THE UNIVERSITY OF MANITOBA

CONSERVATION AND RE-USE OF WATER IN ONION PROCESSING

by

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ABSTRACT

Activated carbon treatment of onion rinse water was used to control the four major quality control criteria of water--physical, physico-chemical, biological and biochemical factors for in-plant recycling.

Adsorption isotherm evaluation of several commercially available powdered activated carbons indicated that "Aqua Nuchar" was the preferred carbon for this study based on optimum adsorption capacity.

A dosage of 0.03%(w/v) of activated carbon at every fifth reuse of the rinse water, was used to control important water quality factors, such as odor, foam, color, turbidity and microbial counts, to give a clear and colorless water with the potential use for a high degree of recycling.

Activated carbon treatment of onion rinsewater with a high degree of recycling was shown to be economically feasible as compared to biological treatment without reuse.

Improvements in product yield and quality, accompanied by major reductions(85%) of water needs and waste management costs(88%) were also made possible by this approach. Advanced designs based on the total system approach were developed for the processing of onions.

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SCOPE OF INVESTIGATION

This study deals with the major matters of water and waste management of the onion processing industry, and suggests improvements which should be considered for adoption by the Industry via pilot-plant studies. In a typical onion processing plant, solid waste and effluents are mainly produced at the peeling and washing processes, and during plant cleaning operations. The feasibility of recycling and simple in-plant treatment were evaluated. Activated carbon treatment was investigated as a method of effluent purification, to permit prompt extensive recyclng of the effluents at feasible cost. The economic feasibility of the recommended processes was then assessed.

I. INTRODUCTION

Water is used extensively within food processing plants, as a convenient transportation medium and helps to maintain sanitary conditions. Water is necessary for cleaning raw materials. However, solubles leached during processing add to the organic load in the plant effluent. Water can be recirculated within equipment, and reused at upstream operations in food processing(5), but additional water savings by reuse are possible and needed. Reclamation of the water is sometimes necessary. Blanching is essential in the preparation of many vegetables for canning and freezing, but generates high pollutional loads. Nutrients and minerals are leached or destroyed to some degree during blanching. Peeling by some methods also produces strong pollutional loads.

Extensive research is needed in many phases of the food industry's waste problems: the sources, quantities, and characterization of waste loads during processing, water reclamation, recirculation, and reuse in the plant; new, low pollution methods of blanching and peeling; improved monitoring methods, and cost estimates for all waste control methods.

Where water conservation is practiced there are concurrent changes in quantity and characteristic of wastes. Process improvements have produced some new properties in wastes, and water economics have resulted in the concentration of waste loads in certain process streams. Faced with a wide expansion in the potential waste load, regulatory authorities have been forced to tighten controls and stimulate industry's critical examination of its contribution to the pollution problem.

Government Policies Relating to Water Pollution Control

On Oct 18,1972, a comprehensive program enacted to clean up the nation's waters, became law in the United States. It was known as the Federal Water Pollution Control Act, 1972 Amendment. The new law mandates a sweeping Federal-State campaign to prevent, reduce or eliminate water pollution(39).

The law provides two general goals; 1. to achieve wherever possible by 1983, a goal of water quality clean enough for the production and propagation of fish, shellfish and wildlife and, 2. the elimination of discharge of pollutants into all waters by 1985.

Under Title III, the law establishes deadlines for actions to control water pollution from industrial sources. Industries discharging wastes into the nation's waters must apply "best practicable control technology"("B.P.T."), currently available by July 1st 1983. The legislative history of the law indicated that in defining "best practicable", the Congress expects the

EPA (Environmental Protection Agency) to consider the cost of pollution control, the age of each facility, the process used, and the economic impact of any proposed "clean-up" measures.

For industries which discharge waste into a municipal treatment plant, pretreatment standards will be applied to ensure that the industrial pollutants do not interfere with the operation of the plant or pass through the plant without adequate treatment.

The strong emphasis on the importance of public participation to prevent, reduce and eliminate water pollution in the U.S. policies, is also realized by the Canadian Government. The Environmental Protection Service of the Environment Canada issued "Fish Processing Operations Liquid Effluent Guidelines" in June 1975. The aim was to require that all fish processing and fish meal processing facilities operating in Canada apply best practicable treatment technology to their liquid effluents.

Development Needs for the Food Processing Industry

Dr. Gallop, Head of the Food Science Dept, University of Manitoba, mentioned that food processing is really a wastewater business and that the commercial product is really a "by-product" (16). He stressed that industry has to be considered from a total systems concept approach. Optimizing production cannot be continued, while largely neglecting the water and waste consequences of the process chosen. The waste element can be as important as, or in some cases, more important, than the product being put out for commercial sale, in regard to overall economics.

The total system approach is an advanced method of water and waste control in the industry. This approach was described by Dr. Gallop at the Fourth National Symposium on Food Processing Wastes. Dr. F. Agardy(16), in discussing the evaluation of research and development needs for the food processing industry, concluded that it offered the most ideal solution. The concept involves closed-loop systems, where former elements of wastes become important products to the processing operations. Water can be recycled with in-plant treatment, such as by activated carbon adsorption. The activated carbon can be produced from the solid wastes produced at the plant. The activated carbon can also be recycled after regeneration. This process is becoming very feasible especially with the improved, fast(30 seconds) method of regenerating powdered carbon(8). Solid wastes may also be used for by-product recovery(8), or converted into methane for energy requirement. Steam plumes may be condensed for recovery of water, frying oils, and useful heat , and flue gases may be used for neutralizing caustic wastes produced by peeling operations. The total system approach is now being successfully used by the sugar cane industry in Hawaii(4) and by the pulp and paper industry(47).

In summary, industry must face the ever-increasing demands placed on it by Regulatory Authorities, such as by the 1972 Water Quality Act and the Canada Waters Acts, and their implementation deadlines. Industry also needs to respond to environmental quality constraints, as it faces a serious problem in terms of energy. This all dictates the need to develop a sound process design strategy, with a strong pollution control orientation, using the best practicable technology, to reduce all sources of wastage, and of problems, where possible.

In this project, research was focussed on optimizing the management of the effluents produced by onion processing lines. Wastes generated were characterized, so that possible ways for their purification for reuse or for reduction in pollutional load for discharge could be studied. It is expected that the results from this project could benefit the design of other food processing lines.

II. LITERATURE REVIEW

2.1 Onion composition, Plant operation and Generation of effluent

The food composition of onions(51), based on 100 g of edible portion, is shown in table 1. Effluents produced in processing will necessarily be composed of these organic compounds. The type and concentration of organics present in effluents will dictate the necessary treatment required for reuse or for discharge.

There are a variety of products produced from onion processing, including dehydrated onion flakes, canned whole onions, onion rings and canned onion soups. The steps in these processes and the effluents produced, are discussed in the following section. Figure 1 shows a flow diagram for a typical onion dehydration process. Cleaning is performed by both wet and dry methods. Dry cleaning is used to remove dried tops, some loose skins, and dirt. The machinery usually consists of a series of vibrating screens, parallel rollers, air aspirators, or a combination of all three. Dried tops are usually "pinched off" by a series of rollers and combined with the loose dirt and skin, to be collected as dry solid wastes.

Wet cleaning is usually carried out by a series of dip or soak tanks and high pressure water sprays. These cleaning operations are designed to remove soil, loose skins, and any other debris or contaminants which may

Table 1

The Composition Of Onion (*)

Basic: 100 g edible portion

Onions, mature (dry)	Water (%)	Protein (g)	Fat (g)	Carbohydrate	
				Total (g)	Fiber (g)
Raw	89.1	1.5	0.1	8.7	0.6
Cooked, boiled and drained	91.8	1.2	0.1	6.5	0.6
Dehydrated, flaked	4.0	8.7	1.3	82.1	4.4
Onions, Welsh raw	90.5	1.9	0.4	6.5	1.0

*REFERENCE(51)

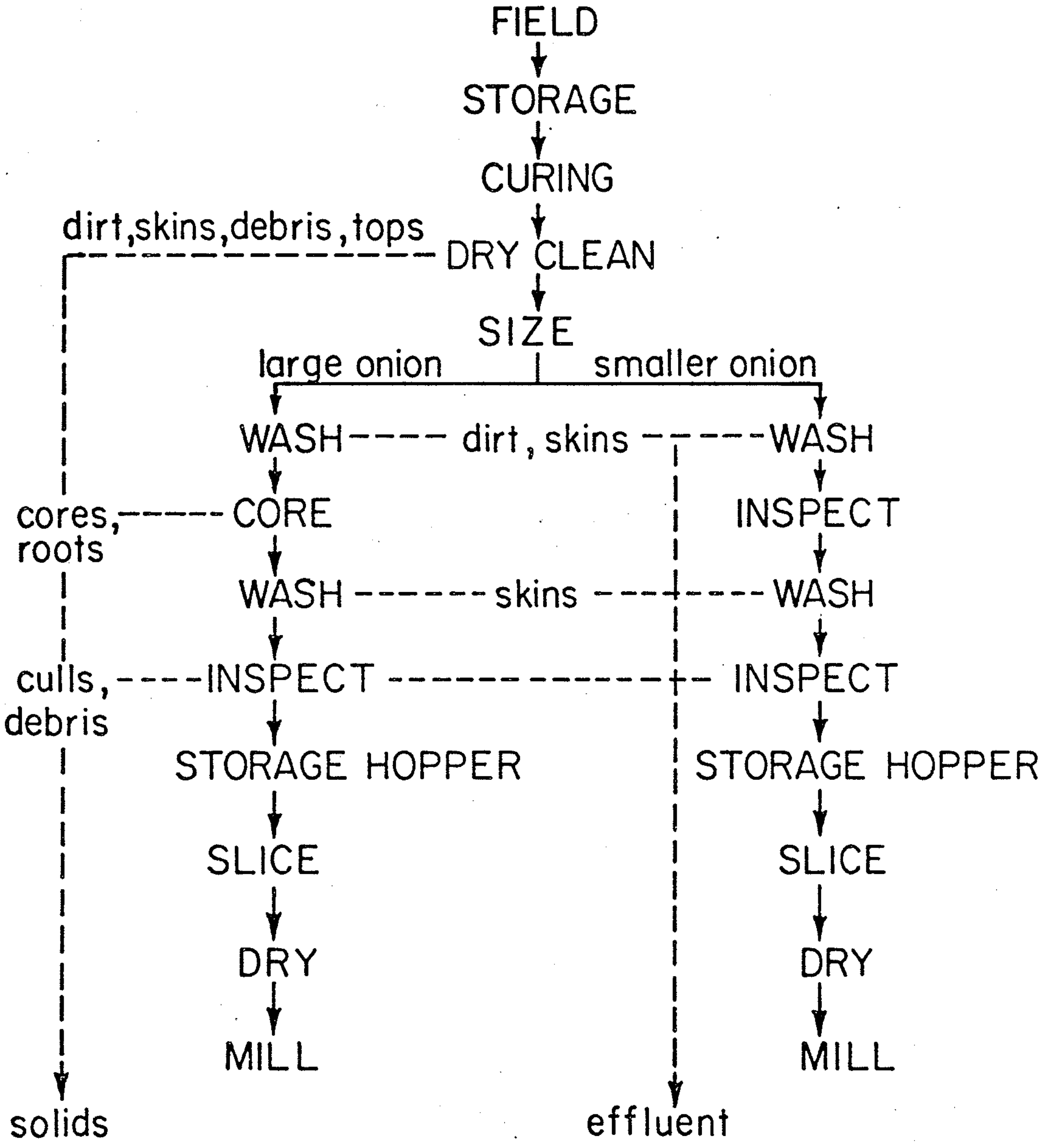

Fig. I TYPICAL DEHYDRATED ONION PROCESSING LINE.

REFERENCE(32)

adhere to the external circumference of the bulbs. Hand trimming is sometimes employed to further remove tops, defective parts of bulbs, or other undesirable blemishes. The waste streams generated throughout these cleaning operations normally contain high levels of fine silt, dirt and loose skins which can either be settled or screened from the final waste effluents.

The main volume of water generated from a typical dehydration process occurs throughout the various washing operations. The effluents are characterized by high suspended solids. The strength of these streams is usually low (approximately 200-300 ppm COD), but the suspended solids are high (typically 200-400 ppm) so that mud settling tanks are a necessary pretreatment before reuse of the water.

In general, these plants run on a 24-hr day, seven day per week production schedule. In-plant cleaning effluents are generated throughout the production day and are usually of high volume and low concentration. The slicing operations generate very little solubles into the wastewaters, because of the extreme sharpness and frequent changing of blades in the absence of flowing water. The major effluent reuse in the dehydration process is recirculation of flume water by counter-current flow to prior washing stages(32). Figures 2 and 3 show the flow diagrams for canned whole onion processing and onion ring

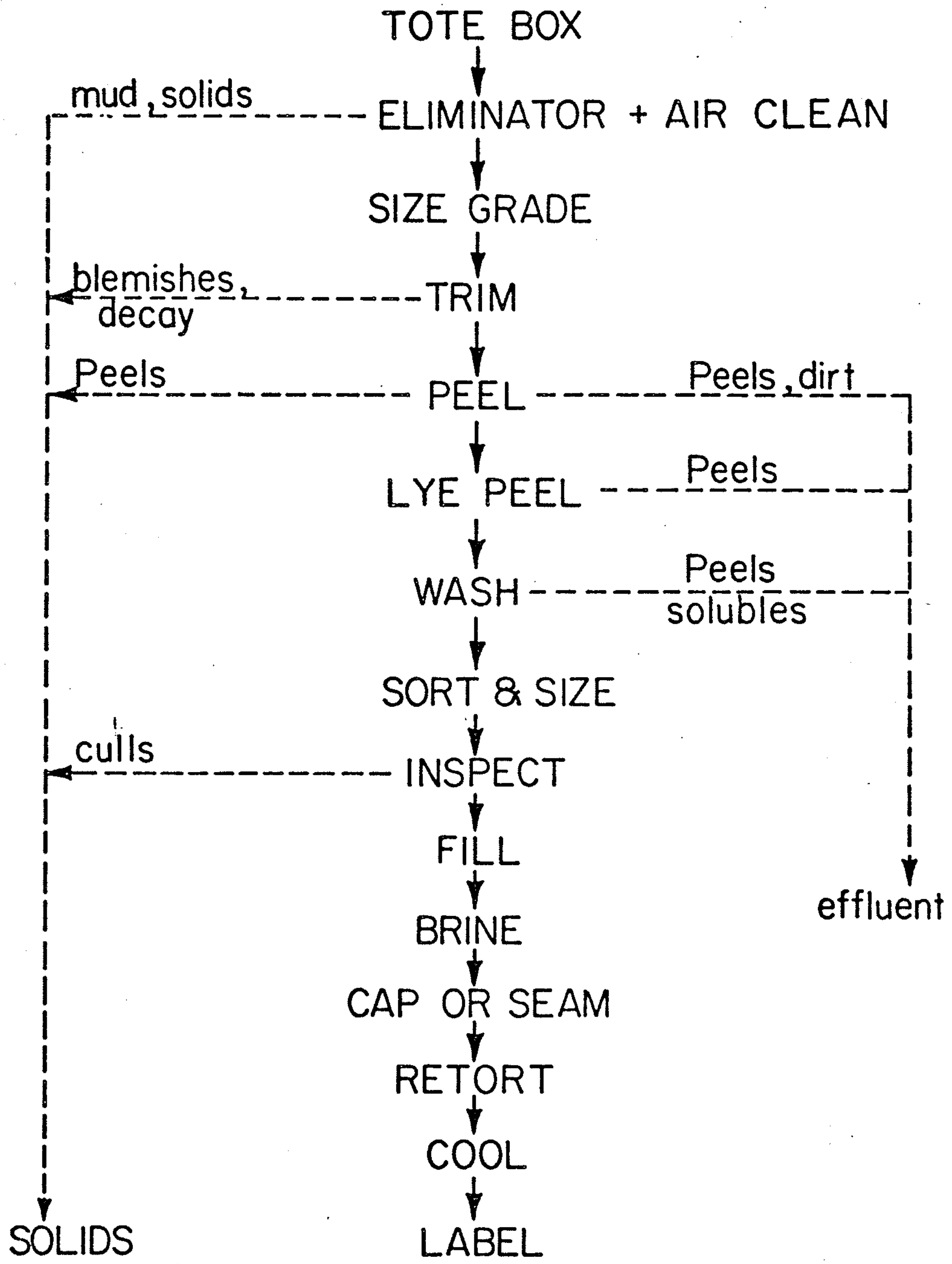

Fig. 2 CANNED WHOLE ONION PROCESSING

REFERENCE (32)

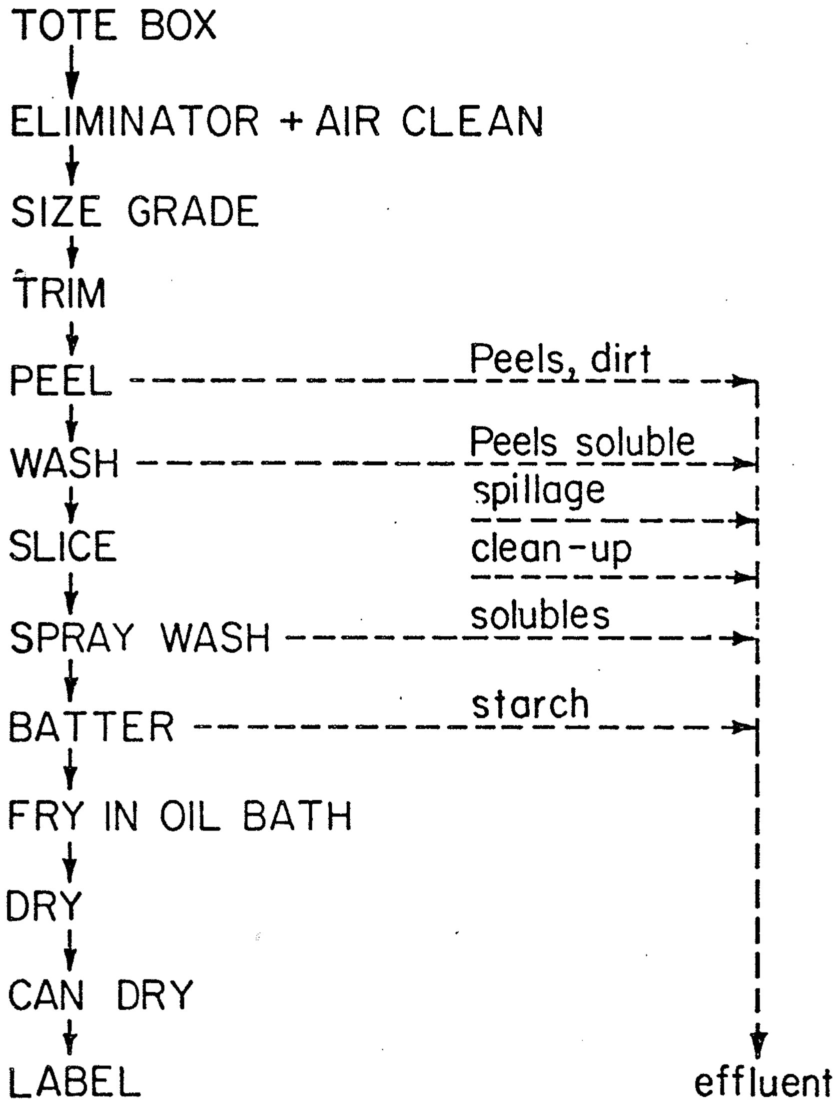

Fig. 3 ONION RING PROCESSING

REFERENCE(32)

processing. The process components contributing substantially to the wastewater are the following:

1. Overflow from fluming operations located between the trimmer and peeler.
2. Overflow and periodic dumping of lye peelers and wash tanks.
3. Spillage and overflow of brine from filling operations.
4. Retort, condensing, and cooling water
5. Cleanup of spills and equipment.

Flume spillage contains soil and organic solubles but the volume of water loss is minimal in most cases. Cooling and retort waters are large in volume but relatively free from contaminants, except for brine removed from the surface of the cans or jars or released when breakage occurs.

Wastewater from the peelers, especially the lye peelers and washers contribute the strongest wasteload. It has the highest COD(Chemical Oxygen Demand) and suspended solids concentrations. Cleanup of spills on a continuous basis and end-of-shift equipment washdown also contributes to the total waste load. Dumping of washers and peelers during cleanup adds a considerable amount of COD and solids to the cleanup flow. Fluming and cooling waters are normally recycled. Continuous recirculation of peeler and wash water with makeup water are also used(32). Figure 4 shows the processing of canned onion soup. The wastewaters

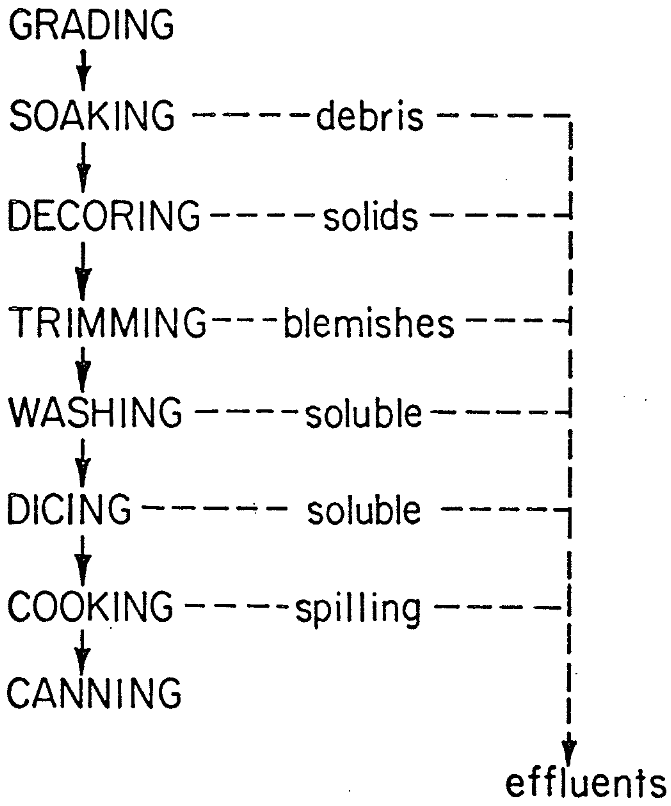

Fig. 4 CANNED ONION SOUP PROCESSING

REFERENCE(32)

generated from the processing line are similar to those from the other processes.

At present, there are proposed treatment schemes recommended to meet the 1977 and 1983 effluent standards(32). For 1977, effluents generated by either dehydrated onions or canned onions should be treated by (a) spray irrigation, (b) aerated lagoons and (c) activated sludge. For the 1983 deadline, the treatment schemes could involve (a) spray irrigation and (b) activated sludge plus filtration plus chlorination.

The recommended effluent standards for processing onions and the raw waste summary are shown in Appendices I and II.

2.2 The Odor Problem in Onion Processing

2.2.1 The Volatile Components Of Onion

From onion processing plants, particularly the dehydration plants, one can smell the distinct odor of the volatiles of onions miles away, depending on the prevailing wind. These volatile components are also dissolved in the rinse water during processing. Any water, if intended for reuse, should not have an objectionable odor and it should be removed by appropriate methods. It is desirable that odor be virtually absent(31). The effectiveness of the method of treatment in removing odorous materials from water is highly variable depending on the nature of the material causing the odor. For this reason, it has not been feasible to specify any permissible criterion in terms of threshold odor number(1).

The chemistry of odor in onions must be understood in order to carry out any treatment. Various studies have been conducted in an attempt to identify the volatile compounds present in onions. Important contributors to the above research were Schwimmer(33,34,35,36), Carson(6), Wong(6) and Kohman(23).

A number of the more important volatile flavor components of onions have been isolated by gas-liquid partition chromatography, and identified by infrared methods and through chemical derivatives. In particular, methyl trisulfide, methyl-n-propyl disulphide, methyl-n-propyl trisulfide, n-propyl disulfide, and n-propyl trisulfide were isolated and identified. Neither monosulfides nor allylic disulfides could be detected(12).

Semmler(41), in 1892, studied the composition of an onion oil and reported that the principal odoriferous volatile component was allyl n-propyl disulfide. This identification has been widely accepted. Kohman(23), in 1947, found that propionaldehyde was an important volatile component obtained from onions. More recently, Niegisch and Stahl(26), using the mass spectrometer for identification, found hydrogen sulfide, sulfur dioxide, acetaldehyde, propionaldehyde, methyl alcohol and n-propyl disulfide, but no evidence of allylic disulfides was obtained.

Compounds which contain sulfur are responsible for the odor from any onion processing plants. Sulfur compounds usually exist in water as sulfates(1). Sulfate waters are most troublesome in this respect. When the sulfate content of the water is high, the presence of a relatively small amount of inoffensive organic matter, such as cellulose or carbohydrate composition, free from sulfur and nitrogen, may produce odor of hydrogen sulfide and other sulfur compounds. No odor would have resulted if the same effluent was discharged in a low sulfate water.

2.2.2 The Free Amino Acids Of Onion

The study of the free amino acids content of onions is important in that it is a contributing factor to the odor problem of onions. Niegish(26) 1956, and Schwimmer(34) 1961, reported that the pungent properties of onions are related to their amino acid composition.

Free amino acids in four onion cultivars were studied by two dimensional ascending paper chromatography with the amino compounds identified(24). The more abundant amino acids are tabulated in table 2.

Table 2

Estimated Amino Acid Content(mg/100g onion) Of Onion(*)

Amino acid	SPWG	Y-53	AFW	W-45
Alanine	1.13	0.93	1.85	1.35
Aspartic acid	1.05	1.60	1.93	0.63
Arginine	16.33	20.68	16.41	25.07
Glutamic acid	3.65	2.95	4.83	3.13
Glycine	0.33	0.46	0.43	0.32
Leucines	3.50	3.93	3.25	3.30
Lysine	9.61	9.44	12.95	10.50
Methionine sulfoxide	1.57	1.49	2.05	1.63
Phenylalanine	3.50	2.40	3.50	2.75
Serine	0.51	0.56	0.45	0.44
S-methyl cysteine	0.93	1.15	1.30	1.93
Threonine	0.95	0.93	1.10	1.43
Tyrosine	3.20	1.63	4.30	2.80
Valine	1.00	0.62	0.92	1.07
Total	47.26	49.07	55.27	56.35

SPWG - Southport white globe

Y-53 - Large yellow bulb

W-45 - White bulb of medium size

AFW - Australian flat white

*REFERENCE(24)