Table IV. Relative Fluorescence of Sweet Potato Flours[a]

sample	relative fluorescence[b,c]
"Centennial" oven-dried flour	4.21[A]
"Jewel" oven-dried flour	3.71[B]
"Centennial" drum-dried flour	3.14[C]
LSD_{05}	0.13

[a] All flours extracted with 70% aqueous methanol to remove β-carotene and nonprotein nitrogen. [b] Mean of four replicates for each sample. [c] Numbers with different superscript letters are different at the $P \leq 0.05$ level.

potatoes processed by drum-drying are subjected to much higher temperatures. A common problem associated with such treatment in high carbohydrate foods is the reaction of the ε-amino group of lysine with reducing groups of carbohydrates which causes the lysine to become nutritionally unavailable. In some cases, acid hydrolysis prior to amino acid analysis can liberate nutritionally unavailable lysine. Subsequent amino acid analysis would indicate that the lysine content is higher than it actually is from a nutritionally standpoint (Carpenter, 1973).

Table III shows that the lysine content is higher in oven-dried "Centennial" flour than in drum-dried "Centennial" flour. This is as expected because some of the lysine is irreversibly destroyed. However, lysine levels are essentially identical in drum-dried "Centennial" flour and oven-dried "Jewel" flour. Since levels of other essential amino acids are somewhat higher in the drum-dried flour, one would expect that PER value for "Centennial" drum-dried would be somewhat higher than that of "Jewel" oven-dried flour. The PER for "Jewel" oven-dried flour is much higher than the PER for "Centennial" drum-dried flour.

In an attempt to determine if nutritionally unavailable acid hydrolysable lysine was responsible for this discrepancy, we performed the flourometric procedure for available lysine (Goodno et al., 1981) on methanol-extracted flours. Solvent extraction was necessary to remove β-carotene, which has a λ_{max} very close to the emission maximum for the lysine–phthalaldehyde reaction product.

From relative fluorescence data (Table IV), the available lysine decreases in the same order as the PER values, that is, "Centennial" oven-dried > "Jewel" oven-dried > "Centennial" drum-dried. Our study indicates that for drum-dried vegetable products containing high carbohydrate levels, the relative fluorescence assay is a better measure of nutritionally available lysine than is the acid hydrolysis–amino acid analysis procedure.

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Registry No. L-Lysine, 56-87-1.

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Pectic Substances in Raw and Cooked, Fresh or Processed Spanish Vegetables

Concepción Vidal-Valverde,* Manuel Perez Lopez, and Enrique Rojas-Hidalgo

The content of pectic substances (PS) (as anhydrogalacturonic acid) (AGA) was determined on samples of 19 fresh vegetables (raw and cooked), 8 fresh vegetables (raw), 5 frozen vegetables (raw and cooked), and 5 canned vegetable products (3 of which were also analyzed after frying). The PS content of fresh vegetables ranged between 0.19% (mushroom) and 2.5% (potato). The culinary process produces a decrease in the PS content that is most pronounced in the case of frying. Frozen vegetables had a PS content similar to that found in fresh vegetables. The PS content of canned vegetables, however, was lower than those observed in fresh or frozen vegetables. Cooking of processed vegetables produces effects on the PS content that are similar to the effects observed in cooking fresh vegetables.

The beneficial effects of pectic substances upon the human physiology have been demonstrated by different authors in numerous publications. These compounds slow down the absorption of soluble carbohydrates, causing a lesser increase of postprandial blood sugar in normal individuals, as well as in type I and type II diabetics (Jenkins et al., 1976, 1977b, 1978; Kay and Stitt, 1978). They eliminate or reduce the dumping syndrome of gastrectomized subjects (Jenkins et al., 1977a; Labayle et al., 1980). They decrease the level of cholesterol in the blood

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Table I. Content of Pectic Substances (as Anhydrogalacturonic Acid) of Vegetables

vegetables	date of analysis	edible matter proportion of wt purchased	% water edible portion	% AGA, fresh matter of edible portion	% AGA, dry matter of edible portion
Artichokes (*Cynara scolymus*, L.)					
fresh					
raw	February	0.58	82.4	1.65 ± 0.05	9.37 ± 0.28
boiled, 75 min	March	0.79	87.5	0.90 ± 0.05	7.20 ± 0.40
canned		1.00	87.7	0.61 ± 0.03	4.96 ± 0.24
frozen					
raw		1.00	87.1	1.02 ± 0.02	7.91 ± 0.15
boiled, 25 min		0.94	85.1	1.10 ± 0.02	7.38 ± 0.13
asparagus (*Asparagus officinalis*, L.)					
fresh					
raw	May	0.51	91.8	0.31 ± 0.01	3.78 ± 0.12
boiled, 70 min	May	0.44	91.3	0.25 ± 0.03	2.87 ± 0.34
canned		1.00	93.2	0.25 ± 0.01	3.68 ± 0.15
broad beans (*Vicia faba*, L., var. *mayor*, L.)					
fresh, with pod					
raw	April	0.95	86.2	1.50 ± 0.07	10.87 ± 0.51
boiled, 50 min	April	0.82	85.5	0.96 ± 0.01	6.62 ± 0.07
raw, without pod	April	0.28	83.7	2.47 ± 0.16	15.15 ± 0.98
frozen, without pod					
raw		1.00	73.7	1.79 ± 0.07	6.81 ± 0.27
boiled, 30 min		1.07	78.8	1.48 ± 0.13	6.98 ± 0.61
green beans (*Phaseolus vulgaris*, Savi)					
fresh					
raw	March	0.97	90.1	0.78 ± 0.01	7.88 ± 0.10
raw	August	0.98	90.3	0.79 ± 0.07	8.14 ± 0.72
raw	July	0.93	88.9	1.27 ± 0.04	11.44 ± 0.36
boiled, 35 min	July	0.96	91.6	0.88 ± 0.04	10.48 ± 0.48
canned		1.00	92.1	0.61 ± 0.03	7.72 ± 0.38
canned, fried, 10 min		0.98	71.6	0.58 ± 0.03	2.04 ± 0.11
frozen					
raw		1.00	88.5	1.22 ± 0.10	10.60 ± 0.87
boiled, 18 min		0.97	90.8	1.05 ± 0.06	11.41 ± 0.65
beet rot (*Raphanus sativus*, L., var. *cruenta*, L.)					
fresh	July	0.70	89.1	0.66 ± 0.04	6.06 ± 0.37
brussels sprouts (*Brassica oleracea*, L., var. *gemmifera* Zenker)					
fresh					
raw	February	0.77	82.3	1.33 ± 0.04	7.51 ± 0.22
raw	March	0.83	84.6	1.14 ± 0.05	7.40 ± 0.32
boiled, 45 min	March	0.93	88.4	0.80 ± 0.02	6.90 ± 0.17
red cabbage (*Brassica oleracea*, L., var. *capitata*, f., D.C.)					
fresh					
raw	February	0.89	87.2	0.96 ± 0.06	7.50 ± 0.47
boiled, 40 min	March	0.80	90.6	0.55 ± 0.07	5.85 ± 0.74
white cabbage (*Brassica oleracea rubra*, L., var. *capitata*, f., *alba*, D.C.)					
fresh					
raw	January	0.91	90.9	0.60 ± 0.04	6.59 ± 0.44
raw	July	0.83	92.7	0.44 ± 0.02	6.03 ± 0.27
raw	March	0.88	89.4	0.66 ± 0.03	6.23 ± 0.28
boiled, 80 min	March	0.80	89.2	0.54 ± 0.02	5.00 ± 0.18
cardoon (*Cynara cardunculus*, L.)					
fresh					
raw	February	0.74	93.2	0.54 ± 0.02	7.94 ± 0.29
raw	March	0.61	93.7	0.35 ± 0.04	5.55 ± 0.63
boiled, 80 min	March	0.62	94.5	0.23 ± 0.01	4.18 ± 0.18
carrot (*Daucus carota*, L., var. *sativa*, D.C.)					
fresh					
raw	August	0.86	86.9	1.18 ± 0.03	9.01 ± 0.23
raw	July	0.85	87.8	0.98 ± 0.01	8.03 ± 0.08
boiled, 70 min	July	0.86	89.1	0.64 ± 0.01	5.87 ± 0.09
cauliflower (*Brassica oleracea*, L., var. *botrytis*, f., *cauliflora* Duch)					
fresh					
raw	January	0.75	85.4	0.91 ± 0.07	6.23 ± 0.48
raw	April	0.80	88.9	0.55 ± 0.01	4.95 ± 0.09
boiled, 35 min	April	0.84	90.8	0.62 ± 0.07	6.74 ± 0.76
chard (*Beta vulgaris*, L., var. *cycla*, L.)					
fresh					
raw	May	0.94	92.6	0.48 ± 0.01	6.49 ± 0.13
raw	April	0.84	91.4	0.40 ± 0.04	4.65 ± 0.46
raw	November	0.68	91.7	0.57 ± 0.05	6.87 ± 0.60
boiled, 45 min	November	0.72	92.4	0.35 ± 0.05	4.61 ± 0.66

Table I (*Continued*)

vegetables	date of analysis	edible matter proportion of wt purchased	% water edible portion	% AGA, fresh matter of edible portion	% AGA, dry matter of edible portion
cucumber (*Cucumis sativus*, L.)					
fresh					
raw	August	0.70	94.3	0.32 ± 0.01	5.61 ± 0.17
eggplant (*Solanum melongena*, L.)					
fresh					
raw	June	0.78	94.6	0.79 ± 0.02	14.63 ± 0.37
raw	July	0.65	94.3	0.67 ± 0.04	11.75 ± 0.70
fried, 7 min	July	0.41	54.7	1.61 ± 0.07	3.55 ± 0.15
escarole (*Cichorium endivia*, L.)					
fresh					
raw	October	0.90	95.5	0.45 ± 0.01	10.00 ± 0.22
leek (*Allium porrum*, L.)					
fresh					
raw	April	0.50	88.6	0.70 ± 0.02	6.14 ± 0.17
raw	May	0.65	82.8	1.00 ± 0.06	5.81 ± 0.35
boiled, 75 min	May	0.59	87.9	0.42 ± 0.03	3.47 ± 0.25
lettuce (*Lactuca sativa*, L.)					
fresh					
raw	March	0.75	94.7	0.37 ± 0.01	6.98 ± 0.19
raw	June	0.56	90.2	0.67 ± 0.05	6.84 ± 0.51
mushroom (*Psaliota campestris*, Fr)					
fresh					
raw	March	0.85	89.7	0.19 ± 0.01	1.84 ± 0.10
onion (*Allium cepa*, L.)					
fresh					
raw	October	0.94	92.2	0.59 ± 0.02	7.56 ± 0.26
peas (*Pisum sativum*, L., var. *vulgare*, L.)					
canned		1.00	82.1	0.31 ± 0.03	1.73 ± 0.17
canned, fried, 5 min		1.00	51.8	0.35 ± 0.01	0.73 ± 0.02
frozen					
raw		1.00	78.5	1.16 ± 0.09	5.39 ± 0.42
fried, 5 min		0.97	68.1	1.17 ± 0.03	3.67 ± 0.09
green pepper (*Capsicum annum*, L., var. *grosum* Bailey)					
fresh					
raw	June	0.84	93.4	0.38 ± 0.07	5.76 ± 1.06
raw	August	0.80	92.3	0.54 ± 0.04	7.01 ± 0.52
fried, 5 min	August	0.56	85.3	0.75 ± 0.01	5.10 ± 0.07
potatoes (*Solanum tuberosum*, L.)					
fresh					
raw	July	0.82	80.1	2.52 ± 0.07	12.66 ± 0.35
boiled, 30 min	July	0.81	79.3	1.96 ± 0.16	9.47 ± 0.77
fried, 5 min	July	0.85	56.9	4.01 ± 0.17	9.30 ± 0.39
radish (*Raphanus sativus*, L., var. *alba*)					
fresh					
raw	July	0.39	92.1	0.43 ± 0.01	5.44 ± 0.13
spinach (*Spinacia oleracea*, L.)					
fresh					
raw	May	0.78	86.8	0.81 ± 0.05	6.14 ± 0.38
boiled, 15 min	May	0.74	91.8	0.68 ± 0.01	8.29 ± 0.12
frozen					
raw		1.00	88.1	1.17 ± 0.08	9.83 ± 0.67
boiled, 20 min		0.87	90.5	0.56 ± 0.03	5.89 ± 0.31
squash (*Cucurbita pepo*, L., var. *medullosa* Alef)					
fresh					
raw	June	0.69	94.4	0.37 ± 0.04	6.61 ± 0.71
raw	July	0.70	97.5	0.32 ± 0.02	12.80 ± 0.80
fried, 5 min	July	0.32	78.2	0.86 ± 0.03	3.94 ± 0.14
tomato (*Solanum lycopersicum*, Mill)					
fresh					
raw, unripe	January	0.97	93.2	0.39 ± 0.04	5.73 ± 0.59
raw, ripe	January	0.96	94.1	0.26 ± 0.02	4.41 ± 0.34
raw, ripe	June	0.87	91.1	0.35 ± 0.02	3.93 ± 0.22
ripe, fried, 20 min	June	0.61	65.6	0.67 ± 0.01	1.95 ± 0.03
canned		1.00	92.9	0.33 ± 0.02	4.67 ± 0.28
canned, fried, 20 min		0.65	77.0	0.44 ± 0.05	1.91 ± 0.22
turnip (*Brassica napus*, L., var. *sculenta*)					
fresh					
raw	August	0.84	92.1	0.42 ± 0.01	5.32 ± 0.13
turnip top (*Brassica napus*, L.)					
fresh					
raw	April	0.88	87.8	1.20 ± 0.04	9.84 ± 0.33
boiled, 25 min	April	1.06	89.6	1.05 ± 0.05	10.10 ± 0.48

and increase the elimination of bile salts, fecal sterols, and total fecal fat (Keys et al., 1960; Palmer and Dixon, 1966; Lopez et al., 1968; Jenkins et al., 1975; Kay and Truswell, 1977, Kay et al., 1978).

There is very scarce information regarding the pectic substances content in vegetables, especially in cooked vegetables. In a previous work we determined the pectic substances in fresh, dried, desiccated, and oleaginous Spanish fruits (Vidal-Valverde et al., 1982a). In the present work we carried out the determination of the pectic substances in raw and cooked vegetables, fresh or processed, commonly consumed in the Spanish diet, in order to assist in designing appropriate diets, which could help in the treatment of some diseases.

MATERIALS AND METHODS

Sample and Sample Preparations. The vegetables analyzed were obtained from local retail markets. Fresh vegetables were weighed (about 2 kg of each), nonedible parts were eliminated, and the edible portion was reweighed. Part of this sample was analyzed as such, and an aliquot of the edible portion was cooked in boiling water or fried in olive oil, simulating home preparation techniques.

Frozen vegetables (about 1 kg of each) were defrosted and weighed. Part of this sample was analyzed as such and part was subjected to the culinary process, drained, and weighed. About 1 kg of each canned vegetable was drained and weighed. A portion of a few of them was cooked. All samples were homogenized in a Waring Blendor.

The dry matter content was calculated from weight loss after heating in a vacuum oven at 35 °C until a constant weight was reached.

Determination of Total Pectic Substances. The total pectic substances (PS) (as anhydrogalacturonic acid, AAG) were determined as described in previous papers (Vidal-Valverde et al., 1982a,b).

Prior to the extraction of total PS a selective removal of soluble carbohydrates was carried out. To this end two aliquots (20 g each) of the edible sample (raw or cooked) were extracted by boiling under reflux with 80% aqueous ethanol following the method of Krause and Bock (1973). If both replicates afforded a similar weight of nonsoluble material, the extraction of total PS was carried out. An aqueous solution (0.25%) of ammonium oxalate–oxalic acid was used for this purpose according to the method of Dekker and Richard (1972). Four replicated extractions were carried out with each vegetable by using a 10 mg of ethanol-insoluble material for each replicate extraction. Each of the replicate extractions was subjected first to alkaline hydrolysis, according to McCready and McComb (1952), McComb and McCready (1952), and Krause and Bock (1973), and then to enzymatic hydrolysis with 2–4 mg of polygalacturonase (Sigma, EC 3.2.1.15) following the method of Dekker and Richards (1972).

The concentrations of galacturonic acid obtained through these processes were adjusted separately by adding distilled water to reach 10–80 μg/mL.

The AGA content of each replicate sample was measured colorimetrically by using a 0.15% carbazole reagent (in absolute ethanol) following the procedure of McCready and McComb (1952). The absorbance was determined at 530 nm (Zeiss PM2DL spectrophotometer).

Four replicates were measured with each one of the hydrolyzed products. Thus, a total of 16 absorption replicates were measured for each edible vegetable sample. For evaluation of the concentration of galacturonic acid, a standard curve was obtained with each run. The blank determination contained all the reagents except pectic substance extracts.

RESULTS AND DISCUSSION

The pectic substance (PS) content (as anhydrogalacturonic acid) of a series of raw and cooked, fresh or processed vegetables was investigated.

Table I shows the month of analysis, which, in the case of fresh vegetables, gives an indication of the harvest time, the proportion of edible matter to the total weight purchased, the water content of the edible portion, and the PS content of vegetables investigated, on a fresh and dry matter basis of the edible portion.

The PS content of fresh vegetables ranged between 0.19% in mushroom and 2.52% of potato (fresh matter basis). There was some slight change in the PS content at harvest time for those vegetables analyzed in different months of the year. The effect of cooking on the PS content of the edible portion was shown on a dry matter basis. The mean values obtained for raw vegetables (fresh, frozen, or canned) and those corresponding to the same vegetables subjected to a culinary process have been submitted to the Student's t test.

Boiling slightly decreased the PS content of fresh vegetables, expressed as a percentage of fresh matter. This decrease was more pronounced when it was indicated as a percentage of dry matter ($P < 0.05$). Only in the case of cauliflower and spinach is a slight increase observed ($P < 0.05$). This increase might be a result of the solubilization and elimination of other substances during the boiling process.

Frying causes an increase of the PS content on a fresh matter basis, explained by the water loss that takes place during this process. On the contrary, the PS content on a dry matter basis was drastically reduced ($P < 0.05$).

There is some information in the published literature regarding the PS content of some of the raw vegetables studied here (Kertesz, 1951; Hardinge et al., 1965; Charlampowicz et al., 1966; Krause and Bock, 1973; Rinaudo, 1975; Spiller and Sorensen, 1976; Campbell and Palmer, 1978; Bailey et al., 1978). A large dispersion of values is observed for the same vegetable by different authors. This situation may reflect the influence of factors such as soil, climate, method of analysis, etc. on the PS content of vegetables, as is the case of carbohydrates (Southgate et al., 1978) and alkaloids (Mothes, 1960).

No information was found on the PS content of fresh cooked vegetables or processed vegetables, either raw or cooked.

Frozen vegetables presented a PS content similar to that found in fresh vegetables. The PS content of canned vegetables was lower than in the case of fresh vegetables.

Boiling decreases the PS content of frozen vegetables. This decrease is significant ($P < 0.05$) in the case of artichokes, spinach, and green beans. Frying causes a drastic decrease of the PS content of canned vegetables.

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Characterization of Sunflower Protein

M. Kabirullah and Ron B. H. Wills*

Sunflower protein isolates were prepared based on their solubility in alkali, water, and sodium chloride. The protein isolates were analyzed for proximate composition and amino acid content, and their solubility was determined over the pH range 1–11. The proteins were fractionated and characterized by gel filtration chromatography, ultracentrifugation, and gel electrophoresis and found to contain six to seven protein fractions with molecular weights ranging from 450×10^3 to 10×10^3. The major fraction had a molecular weight of 125×10^3, and the average molecular weight was calculated to be 180×10^3.

In recent years sunflower production and utilization has increased in many countries (Bureau Agricultural Economics, 1979) and considerable work has been done on processing, nutritional, and functional properties and food uses of sunflower oilseed meal protein (Robertson, 1975; Dorrell, 1978; Sosulski, 1979). Studies on the characterization of sunflower protein are either incomplete (Sabir et al., 1973; Baudet and Moss, 1977) or were carried out with protein that had been modified by chemical treatment (Joubert, 1955; Rahma and Rao, 1979). In this paper we have fractionated and characterized sunflower protein obtained by isolating the albuminous fraction in water, the globular fraction in salt, and the total protein in alkali solutions by gel filtration, chromatography, ultracentrifugation, and gel electrophoresis.

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MATERIALS AND METHODS

Materials. Proteins were isolated by suspending the dehulled and defatted (petroleum ether, 40–60 °C) sunflower oilseed meal (10%) in water (pH 6.5), 1 M NaCl (pH 7.0), and 1 M NaOH (pH 11.0), separately, to isolate albuminous, globular, and total sunflower protein, respectively. The suspension was stirred for 1 h at room temperature and then centrifuged. The supernatant was adjusted to pH 4.5 with 1 M HCl and centrifuged. The protein precipitate was dialyzed against distilled water and freeze-dried. The water-isolated albuminous fraction does not necessarily represent the albumins only; salts present in the meal might have solubilized some globular proteins, and similarly, the salt-isolated globular proteins might

