CITRUS PULP WITH AND WITHOUT SEEDS[1]

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The technology of seed removal from citrus pulp and the ramification thereof were studied and are discussed. The seed content of undried and dried citrus pulp and the seasonal variation in seed content were tabulated for the more common *Citrus* varieties. From a study of the protein content of the pulp components, it was calculated that complete removal of seeds would only decrease the protein content of dried citrus pulp from 2%to 14% depending on the seediness of the variety. The high protein content found in the rag and pulp fraction of citrus pulp suggested that this component, in addition to seeds, be separately recovered for highest economic return. The removal of seeds in excess of that required to maintain the guaranteed analysis of citrus pulp would result in a more uniform product with a higher flavonoid content and would provide a greater economic return to the processor.

INTRODUCTION

The separation of seeds from citrus processing residues prior to manufacture of dried citrus pulp has become more prevalent within the industry in recent years. Although seed removal is more profitable, some fear that the practice will drastically alter the pulp analysis. It is the intent of this paper to show that these fears are unnecessary, and that the removal of excess seeds, to the contrary, will make a more uniform, improved product while enabling the processor to realize an additional profit from the fat subsequently recovered. Other objectives of this investigation were to study the protein distribution in citrus pulp and the factors influencing protein content.

Until 2 seasons ago, citrus seeds were recovered primarily from sectionized grapefruit. Separation of seeds was effected by a system of screens and paddle finishers. This arrangement did not adequately recover seeds from citrus fruit in a juice line, and the problem was not resolved until the industry substituted a series of fast moving tilted belts for the screen system. With a belt separator, the peel residue adhers to the belt while the seeds bounce to the low side. Seed separation from the pulp and peel became more difficult during the 1965-66 season when pulp washing and tight juice finishing were eliminated. This difficulty has been corrected by an advanced model that can recover approximately 75% of the seeds by thinly spreading the peel residue on a wide, tilted, fast-moving belt.

At present, seeds are not separated in every processing plant, so dried citrus pulp contains a varying quantity of whole or cracked citrus seeds that is dependent upon fruit variety, time of season, and whether or not mechanical separators have been installed. The seed content of 25 samples of dried citrus pulp examined by Ammerman *et al.* (1) ranged from 1.8% to 8.3%, with an average content of 4.8%. The average nutrient composition of 10 samples of whole seeds was reported by the same authors as being: 3·4% ash, 16,2% protein, 54.1% ether extract, 13.2% crude fiber, and 22.1% nitrogen-free extract on a dry matter basis. For comparison, average values of the major feed ingredients in dried citrus pulp over the past 3 seasons were calculated from the Florida Department of Agriculture's analyses (3) and are presented in Table 1. Also shown are the ranges for protein and fat contents, since these values are considerably influenced by fruit variety. The seedless varieties are considered reponsible for the minimum values. When the average composition of dried citrus meal (fine citrus pulp) was similarly calculated from a fewer number of analytical results, there was a consistently lower moisture and fat content but higher percentages of ash and protein than in the dried citrus pulp.

EXPERIMENTAL METHODS

The percentage of seeds in many *Citrus* varieties was determined by carefully separating the individual components, juice, rag and pulp, seeds, and peel. Juice was discarded and the percentage of seeds in the dried pulp of the respective varieties was determined from the weight of the other components after drying.

The protein content of a second group of varieties was studied by determining the nitrogen content of the individual compoments. Nitrogen analyses were made by the semimicro

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Table 1.--Seasonal variations in dried citrus pulp. Calculated from Florida Department of Agriculture's Feed Laboratory Ingredient Analyses (3).

Composition	Season		
	1962-1963	1963-1964	1964-1965
Moisture, Avg. %	8.6	8.8	8.5
Protein, Avg. %	6.5	5.9	6.2
(range %)*	7.4-5.7	7.0-5.3	7.4-5.5
Fat, Avg. %	4.0	3.4	4.2
(range %)*	7.7-2.3	7.1-2.0	7.6-2.0
Fibre, Avg. %	11.2	12.1	12.4
Ash, Avg. %	4.8	4.7	4.6
N.F.E., Avg. %	64.0	65.0	64.1
No. of samples	299	310	380
Samples, % less than 6% protein	3	55	23

*Three highest and 3 lowest analyses discarded for each season.

Kjeldahl-Gunning procedure and protein content was obtained by multiplying with a factor of 6.25.

Other trials were performed to measure: the effect of charring and high temperatures of a drier upon the protein-rich pulp fraction, the percentage of oil in the seeds and other components by solvent extraction, and the quantity of peel oil remaining in citrus pulp after drying (Clevenger distillation).

Results and Discussion

The percentage of seeds in fresh *Citrus* and the related percentage for the corresponding dried pulp are shown in Table 2. Whole fruit contained twice the percentage of seeds in the early versus the late portion of a season. In the dried pulp (calculated at 8% moisture), however, the seed percentage was more constant. In seedy varieties, seeds were recognized as being more than a minor component, viz. 18.7% in 'Duncan' grapefruit. Percentage-wise, the seed content in dried pulp is 3 to 4 times higher than in whole fruit, depending on whether it is the early or latter part of a season.

The possible loss by seed removal of an excessive portion of the protein from dried citrus pulp was evaluated by analyzing the quantity of nitrogen in the component portions of 4 *Citrus* varieties. Results are summarized in Tables 3 and 4. First consideration was given to the relative proportions of the components. They were quite similar on a whole fruit basis, but noticeably different on a dry weight basis by virtue of the variable seed content and lower moisture content of seeds. In the absence of a protein profile for any of of the citrus com-

Table 2.--The percentage of seeds in *Citrus* and the related percentage in the corresponding dried pulp are shown for a season.

Variety and month of season	Seeds in grapefruit: Whole fruit (%)	Seeds in grapefruit: Dried pulp (%)	Variety and month of season	Seeds in oranges: Whole fruit (%)	Seeds in oranges: Dried pulp (%)
'Duncan'			'Pineapple'		
October	6.8	18.7	October	5.2	14.2
December	4.8	15.2	December	3.2	11.2
February	4.3	13.9	February	3.1	11.2
April	2.9	11.2	April	2.7	10.2
'Foster Pink'			'Parson Brown'		
October	5.0	10.4	October	3.5	9.5
December	4.1	11.5	December	2.4	7.5
February	3.1	11.1	February	2.2	8.5
April	2.6	10.9	April	1.7	7.0
'Marsh'			'Valencia'		
October	0.5	1.7	October	1.2	3.5
December	0.3	1.9	December	0.8	3.2
February	0.3	1.8	February	0.7	3.2
April	0.3	2.2	April	0.7	3.2

Table 3.--Component and nitrogen analyses for 2 orange varieties.

Orange variety	Component part	Whole fruit (wet basis): % of total	Whole fruit (wet basis): Moisture %	Peel residue (dry basis): % of total	Peel residue (dry basis): Nitrogen %	Peel residue (dry basis): % of total N
'Valencia'	Seeds	0.6	60.2	2.3	2.51	4.4
	Peel	26.4	74.4	62.7	1.00	52.6
	Rag and pulp	21.6	82.6	35.0	1.47	43.0
	Juice*	51.4				
'Valencia'	Seeds	0.5	56.9	2.3	2.28	4.9
	Peel	24.1	76.1	57.0	0.94	50.2
	Rag and pulp	26.8	84.6	40.7	1.17	44.9
	Juice*	48.6				
'Pineapple'	Seeds	2.6	50.0	10.5	2.51	24.0
	Peel	25.0	72.1	55.6	.80	40.4
	Rag and pulp	23.0	81.5	33.9	1.16	35.6
	Juice*	49.4				
'Pineapple'	Seeds	2.3	51.3	11.0	2.43	21.4
	Peel	21.0	76.9	46.2	.94	35.0
	Rag and pulp	30.1	85.1	42.8	1.27	43.6
	Juice*	46.6				

*Nitrogen and moisture content were not determined for juice.

Table 4.--Component and nitrogen analyses for 2 grapefruit varieties.

		Whole fruit (wet basis)		Peel residue (dry basis)		
Grapefruit variety	Component part	% of total	Moisture %	% of total	Nitrogen %	% of total N
Seedy	Seeds	2.8	59.3	11.0	2.67	21.1
	Peel	25.3	78.5	53.2	1.02	39.2
	Rag and pulp	23.1	83.6	35.8	1.54	39.7
	Juice*	48.8				
Seedy	Seeds	3.0	55.7	12.9	2.79	26.0
	Peel	27.9	79.9	55.5	.98	39.1
	Rag and pulp	19.8	83.8	31.6	1.54	34.9
	Juice*	49.3				
Seedy	Seeds	3.8	56.7	14.6	2.51	21.4
	Peel	29.2	79.4	52.7	1.01	35.0
	Rag and pulp	22.0	83.1	32.7	1.54	43.6
	Juice*	44.9				
'Marsh'	Seeds	0.4	50.7	2.1	2.54	4.1
	Peel	27.7	81.7	60.0	1.04	48.8
	Rag and pulp	25.5	85.7	37.9	1.59	47.1
	Juice*	49.4				

*Nitrogen and moisture content were not determined for juice.

ponents, protein was considered proportional to nitrogen and was calculated by using the factor 6.25. The component richest in nitrogen was always the seeds, which ranged from 2.3% to 2.8% nitrogen. Grapefruit seeds showed a slightly higher range than orange seeds. The second richest source of protein in dried citrus pulp was the rag and pulp fraction, which contained as much as 10% protein. As it constituted at least a third of the dry weight, the rag and pulp fraction appeared to be a potential source of high protein food. Recently, portions of this fraction have been recovered and dried commercially for addition to processed meats. The total percentage of protein in dried citrus pulp, however, was most diluted by the low nitrogen content of the peel. Unfortunately, the peel fraction is the largest component of dried citrus pulp. Table 3 and 4 further show that the actual amount (percentage X weight) of protein in dried citrus pulp is unevenly distributed between the components, and that seeds contribute only 5% to the total in non-seedy varieties and 25% when the very seedy type are processed.

The change in percentage of protein brought about by complete seed removal was computed from the individual component analyses. These results are shown in Table 5. Removing seeds, the most concentrated protein fraction, can only decrease the protein of the remainder, but this decrease is modified by the fractional weight of seeds to the total. The decerase was only about 2% in the less seedy varieties and approximately 14% in the more seedy types. These percentages would be somewhat less in actual practice since only a portion of the seeds can be separated. When 6% protein is guaranteed in dried citrus pulp, as most often is the case, then complete seed removal from 'Pineapple' citrus pulp could cause the most serious deficiency. The likelihood of protein deficiency is seasonal, however, as shown by Table 1. During the 1962-63 season only 3% of the analyzed samples were deficient, but in the 1963-64 season, 55% were less than 6% protein. An extensive sampling of 'Valencia' orange fruits from commercial groves by Koo *et al.* (4) showed that the nitrogen content of whole fruit (dry basis) ranged from

0.72% to 1.12%. On this basis, the application of nitrogen in fertilizer could be the most influential variable on dried citrus pulp. Logically, the protein range of dried citrus pulp is influenced additionally by the variability of protein in whole fruit, and 1 alternative is to guarantee a lesser amount.

The partial or complete removal of seeds from dried citrus pulp has other ramifications as well. It has been shown by Ammerman *et al.* (2) that citrus seed meal protein has an average apparent digestibility coefficient of 55.5%. In a not too different ration, the similar coefficient for the protein of citrus pulp was 82% to 84% in another study (1). Therefore, although removal of seeds from citrus pulp would decrease the total protein content, that which remains would appear to necessarily be more digestible. The digestibility and variability of the protein fraction of dried citrus pulp are further confounded by drying changes. When triplicated 'Valencia' peel samples were dried to a light, medium, and dark color by raising the drying temperature, they contained 6.1%, 6.7%, and 7.4% protein by nitrogen analysis and 3.1%, 3.2%, and 3.5% ash content, respectively. Although the apparent protein content of dried pulp was increased by charring, this gain was at the loss of other portions of the product, and it should be avoided. Furthermore, charring of citrus pulp has been shown by Ammerman *et al.* (2) to reduce the digestibility coefficient of the protein fraction.

It has recently been shown by Pounden and Frank (5) that inclusion of dried citrus pulp in a dairy animal's ration seems to decrease the incidence of mastitis from *Streptococcus agalactiae* and that this was more specifically attributive to the hesperidin present in citrus pulp. Since hesperidin has never been reported in the seeds, it again seems logical that the remaining citrus pulp would have an increased percentage of this bioflavonoid. Quite possibly, this is an important factor and hesperidin could be the single most important ingredient in citrus pulp, in which case, at today's prices citrus pulp should be worth considerably more per ton. Seed removal would result in a more uniform product physically, and would eliminate seed segregation which often occurs in transit.

A natural consequence of seed removal is the decreased fat content of the citrus pulp. This is shown in Table 5. The fat or oil is not lost, but sold in a more profitable outlet. Peel oil can be still present in citrus pulp after seed removal and can be construed as fat by the standard ether extraction procedure. When dried citrus pulp samples were heated in a Clevenger peel oil recovery apparatus, it was found that as much as 0.4% peel oil was still present. Even higher quantities of peel oil can be expected in a course citrus pulp dried carefully at reduced temperatures.

Table 5.--Protein and fat contents of dried citrus pulp (on 8% moisture basis) before and after seeds are removed.

Variety	Protein %		Fat %	
	Seeds present	Seeds removed	Seeds present	Seeds removed
'Valencia' orange	6.47	6.30	2.3	1.5
'Pineapple' orange	6.72	5.83	5.1	1.3
Seedy grapefruit	7.61	6.73	5.1	1.2
'Marsh' grapefruit	7.28	7.11	1.3	0.7

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SEPARATION OF SHELLED SOUTHERN PEAS FOR QUALITY[1]

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INTRODUCTION

The southern pea is an important source of food, particularly in the southern portion of the United States. Its utility as a vegetable is determined primarily by its composition and palatability, both of which are greatly influenced by the stage of maturity at which this vegetable is harvested.

Southern peas from Florida are available at major metropolitan areas on the eastern seaboard in three forms: fresh, frozen, and canned. Although records are not available to document the extent of production in Florida, statistics show that 311 carlot equivalents of southern peas were shipped from the state during the 1964-65 season. These peas were used by processors in other areas and also merchandised fresh at retail outlets. A substantial quantity of peas produced in Florida was consumed locally as well as being shipped out as frozen and canned products.

The relationship of degree of maturity of southern pea to its quality is more important than for many other vegetable crops because of the rapidity of the maturing process, as indicated by Hoover (2), who suggested that the optimum time of harvest is between the 15th and 17th day after flowering.

In a "once over" harvest by machine, although performed at a time when the majority of the peas are at optimum maturity, there will be peas of varying stages of development, i. e. immature, green-shell and overmature peas together.

In the processing industry, peas of varying maturities are undesirable. The separation of southern peas by a combination of sieve sizing and brine solution was reported by Stephens, et al. (3). They found that peas that had been sized could be separated into mature (sinkers) and immature (floaters) categories more precisely than peas which had not been sized. Separation of overmature peas which had begun to dry from the same sized green, immature peas was easily accomplished by brine flotation.

The objective of this study was to determine if a brine-sizing technique of separating peas could be useful for separating shelled southern peas into three stages of maturity: 1) immature, 2) green-shell, and 3) overmature peas. Such a separation would be very desirable to processor as well as handlers of the fresh shelled peas, particularly in relation to removing the overmature peas of lesser quality from those of optimum maturity and quality.

METHODS

Pods of Floricream variety were harvested at immature, green-shell and overmature stages of maturity as shown in Figure 1 in accordance with the following classification. Immature stage consisted of peas which had hulls of a dark green color and firm texture. The seeds were small, green and underdeveloped. Green-shell peas were larger; the pods were lighter green or had yellow as well as green areas; they were succulent and were optimum in development, and color of the seeds ranged from light green to yellow. Overmature peas were those which were in varying stages of dryness; the seeds were cream to creamy-white in color, desiccated, and therefore reduced in size.

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