67
SD	41.23	13.98	45.97	12.73	21.35
CV	0.36	0.14	0.39	0.14	0.22
Two Hours					
Mean	78.57	82,45	78.61	84.33	86.28
SD	21.83	11.96	21.01	12.65	17.52
CV	0.27	0.14	0.26	0.14	0.20
Three hours					
Mean	70.46	80.25	66.28	83.50	79.33
SD	12.54	8.33	13.39	10.37	11.49
CV	0.17	0.10	0.20	0.12	0.14
Fasting Insulin					
Mean	5.91	5.66	5.03	6.08	7.99
SD	3.64	3.68	2.50	4.42	7.15
CV	0.61	0.64	0.49	0.72	0.89
Two hours Insulin					
Mean	12.76	3.74	13.43	6.28	9.44
SD	13.04	2.88	12.88	2.65	8.13
CV	1.02	0.77	0.95	0.42	0.86

Table III. Descriptive Statistics of Blood Glucose (mg dL^{-1}) and Insulin (µIU ml^{-1}) levels with various treatments of persons is diabetes

Parameters	Glucose (Control) (T_1)	White Star (T_2)	Glucose+ Caiapo (T_3)	White Star (Skin) (T_4)	Beauregard (T_5)
Fasting Blood					
Mean	212.60	220.74	225.06	253.12	227.59
SD	90.25	88.66	99.36	112.86	95.29
CV	0.42	0.40	0.44	0.47	0.41
One Hour					
Mean	337.60	255.47	344.53	244.35	263.53
SD	103.95	102.32	104.24	121.12	97.87
CV	0.30	0.40	0.30	0.49	0.37
Two Hours					
Mean	296.45	246.42	301.53	216.29	257.76
SD	111.34	87.07	113.91	93.90	98.90
CV	0.37	0.35	0.37	0.43	0.38
Three hours					
Mean	232.70	230.05	246.65	203.94	226.65
SD	95.65	83.38	109.29	87.73	89.89
CV	0.41	0.36	0.44	0.43	0.39
Fasting Insulin					
Mean	7.76	8.91	6.71	6.27	9.00
SD	6.65	4.60	4.61	5.42	5.01
CV	0.85	0.51	0.68	0.86	0.55
Two hours Insulin					
Mean	12.85	5.21	10.42	7.61	12.63
SD	6.35	2.84	7.53	5.24	5.79
CV	0.49	0.54	0.72	0.68	0.45

administering the treatments to the participants. Five judges from the Institute of Food Sciences were selected for the sensory evaluation. The attributes of the sensory evaluation were color, flavor, taste and texture. Each attribute was evaluated using at nine point hedonic scale. Overall, summing all parameters, Beauregard scored 7.7 followed by White star (7.1) and White Star skin (6.5). Beauregard faired better in all attributes than the others. Its color, size

and texture were preferred by the evaluation team. The size of the Pakistani cultivar was small because of the summer crop; however, winter sweet potato size was bigger and more palatable.

Anthropometric characteristics. The basic characteristics of the participants are described below:

Age. The mean age of the persons with diabetics (N: 20) was 48 years (±9.60) and that of the healthy participants was (N; 20) 35 years (±10.70), thus the healthy participants were relatively younger. In the Ludvik *et al.* (2004) study, the mean age of the participants with diabetics was 58 years. The participants with diabetics had diabetes for the past 10 to 12 years. One participant with diabetics was young (18 years), showing a syndrome of MODY (Maturity onset of Diabetes in Young), a case of type 2 diabetes.

Weight. The mean weight of participants with diabetics (N: 20) was 152 lbs (±19.54), while that of healthy participants (N: 20) was 144 (±6.26). In diabetic subjects, 17 were over weight (male: 5 & female: 12) and in healthy participants subjects, three were overweight (male: 1 & female: 2).

Height. The mean height of participants with diabetics was 5 ft 2 inches (±0.49) and that of healthy participant was 5 ft 6 inches (±0.18). The greatest height was 6 ft for both healthy participant diabetic participants.

Body mass index (BMI). The BMI was calculated with the following formula:

$$BMI = ((Wt*705)/(Ht)/(Ht)) \quad (1)$$

Where: Wt: weight of subjects in lbs; and Ht: Height of subjects in inches.

The average BMI for diabetic subjects (N: 20) was 26.13 (±3.4), of which three were showing obesity (male: 1 & female: 2) and 14 were overweight and the rest were within the health weight range. The mean BMI of healthy participants was 22.96 (±0.53), one male was obese and one male and one female were overweight. The BMI in the study for both diabetic and healthy participants was less as compared to Paisey *et al.* (2002), who conducted a 5-years follow-up of an intensive weight loss program in established type-2 diabetics BMI was > 30. The BMI was 27.7 in another (Ludvik *et al*., 2004) study but consistent with the study Juntunen Katri *et al.* (2002) study (BMI: 22.9).

Descriptive analysis of the study. The descriptive parameters of healthy participants are given in Table II. The mean fasting blood glucose level ranged from 82.65 (T_2) to 91.44 mg dL^{-1} in all treatments with CV varying from 11 to 16%. However, one hour blood glucose level mean values were higher except T4 with (T_1) and (T_3) the highest and the CV ranging from 14 to 39%. The corresponding values for two and three hours were lower than one hour mean values. The mean T_3 (glucose+Caiapo) postprandial blood glucose level was lower than other test foods. This showed that blood glucose level peaked in the first one hour with CV varying 10 to 26%. The insulin level during fasting varied from 5 to 7.9 µIU mL^{-1} and by two hours varied from 3.7 to 13.43 µIU mL^{-1}. The Insulin response was higher in postprandial analysis of T_2 and T_4 as compared to other treatments (Fig. 3).

Fig. 1. Coomassie Blue Staining

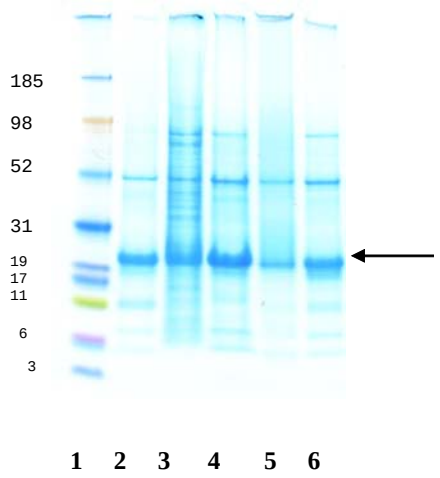
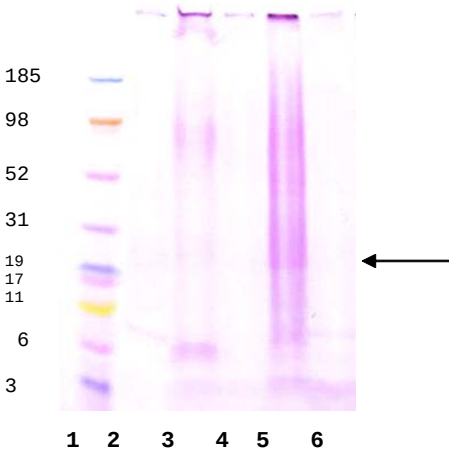


Fig. 2. Glycoprotein Staining

1. Marker
2. Caiapo
3. Beauregard skin
4. Beauregard flesh
5. White star skin
6. White star flesh



The mean value of fasting blood glucose level of participants with diabetics varied (in mg dL^{-1}) from 212 in T_1, 220 in T_2, 225 in T_3, 253 in T_4, to 227 in T_5 with a CV between 40 and 47% (Table III). The glucose tolerance test showed that the subjects were chronic diabetics and their threshold glucose level was very high implying that they were managing their disease very well. The mean value of the 2 h postprandial blood glucose level (in mg dL^{-1}) was 296 in T_1, declined to 246 in T_2, insignificantly increased to 301 in T_3; substantially decreased to 216.29 in T_4 (despite a mean fasting glucose level at 253) and decreased to 257 in T_5, respectively, with CV ranged 35% to 43%. The results were consistent with Ludvik *et al.* (2004) (the blood values declined from 143 to 128 mg dL^{-1}) except T_3 which was swamped with glucose. The mean value of Ludvik *et al.* (2004) study of diabetic subjects was 214.6 mg dL^{-1} as

compared to 248.7 mg dL^{-1} for the placebo group. The absolute postprandial decrease (~30 mg dL^{-1}) was higher in the present study.

The mean value of fasting insulin varied from 6.2 to 9 μIU mL^{-1}, showing high variation. The average value of two hours insulin varied from 5.2 to 12.2 μIU mL^{-1} again displaying high variation. The participants with diabetics were chronic patients and they showed insulin secretion at varied level with various treatments. The white star (followed by its skin) servings showed better results in lowering postprandial blood glucose level in diabetic subjects (Fig. 4). Following treatment with glucose and Glucose+Caiapo and Beauregard, insulin sensitivity ameliorated significantly when assessed both with oral glucose tolerant test from 7.76 to 12.5 μIU mL^{-1} in T_1; 6.71 to 10.42μIU mL^{-1} in T3 and 9.00 to 12.63 μIU mL^{-1} in T_5. Improvement of insulin sensitivity was observed in T_2, while T_4 was better than T_3 and T_5. The results were similar to Ludvik et al (2003) for Caiapo and White star. The postprandial insulin response was better with white star followed by its skin and Caiapo.

CONCLUSION

The sweet potato has blood glucose lowering effect in persons with diabetics, while Caiapo showed similar results in healthy participants. White star and its skin showed better results as evident from the postprandial glucose level and insulin response. However, Caiapo showed lower postprandial blood glucose level in healthy participants. The physiologic data would be more valuable in advising people with diabetes than would simple chemical analysis. The results are at variance because the present study was cross sectional and the earlier studies were longitudinal. These findings represent a significant opportunity for the North Carolina and Pakistan farming community/industry to consider developing new markets for important sweet potato products that offer anti-diabetic health benefits.

Acknowledgment. Special thanks to Dr. Troung, USDA/ NCSU, Dr. Hangama Allen and Dr. Debbie for providing sweet potato product and professional support for design and providing protocol of the study. The authors are also highly thankful to Director, PINUM, Faisalabad and his team for taking and analyzing the blood samples for glucose and insulin level.

REFERENCES

American Diabetes Association, 2002. Unproven therapies (Position Statement). *Diabetes Care*, 25 (Suppl. 1): S133

Anthony, P.F., C.B. Turner and S.A. Piletsky, 1999. *In vitro* diagnostics in diabetes meeting the challenge. *Clin. Chem*., 45: 1596–601

AOAC, 1990. *Official Methods of Analysis. Association of Official Analytical Chemists.*15th Ed. Arlington Virginia

Chang Tsung-Chain and S.U. Jong-Ching, 1986. Starch Phosphorylase Inhibitor from Sweet Potato. *Plant Physiol.,* 80: 534–8

Cooley, J.S., 1948. Sweet Potato-World Production and Food Value. *Econ. Bot.,* 7: 83

FAO, 1998. *Carbohydrates in Human Nutrition*. Food and Nutrition Paper 66 Report of a joint FAO/WHO Consultation, Rome

Jawad Fatima, 2003. *Diabetes in Pakistan*, *Diabetic Voice*, Vol. 48 Issue # 2, July 2003

Juntunen Katri, S., Leo K. Niskanen, Kirsi H. Liukkonen, Kaisa S. Poutanen, Jens J. Holst and Hannu M. Mykkänen, 2002. Postprandial glucose, insulin and incretin responses to grain products in healthy subjects. *American J. Clinical Nutrition*, 75: 254–62, February 2002, © 2002 American Society for Clinical Nutrition

Kusano, S., H. Abe and H. Tamura, 2001. Isolation of antidiabetic from white-skinned sweet potato (*Ipomoea batatas* L.) *Biosci. Biotechnol. Biochem*., 65: 109–14

Larmound, E., 1977. *Laboratory Methods for Sensory Evaluation of Foods*. Research Branch, Department of Agriculture, Ottawa, Canada, Publication No. 1637

Ludvik. B., W. Waldhausl, R. Prager, A. Kautzky-Willer and G. Pacini, 2003. Mode of action of ipomoea batatas (Caiapo) in type 2 diabetic patients. *Metabolism*., 52: 875–80. Department of Medicine, Division of Endocrinology and Metabolism, University of Vienna, Austria

Ludvik, B., B. Neuffer and G. Pacini, 2004. Efficacy of Ipomoea batatas (Caiapo) on diabetes control in type 2 diabetic subjects treated with diet. *Diabetes Care*, 27: 436–40. Department of Medicine III, Division of Endocrinology and Metabolism, University of Vienna, Vienna, Austria, Bernhard.Ludvik@Akh-Wien.Ac.At

Murthy, H.B.N. and M. Swaminathan, 1954. Nutritive Value of different varieties of Sweet Potato. *Current Sci*., 29: 14

Paiesey, R.B., J. Frost, P. Harvey, A. Paisey, L. Bower, R.M. Paisey and P. Taylor, 2002. Five year results of a prospective very low calorie diet or conventional weight loss program in type 2 diabetes. *J. Human Nutr. Dietetics*, 15: 121-7

Purcell, A.E., H.E. Swasgood and D.T. Poep, 1972. Protein and Amino acid Content of Sweet Potato Cultivars. *J. American Soc. Hort. Sci.,* 97: 30

Purcell, A.E., W.M. Jr. Walter and F.G. Geisbrechi, 1978. Root, Hill and Field Variance in protein content of North Carlina Sweet Potato. *J. Agric. Food Chem.,* 26: 362

Purcell, A.E., W.M. Walter and L.G. Wilson, 1989. *In*: Michail Eskin, N.A. (ed.), *Sweet Potato–Chapter 10 was Contributed in Book on Quality and Preservation of Vegetables*". Department of Food and Nutrition, University of Manitoba, Canada, CRC Press, BOCA Raton, Florida

Rybicki, E. and M. Purves, 2005. *SDS-PAGE Electrophoresis*. University of Cape Town: Department of Microbiology. Available at http://www.mcb.uct.ac.zu/sdspage.html

Whitechair, C.K., W.D. Gallup, M.C. Bell and H.M. Briggs, 1949. Efficiency of urea in supplementing corn and sweet potato. *Oklahoma Agric Exp. Stn. MP,* 15: 19

WHO, 1998. "*The World Health Report, Life in the 21st Century, A Vision for All*". World Health Organization, Geneva

(Received 13 February 2008; Accepted 19 March 2008)