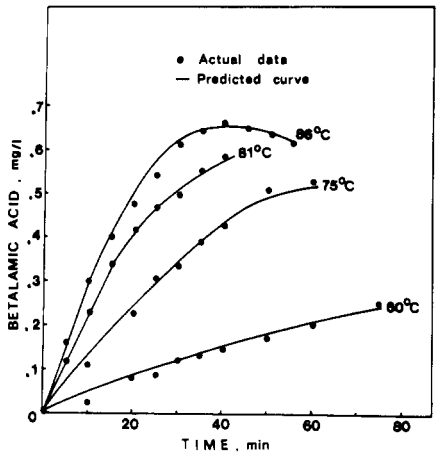

Figure 5. Predicted and actual concentration of betalamic acid.

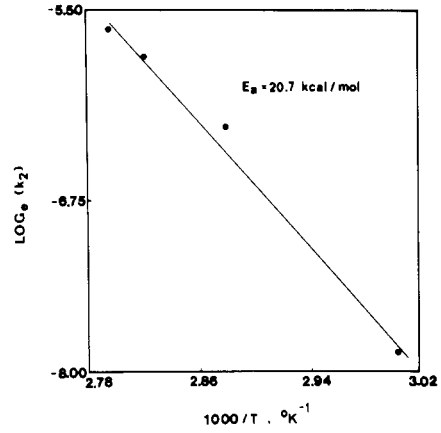

Figure 6. Rate constant (k_2) for betalamic acid as a function of temperature.

Similarly to betanin, the rate constant of betalamic acid can be fitted into Arrhenius temperature coefficient pattern (Figure 6), yielding an energy of activation of 20.7 kcal/mol.

While both betanin and betalamic acid have close value of energy of activation, betalamic acid seems to be approximate one order of magnitude more thermal stable than betanin; thus, explaining the shift toward the lower region of the visible spectrum of a thermal treated beet root juice or puree (Aurstad and Dahle, 1973; von Elbe et al., 1974b).

In conclusion, the proposed kinetic model describing the degradation of betanin to betalamic acid and the degradation of the latter to cleavage products was verified. The model enables one to predict the retention of these pigments under variable conditions of process temperature and time.

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Root, Hill, and Field Variance in Protein Content of North Carolina Sweet Potatoes

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Variation in protein content of Centennial and Jewel sweet potatoes grown in North Carolina was studied. Standard deviations of percent protein dry basis between roots of single hills were 0.79 for Centennial and 0.69 for Jewel and between hills within fields, 0.81 for Centennial and 0.73 for Jewel. The range of protein content from a number of hills was 5.27–7.24% for Centennial and 3.99–8.81% for Jewel.

Sweet potatoes have nutritional value that would recommend them for increased consumption. They are an excellent source of vitamin A value (Miller et al., 1949), and they provide a significant quantity of high quality protein (Nagase, 1957; Purcell et al., 1972). If the nutritional value of sweet potatoes is to be exploited in an effort to increase consumption, it will be necessary to provide nutritional labeling (Federal Regulation 21CFR101.9). Differences in protein content among cultivars has been reported to range from about 2–10% dry basis (Cooley, 1948; Purcell et al., 1972). Variation of protein content within cultivars has not been as well documented (Constantin et al., 1974; Li, 1976a,b).

During the conduct of other work some samples of sweet

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Table I. Means and Standard Deviation of Protein Content in Roots, Hills, and Fields of Two Sweet Potato Cultivars

	Centennial		Jewel	
	Mean % protein dry basis	SD[a]	Mean % protein dry basis	SD
Roots	5.90	0.79	4.96	0.69
Hills	6.09	0.81	5.40	0.73
Fields	6.09	0.63	5.40	1.62

[a] SD, standard deviation

potatoes were found to contain twice the concentration of protein as other samples of the same cultivar (Purcell et al., 1976a,b). In 1972 data were obtained from 16 cultivars replicated four times in a single planting. These permitted calculation of a replicate LSD of 0.76%, protein dry basis. During that same year, protein content in freshly harvested roots from four different fields ranged from 6.1–10.7% for Centennial and 5.3–10.6% for Jewel. The differences between maximum and minimum values were six to seven times the LSD cited above, the only measure of variation available at that time.

In 1973 protein data for stored roots at one location was obtained from ten composites of six roots each and 36 individual roots of Jewel and Centennial. Data from another location was obtained from 36 individual roots of each cultivar and from a three-box composite (ca. 300 roots) of Centennial and two three-box composites of Jewel. This data permitted calculation of mean protein contents for each cultivar from each location, and an LSD between locations as follows:

Cultivar	Location	% protein (dry basis)
Centennial	a	5.91
	b	9.25
Jewel	a	4.36
	b	6.87
LSD (0.05)		0.54

Because of the large variations in protein content due to location, we undertook to determine how much variation might occur among roots from a single hill, hills from a single field, and among various fields.

The objective of our study was to provide statistical data on the sources of variation in protein content in Centennial and Jewel sweet potatoes grown in North Carolina.

MATERIALS AND METHODS

Selection of Samples. Jewel and Centennial sweet potatoes were obtained from three North Carolina Agricultural Experiment Stations (AES) or farms. Additional samples of Jewel were taken from nine private farms and Centennial from six private farms. The AES plantings were replicated seven times, and roots from one hill in each replicate were analyzed. Fields at private farms ranged from 2 to 10 acres. A diagonal line was sighted across each field, and four hills, about equally spaced along the line, were selected for analysis. All roots larger than 1 cm diameter were taken. For measurement of root-to-root variation, all roots from 16 hills were analyzed individually for protein content. All other hills were analyzed as composites of each hill to measure hill-to-hill variation in each field. Protein content of each field was estimated as calculated means of the hills from each field.

Sample Preparation and Analysis. Roots were cut into 3-mm slices and dried to constant weight in a forced draft oven, first for 16 h at 70 °C, then for 8 h at 80 °C. Dried slices were ground to a powder in a blender. Nitrogen content was determined by the macro-Kjeldahl procedure with copper and selenium catalysts as previously reported (Purcell et al., 1972).

RESULTS

Standard deviation of protein content among individual roots, among hills, and among fields were calculated (Table I). Variation among roots within a hill was smaller than hill-to-hill variation. For Jewel, standard deviation among fields was greater than among hills from a single field. The limited sampling area for Centennial did not show this same trend.

Roots. Standard deviation of protein content among roots from a single hill was 0.79 for Centennial and 0.69 for Jewel. Root size had a very small effect on protein content. The correlation coefficient between protein content and root diameter was 0.19 and between protein content and root weight was 0.15. Although these coefficients are significant at the 0.05 level, the effect of root diameter accounted for only about 4% of the observed variation in protein content.

Fields. Protein content of cultivars varied significantly among fields (Table II). Protein content of Jewel varied from 3.99 to 8.81%. The range for Centennial was not as great. There was no significant source–cultivar interaction. Protein content of Jewel and Centennial roots in the AES

Table II. Protein Content of Centennial and Jewel Sweet Potatoes from Various Fields and Areas (Means and Ranges for Four Hills/Farm)

		% protein dry basis			
		Centennial		Jewel	
Farm	Area	Means	Range	Means	Range
Castle Hayne AES[a]		6.85^{bc}	(4.92-8.49)	5.73^{y}	(5.01-6.28)
Clayton AES[a]		5.51^{a}	(4.34-6.58)	4.13^{z}	(2.96-5.12)
Clinton AES[a]		5.27^{a}	(4.26-6.31)	4.63^{zy}	(3.22-6.18)
A	Dunn			4.19^{z}	(3.50-4.71)
L	Dunn	5.63^{ab}	(5.32-6.15)	4.43^{z}	(3.94-4.91)
R	Dunn	5.96^{ab}	(5.50-6.57)		
W	Dunn	5.89^{ab}	(5.11-6.99)		
P	Dunn			4.24	(3.69-4.53)
W	Tabor City			5.43^{y}	(4.87-6.27)
W_1	Tabor City			4.44^{z}	(3.16-5.28)
W_2	Tabor City			3.99^{z}	(3.66-4.36)
WF_1	Wake Forest	7.24^{bc}	(6.09-8.70)	6.82^{yx}	(5.46-8.40)
WF_2	Wake Forest	6.28^{abc}	(5.43-7.32)	7.91^{x}	(7.01-8.62)
WF_3	Wake Forest	6.22^{abc}	(5.33-7.74)	8.81^{xw}	(7.53-10.52)

LSD 0.05 between fields 1.23

[a] Seven hills. Figures with the same superscript are not significantly different.

plantings were roughly parallel.

The private farms from which samples were taken can be segregated into areas. Within an area, the fields which were sampled were no more than 10 miles apart. The centers of the areas, named for the nearest city, were more than 70 miles apart. There were no significant differences in protein content of Centennial due to the area. Jewel roots from the Wake Forest area contained significantly more protein than those from the other two areas. Roots from the Castle Hayne AES contained significantly more protein than those from the Clayton AES and the Dunn area.

We could not explain the cause of these differences. All soils were classed as Norfolk sandy loams, and horticultural practices at the AES farms were essentially the same. The Wake Forest area, with the highest protein roots, was the farthest north. Castle Hayne AES, which had the second highest protein, was the farthest south. Differences of protein content within a cultivar may be a complex function of soil water and soil nitrogen (Constantin et al., 1974; Li, 1976a,b; ARS, 1972), or it may be due to development of different clones within a cultivar.

We have demonstrated the magnitude of variance due to roots, hills, and fields and documented differences due to growing area. These data illustrate difficulties which may arise if nutritional labeling of sweet potatoes were attempted.

Sweet potatoes with 8% protein provide an adequate protein–calorie balance. We have shown that some fields produce roots with protein contents exceeding 8%, although the factors contributing to high protein content are not known. Consistent production of high protein roots could significantly contribute to the world food supply. Hopefully this report will stimulate a search for the factors affecting protein content of sweet potatoes.

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Occurrence of Sesquiterpenes in Mountain Cheese Volatiles

Jean-Pierre Dumont and Jacques Adda*

GC–MS analysis performed on Beaufort cheese volatiles has led to the identification of 140 components including nine sesquiterpenes. Sesquiterpenes were only found in cheeses made from summer milk when cows were grazing on high-altitude pastures. Influence of the traditional ripening process on volatile flavor compounds is also discussed.

Beaufort is a Gruyere type of cheese manufactured on a small scale in a limited area of the French Alps (Davies, 1976). It differs from the Swiss type, the flavor of which is well documented (Langler et al., 1967; Langsrud and Reinbold, 1973), by its smeary coat resulting from repetitive hand rubbings with a brine-soaked-cloth; its maturing temperature is lower (12–14 °C for at least 6 months); and, during summertime, cheeses are made with milk from cows grazing on the upper alpine slopes (1500–2500 m).

The quality of the grass with its specific flora has often been claimed to account for the delicate aroma of mountain cheeses which are highly valued. But, up till now, no definite differences in the flavor composition has ever been put forward. This paper deals with the identification of major neutral flavor compounds both in summer and winter cheeses; the influence of surface bacterial growth has also been considered to explain the formation of some of the volatile components.

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METHODS

Six summer cheeses samples (four 6-months and two 18-months old ones) and three winter cheeses samples (6-months old) were supplied by a cheese cooperative. From each sample, three different parts were studied separately (the rind, a 5-mm thick zone just under the rind, and the core of the cheese). Two samples of smear organisms suspension in brine were also studied. The flavor extracts were obtained as previously described (Dumont et al., 1976; Dumont and Adda, 1972).

Freon 11 extract was fractionated by chromatography on silicic acid (Palmer, 1973). Gas chromatography was carried out on a Giravions Dorand Model 3000 fitted with a metal capillary column, the details of which are described in the caption of Figure 1. The injection port was at 150

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