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VARIATION IN PHYSIO-CHEMICAL CHARACTERISTICS OF SOME CULTIVARS OF SWEET POTATO

SURAYIA ZAKIR, MOHAMMAD SARWAR, JONATHAN ALLEN[*], MUHAMMAD NISAR KHAN[***] AND MASOOD SADIQ BUTT[**]

Institute of Animal Nutrition and Feed Technology (IAN&FT), University of Agriculture, Faisalabad, Pakistan.

Abstract

The present study was conducted to provide proximate analysis and identification of acidic glycoprotein from sweet potato cultivars. For this purpose, two sweet potato cultivars via., White star (Pakistan) and Bearuegard (US) were analysed through BCA protein assay and electophoresis to determine true protien and identify protein banding pattern, respectively. When the sweet potatoes were fed to diabetic persons, the mean value of two hours postprandial blood glucose level were 296 mg/dl ± 111.34 in the control, glucose declined to 246 mg/dl ± 87.07 in White Star and marginally increased to 301 mg/dl ± 113.91 in Glucose + Caiapo treatment; substantially decreased to 216.29 ± 93.16 in White Star (Skin) despite fasting glucose level at 253 mg/dl and decreased to 257 mg/dl ± 98.90 in Beauregard treatment. The average value of two hours insulin varied from 5.21 µlỤ/mL ± 2.84 to 12.85 µlỤ/mL ± 6.35. The preliminary results supported the earlier studies that sweet potato has a blood glucose lowering effect on the person with diabetes and Caiapo showed the same results in normal subjects. White star and its skin showed better results than Beauregard as depicted by the postprandial glucose level and insulin response. These findings present a significant 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.

Introduction

Sweet potato belongs to the plant family *Convolvulaceae.* Current evidence suggests that sweet potato may be useful in controlling blood glucose of person with diabetes. Therefore, the significance of this vegetable is gaining importance as the management of diabetes through diet diversification and by use of biomedicine is gaining popularity.
The present study was undertaken to provide additional information to current literature.

The study differed in many respects with earlier studies including: i) its cross sectional study; ii) identified protein banding pattern and glycoprotein in two elite sweet potato cultivars viz., Beauregard and White Star; iii) Physiochemical analysis of test foods; and iv) various forms of food (sweet potato) tested on persons with diabetes and normal participants. The objective of the this work was to determine physiochemical charateristics of two sweet potato cultivars, via., Beauragard (US) and White star (Pakistan) with skin and skin alone. In addition, both cultivars were analysed through BCA (bicinchoninic acid) Protein Assay and electrophoresis to determine true protein and indentify acidic glyco-protein

[*]Department of Food Sciences, North Carolina State University (NCSU)
[**]Institute of Food Technology, University of Agriculture, Faisalabad
[***]Department of Veterinary Parasitology, Univ. Agric., Faisalabad

Materials and Methods

The sweet potato cultivar, Beauregard, was procured from the Food Science Department, NC 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 and placed over night 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. The sweet potato cultivars were analyzed for moisture, ash, protein, fiber, fat, and nitrogen free extract (NFE) contents according to standard procedures (Anon., 1990). Each cultivar was analyzed for total protein using a BCA (bicinchoninic acid) kit. BSA (bovine serum albumin) 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. Similarly, the same samples were run to determine glycoproteins. Dehydrated sweet potato and skin alone were tested for general appeal by a consumer taste panel. For this purpose, it was analyzed for various sensory attributes like color, flavor, taste, texture and over all acceptability following 9-point hedonic scale described by Larmond (1977).

The participatory rapid appraisal (PRA) was conducted on 20 persons each in case of normal participants and persons with diabetes from the city and the suburbs of Faisalabad.

Following treatment were given to the normal and persons in diabetes:

1. Glucose (Control) (T_1)
2. White Star (T_2)
3. Glucose + Caiapo (T_3)
4. White Star (Skin) (T_4)
5. Beauregard (T_5)

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 persons in diabetes 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, ash and NFE. The dry matter of Beauregard, White Star and skin of White Star was 17.54 % ± 1.51, 17.89 % ± 0.77 and

18.97 % ± 0.77, 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 (DM). The comparison of proximate analysis (Table 1) showed that crude protein was 2.54 % ± 0.15, 2.92 % ± 0.08 and 4.88 % ± 0.11, fat varied from 1.13 % ± 0.33, 1.04 % ± 0.26 and 1.23 % ± 0.10 respectively in Beauregard, White star and White Star skin. Likewise, the fiber content was 2.26 ± 0.13, 2.10 ± 0.13 and 9.19 % ± 0.36; ash was 3.91 ± 0.10, 3.92 ± 0.08 and 7.01 % ± 0.22 in the corresponding products. The NFE content was non significant in case of both the cultivars.

The means regarding protein contents agreed with the previous findings (Whitechair *et al*., 1949; Murthy & Swaminathan, 1954; Cooley, 1948), who reported that the protein levels of sweet potato ranged from 1.73 to 11.8 % (dry weight basis), however, protein content varied 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). Likewise, the mean values for fat content are also in line with the previous research that lipids and fatty acids (minor class of components) ranged from 0.29 to 2.7 % (Purcell *et al*., 1972).

BCA protein assay: The mean values for total protein extracted through BCA assay was 1.75 % ± 0.10 and 2.79 % ± 0.20, respectively, in the skin and flesh of Beauregard and the corresponding values for White Star were 3.45 % ± 0.10 and 2.10 % ± 0.13. The results agree with the work of Purcell *et al*., (1978). In another study, Purcell & Walter (1985) revealed that crude protein ranged from 1.3 to 10% (dry weight basis) and varied from variety to variety which is what the current research focused.

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 (Fig. 1) that all samples showed essentially the same protein banding pattern, a result suggesting homology between the test cultivars and 22,000 kDa was similar both in the cultivars with reference to Caiapo. The staining patterns (Fig. 2) revealed the presence of magenta color in the skin samples showing the presence of glycoprotein in the skin. The results of the electrophoresis were indicative of acidic glycoprotein and were consistent with the reports of Kusano *et al*., (2001), Maeshima *et al*., (1985) and Chang & SU (1986) who found protein at 30 kDa 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 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 9 point hedonic scale. Over all summing all parameters, Beauregard scored 7.7 ± 0.26 followed by White Star 7.1 ± 0.24 and 6.5 ± 0.18 for White Star skin. Beauregard faired better in all attributes than that of the other. 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 is bigger and more palatable.

Table 1. 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

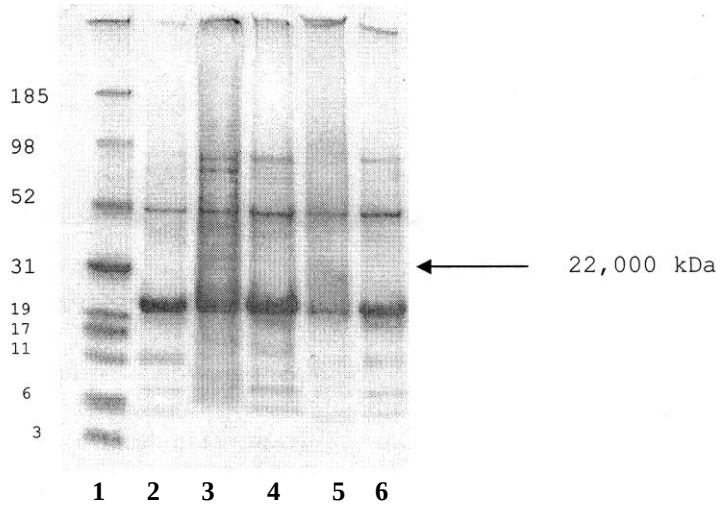

Fig. 1. Coomassie blue staining.

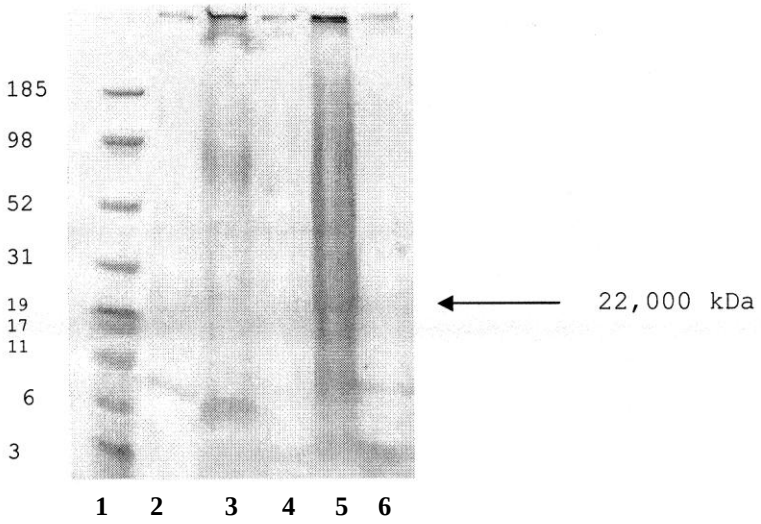

Fig. 2. Glycoprotein staining.

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

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 (SD ± 9.60) and that of the healthy participants was (N; 20) 35 years (SD ± 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 have diabetes for the past 10 to 12 years. One the participants with diabetics was relatively 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 (SD ± 19.54), while that of healthy participants (N: 20) was 144 (SD ± 6.26). In diabetic subjects, 17 were over weight (male: 5 and female 12) and in healthy participants subjects, three were overweight (male: 1 and female: 2).

Height: The mean height of participants with diabetics was 5 ft 2 inches (SD ±0.49) and that of healthy participant was 5ft 6 inches (SD ± 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)) (1)

where:
Wt: weight of subjects in lbs;
Ht: Height of subjects in inches

The average BMI for diabetic subjects (N: 20) was 26.13 (SD ± 3.4), of which three were showing obesity (male: 1 and female: 2) and 14 were overweight and the rest were within the health weight range. The mean BMI of healthy participants was 22.96 (SD ±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-year follow-up of an intensive weight loss programme in established type 2 diabetic participants BMI was > 30. The BMI was 27.7 in a study done by Ludvik *et al*., (2004).

Descriptive analysis of the study: The descriptive parameters of healthy participants are given in Table 2. The mean fasting blood glucose level ranged from 82.65 mg/dl ± 11.05 (T_2**)** to 91.44 mg/dl ± 15.17 in all treatments with Coefficient of Variation (CV) varying from 11 to 16%, however, one hour blood glucose level mean values were higher except

T_4 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 the 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 levels peaked in the first one hour with CV varying 10 to 26%. The insulin level during fasting varied from 5 µIU/ml ± 2.51 to 7.9 µIU/ml ± 7.15 and by two hours varied from 3.7 µIU/ml ± 2.88 to 13.43 µIU/ml ± 12.88. The Insulin response was higher in postprandial analysis of T_2 and T_4 as compared to other treatments (Fig. 3).

Table 2. Descriptive statistics of blood glucose (mg/dl) and insulin (µIU/ml) 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

The mean value of fasting blood glucose level of participants with diabetics varied from 212 mg/dl ± 90.25 with T_1, 220 mg/dl ± 88.66 with T_2, 225 mg/dl ± 99.36 with T_3, 253 mg/dl ± 112.86 with T_4, to 227 mg/dl ± SD 95.29 in T_5 with a coefficient of variation (CV) between 40 and 47% (Table 3). The glucose tolerance test showed that the subjects were chronic diabetics and their threshold glucose level was very high meaning thereby that they were managing their disease very well. The mean value of the two hours postprandial blood glucose level was 296 mg/dl ± 111.34 in T_1, declined to 246 mg/dl ± 87.07 in T_2, insignificantly increased to 301 mg/dl ± 113.91 in T_3; substantially decreased to 216.29 ± 93.16 T_4 (despite a mean fasting glucose level at 253 mg/dl) and decreased to 257 mg/dl ± 98.90 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 mg/dl to 128 mg/dl) except T_3 which was swamped with glucose. The mean value of in the studies of Ludvik *et al*., (2004) was 214.6 mg/dl as compared to 248.7 mg/dl for the placebo group. The absolute postprandial decrease (nearly 30 mg/dl) was higher in the present study.

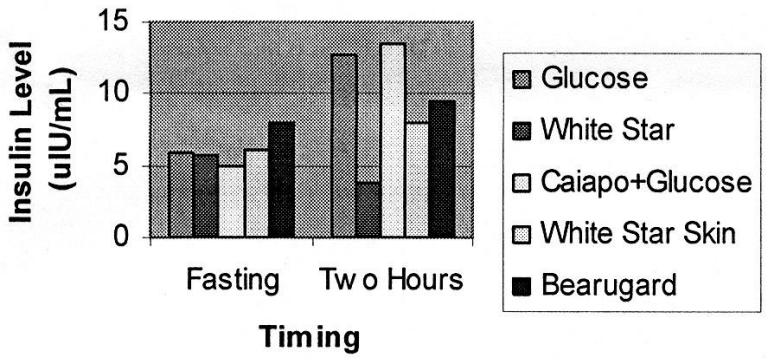

Fig. 3. Mean values of insulin level with various treatments of normal subjects.

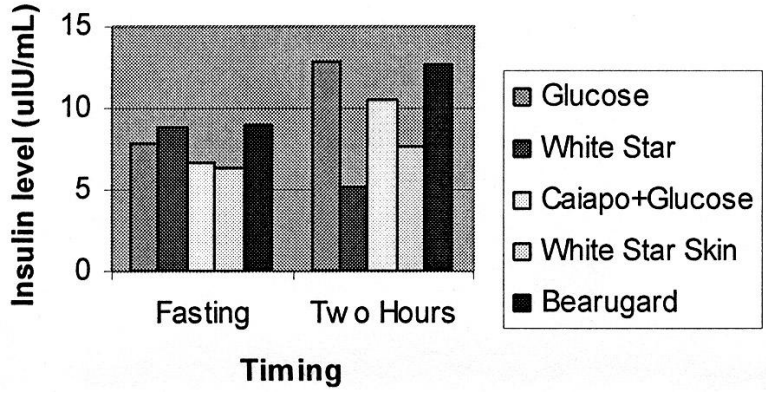

Fig. 4. Mean values of insulin level with various treatments of diabetic subjects.

The mean value of fasting insulin varied from 6.2 µIU/ml ± 5.42 to 9 µIU/ml ± 5.00, showing quite high variation. The average value of two hours insulin varied from 5.2 µIU/ml ± 2.84 to 12.2 µIU/ml ± 6.35, depicting high variation. The participants with diabetics were chronic patients and they showed insulin secretion at varied levels with various treatments. The White Star (followed by its skin) servings showed better results in lowering postprandial blood glucose levels in diabetic subjects (Fig. 4). Following treatment with glucose and Glucose+ Caiapo, and Beauregard insulin sensitivity significantly ameliorated when assessed both with oral glucose tolerant cc test (OGTT) from (7.76 µIU/ml ± 6.65 to 12.5 µIU/ml ± 6.35), in T_1; 6.71µIU/ml ± 4.61 to 10.42µIU/ml ± 7.53 in T3 and 9.00 µIU/ml ± 5.01 to 12.63 µIU/ml ±5.71 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 those of Ludvik *et al.*, (2003) for Caiapo and White Star. The postprandial insulin response was better with White Star followed by its skin and Caiapo.

Table 3. Descriptive statistics of blood glucose (mg/dl) and insulin (µIU/ml) 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

Conclusions

The sweet potato had a blood glucose lowering effect on persons with diabetics and Caiapo showed the same effect in healthy participants. White Star and its skin showed better results as depicted by the postprandial glucose level and insulin response. However, Caiapo showed lower postprandial blood glucose level in healthy participants. The physiology based data would be more valuable in advising people with diabetes than would simple chemical analysis alone. 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.

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References

Anonymous. 1990. *Official Methods of Analysis of the Association of Official Analytical Chemists*, Vol. II, 15th ed. Sec.985.29. The Association: Arlington, VA.

Chang, T.C. and S.U. Jong-Ching. 1986. Starch Phosphorylase Inhibitor from Sweet Potato. *Plant Physiol*., 80: 534-538.

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

Kusano, S., H. Abe and H. Tamura. 2001. Isolation of antidiabetic from white-skinned sweet potato (*Ipomoea batatas* L.). *Biosci. Biotechnol. Biochem*., 65: 109-114.

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

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.

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.

Maeshima, M., T. Saski and T. Asah. 1985. Characterization of major protein in Sweet Potato. *Phytochemistry*, 24: 1899-1902.

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

Paisey, R.B., J. Frost and P. Harvey. 2002. Five year results of a prospective VLCD or conventional weight loss programme in type 2 diabetes. *J. Human Nutr. Dietetics*, 15: 121-27.

Purcell, A.E., H.E. Swasgood and D.T. Poep. 1972. Protein and Amino acid Content of Sweet Potato Cultivars. *J. Amer. 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.

Whitechair, C.K., W.D. Gallup, M.C. Bell and H.M. Briggs. 1949. Efficiency of urea in supplementing Corn and Sweet Potato. *Okla, Agric. Exp. Station, MP*., 15: 19.

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