A COMPUTER-AIDED SYSTEM FOR THE SELECTION OF SIEVE DIAMETERS TO SIZE SORT CLING PEACH HALVES FOR CANNING

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1991

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OF
SIEVE DIAMETERS TO SIZE SORT
CLING PEACH HALVES
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BY

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Dissertation submitted in part-fulfilment
of the requirements for the
Laureatus in Technology (Laur Tech) Food
in the School for Life Sciences at the Cape Technikon.

Date of submission: September 1991

Supervising Committee:
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Abstract

This dissertation reports on a three prong approach to obtain new knowledge on the interdependent effects which buyers' specifications, peach crop attributes and sieve stack arrangement have on the masses of peach halves sorted into classes of average diameter. Applying statistical methods and using suitable application computer programs a computer-aided system was developed to improve on the manual selection of sieve diameters. It was concluded that size sorting peach halves for the purpose of mass classification is inaccurate and counter-productive. It is suggested that modern technology be employed to develop a method to determine peach half masses individually.

Summary

Can ingoing mass and count specifications are largely controlled by classifying peach halves into mass classes. A reciprocating sieve stack is employed to sort the prepared peach halves into size classes, according to sieve hole diameters. The diameters are manually selected to approximate the masses needed. This study was undertaken to improve on the efficiency of the manual methods used.

A four prong research approach was followed. Firstly the buyers' specifications were analysed. Secondly the attributes of the peaches available were studied. Thirdly the effects of sieve diameter on peach half masses were evaluated. Fourthly a computer-aided system using the application program Framework III[1] was developed to include the constraints of the three aforementioned variables. This method permits the quick computation of sieve diameters and stack rearrangements according to changing circumstances.

Data were gathered during the 1988/89 and 1989/90 summer peach crop, sampling from Oom Sarel, Neethling, Woltemade and Kakamas cling peach varieties.

It was found that the frequency distribution of peach half masses determined followed a lognormal distribution scewed towards a greater proportion of lighter halves. For Kakamas peaches, 67.5 % of the halves were estimated to have a mass between[2] 25 g and 75 g, while 82.11 % of the Oom Sarel variety was found to be within this mass class. No attempt was made to distinguish between growing areas.

The regression of peach half mass on half diameter was found to be exponential. At 40 mm diameters peach halves had a mass of about 0.7 g for each millimetre of its diameter, while halves of 60 mm diameter had a mass of about 1.5 g for every millimetre of that diameter. Furthermore, peach halves of different varieties of the same diameter had significantly disparate average masses. The slopes of the regression equation for different varieties were also dissimilar.

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[1] Registered Trademark Of The Ashton-Tate Corporation

[2] Minimum and maximum peach half masses demanded by buyers.

To include the effects of all these factors a computer-aided system using the FRED programming language of Framework III was developed. This system was successfully applied to calculate the sieve stack arrangement for the 1990/91 season with sorting efficiency increasing by as much as 13 %.

It was concluded that the current practice of size sorting peach halves on a horizontal plate with holes of a specific diameter is ineffective as it does not readily permit accurate and continuous control of peach half masses.

However, as no alternative method for sorting peach half masses is presently available, it is recommended that the computer-aided system developed in this study be applied routinely and that the following procedures be introduced to permit reliable sorting.

1. Select, store and process peaches received according to variety.

2. Determine regression constants for peach half mass on sieve diameter as often as possible.

3. Regularly evaluate sieve efficiency against changing fruit and buyers' parameters and compute new sieve stack arrangements as often as appropriate.

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Acknowledgements

First of all, my gratitude[3] to Dr. Chris Loedolff, who not only initiated the thought of preparing this dissertation from applied food technology research data, but who also acted as supervisor for the project. I am also grateful to Mr. Lochner Eksteen for his attention to the food technological aspects; Dr. Hendrik de Kock for his review of the computer-aided system and Mr. Chris Hansmann for his scrutiny of the research.

A word of appreciation is due to Mr. Koos Barnard, the owner of Ashton Canning Co., who kindly agreed that the information be made available for dissertation purposes. To the following members of his company my indebtedness; Mr. Wynand du Plessis and Mr. Ernie Oosthuizen for their consistent encouragement and interest in the progress of this project; Mr. Blackie Swart, who with years of peach half sorting experience, was especially difficult to satisfy.

During the preparation of such a dissertation there is always someone close with forbearance; Maritha you did well !

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[3] Gratitude Is A Fruit Of Great Cultivation; You Do Not Find It Among Gross people - Samuel Johnson

Statement

I, Herman Barend van der Merwe, declare herewith that the contents of this dissertation represent my own work and opinions expressed and recommendations made are my own and are not necessarily those of the Cape Technikon.

Signed HBvd Merwe at Strand

on 13 day of November 1991.

1 Introduction

1.1 General

Uniformity[4] in appearance of canned peach halves appeals to the consumer when a can of fruit is opened and transferred into a domestic receptacle. A feel of brand loyalty unfolds when such a can is hedonicly acceptable to the consumer. The next purchase will determine whether this initial brand preference shall be rooted or rejected by the user. Uniformity in sensory attributes relates to size, count and colour on first examination and to flavour, taste and texture when consumed (South Africa, 1976). Of these quality attributes, the count has an important influence on the brand choice when shopping for family meals (Oosthuizen, 1991). The shopper associates the number of appetizing peach halves in a can with the family members and will buy the brand and can size in accordance (Oosthuizen, 1991; Robertshaw, 1989).

Brand owners of canned peaches specify and declare on the label the drained mass and net mass for each can size. However, for the same can size and mass requirements, different counts are specified by the buyer and if deemed of economic importance also indicated on the label accordingly. It follows that an array of peach half masses is in fact demanded. In effect, the optimum mass of individual peach halves can be calculated by dividing the count into the drained mass.

Production staff, together with sales and marketing teams, are aware of the need to maintain the uniformity of branded product ranges and meet daily to plan production schedules in advance. Due consideration is given to the three major areas of influence viz buyers' specifications, fruit properties and machinery characteristics.

Of the three important factors mentioned, seasonal influences and those associated with different varieties can be considered uncontrollable due to macro and micro climatic variations of

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[4] Having always the same form; not changing in shape, appearance, or character (Kellerman, 1981).

different growing areas. However, peach maturity, which to an important extent determines colour variation, can to a large degree be controlled through careful picking procedures on the farm.

To pack economically canners need to select halves in multiples which together will form a group with both count and total mass according to a particular pack specification. The closer the group mass is to that demanded, the smaller the over-fill amount will be and thus the better the economics of the packing process. The following example illustrates this point. During the 1989/90 fruit canning season it cost 52.1 c to fill an A2½-can with cling peaches to a label drained mass declaration of 500 g (Oosthuizen, 1991). Orders for this peach pack size amounted to 1200 tonne. The projected cost savings of a potential reduction in variation between half masses are demonstrated in Table 1-3.

Prevailing technology uses a series of custom made sieve plates selected according to their hole diameter. These sieves are assembled in a reciprocating stack arrangement. This sieve stack sorts peach halves into classes of comparable uniform diameter (Fig 2-1). Selecting peach halves in this way has limitations due to the natural variations associated with fruit properties and the size of the sieve diameter (Peleg & Bagley, 1987).

With multiple line operations manual mass determination of individual peach halves is not feasible and uneconomical at speed requirements of about 1500 to 2000 peach halves per minute per A2½-pack size line. The development of modern high speed electronic devices is not yet in sight, thus traditional sieve sorting remains the only acceptable operation available at present.

The arrangement of sieve stack, screen diameters and sieve intervals depends on the expertise of individuals having gained experience in canneries through the years. Although their decisions are influenced by the well known fact that peach half masses vary with their diameter, market requirements and perceived effects of fruit properties, such judgments remain estimates at best because the exact nature of these relationships have not been addressed in the literature.

It was visualised that these decisions could be greatly improved on with the aid of modern computer systems, which utilise input data pertaining to both buyers' specifications and fruit characteristics. It is not the objective of this study to derive prediction models for the variations in fruit attributes, but rather to point out statistically significant differences. These factors could then be included in the computations when selecting screen diameters.

Consequently, this study sets out to develop a computer aided system for improving the selection of screen diameters. It compares, evaluates and adjusts the nature of buyers' specifications and secondly, establishes the most important fruit attributes associated with mass variation at a set diameter. Thirdly, it applies modern systems in the interest of improved control, productivity and efficiency.

1.2 **Export Markets**

Table 1-1 shows that between 74 % and 98 % of all canned peaches produced in the RSA since 1985 were sold abroad (Canning Fruit Board, 1991). As a result foreign specifications dominate the quality of canned peaches produced in the RSA. They also influence the standards for good manufacturing practices in the day-to-day operation of most canneries and certainly where the data for this project were collected.

Although canned peaches as a commodity is small in relation to the total food manufacture in the RSA (South Africa, 1991) it realised a steady increase in foreign exchange earnings up to 1986 whereupon it remained relatively constant, at a value in excess of R95 million per year (Canning Fruit Board, 1991). The RSA produces 20 % of the world trade in canned fruit and is second to Greece which accounts for 41 % (Victor, 1991).

Table 1-1. Canned Peach Statistics For RSA

Years	Total[5] Manufact R1,000 million	Food[6] Industry R1,000 million	Canned[7] Peaches R1 million	Canned[8] Peaches crtn's[10] million	Canned[9] Peaches crtn's million	Canned Peaches Exported %
1982	57.57	7.80	44.61	3.059		
1983	62.29	9.30	49.87	3.123		
1984	71.67	10.40	62.39	3.162		
1985	79.00	15.10	77.08	2.474	3.063	80.770
1986	89.70	17.10	94.08	3.144	3.198	98.311
1987	103.74	19.90	95.12	2.526	3.121	80.936
1988	126.36	22.77	95.43	2.502	3.290	76.049
1989	151.32	26.75	95.14	2.254	3.011	74.859
1990	166.39	30.61	98.56	2.400	2.686	89.352

1.3 **Content Control**

The statutory implications of net content control to South African fruit canners not only embrace national regulations (South Africa, 1977), but because of South Africa's traditional international involvement in supplying the world market with high quality canned fruit (Oosthuizen, 1991), canners are compelled to adhere to standards set by buyers operating in the European Economic Countries (EEC). There are thus both national (South Africa, 1977) and international standards (CFPRA, 1985; Robertshaw, 1989) to obey, but even more apt, controls over manufacturing costs within these ardent parameters are essential to maintain pricing competitiveness. The need for knowledge and the implementation of systems geared to improve productivity and effect cost savings seem imperative.

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[5] Turnover Total Manufacture RSA (Central Statistical Services, 1991)

[6] Turnover Food Manufacture RSA (Central Statistical Services, 1991)

[7] Turnover Canned Peaches RSA (Canning Fruit Board, 1991).

[8] Total Canned Peach Exports RSA (Canning Fruit Board, 1991)

[9] Total Canned Peach Production RSA (Canning Fruit Board, 1991)

[10] Cartons of 24 x A2½ cans.

When the filling operation is characterised by a large variation in mass as opposed to small deviations and if standard deviation values of say 10.0 g and 0.5 g, are measured for two different filling lines, both with nominal masses of 500 g, it is important to note that the calculated target masses are quite different (Van der Merwe, 1987) as presented in Table 1-2.

Table 1-2. Influence Of Standard Deviation On Target Mass

	Standard Deviation	
	10.0 g	0.5 g
T_U[11]	513.0	494.0
T_A[12]	506.3	500.3

As control over the filling process improves, smaller standard deviations will be obtained and Table 1-2 shows that the target mass will tend closer to the stated nominal mass. The other interesting observation from Table 1-2 indicates that for a large standard deviation, T_U is greater than T_A, while for an improved control process the requirements of a single unit T_U become smaller than the stipulations for the average sample T_A. It also means that sample size may be reduced (Snedecor & Cochran, 1987). In order to be 95% confident that the total production conforms to the mandatory preconditions, the largest of T_U and T_A is selected as the target mass for filling purposes.

Because the standard deviation is determined by variations in factors associated with the product, fillers, operators, and maintenance of various machines, the standard deviation will vary from filling line to filling line and product to product. Utilising the most representative standard deviation available, target masses as well as control limits have to be calculated for each line and of course, recalculated for major variations in product attributes related to density, shape, size and other geometric changes.

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[11] n = 1

[12] n = 10

Canned fruit exported to the European Economic Countries require a statement of net mass, as well as a statement of drained mass (Robertshaw, 1989). The net mass is of course the sum total of fruit packed (ingoing mass), plus the mass of the covering liquid added. The ingoing mass of a can of peach halves is the sum total of the individual masses of each half contained in that can. The number of halves is commonly known as the count. The variation of masses between the individual masses of peach halves will influence the standard deviation (Van der Merwe, 1987). If it were possible to select halves with identical masses the contribution caused by the variation between individual peach half masses towards the line standard deviation would be nil. Target ingoing masses (DrnWt) will tend smaller with expected corresponding cost savings as demonstrated in Table 1-3.

Table 1-3. Mass Variation[13] and Packed Peach Cost For A2½-Packs

NomWt	n	s	TNE[14]	DrnWt[15]	Cost[16]	TonCost[17]	SeasnCost[18]	Saving
500	8	40	15	535	55.75	R1,114.94	R1,337,928.00	R.00
500	8	35	15	525	54.71	R1,094.10	R1,312,920.00	R25,008.00
500	8	30	15	522	54.39	R1,087.85	R1,305,417.60	R32,510.40
500	8	20	15	515	53.66	R1,073.26	R1,287,912.00	R50,016.00
500	8	10	15	508	52.93	R1,058.67	R1,270,406.40	R67,521.60
500	8	0	15	500	52.10	R1,042.00	R1,250,400.00	R87,528.00

Although the net mass of the can remains constant, the drained mass changes from the time the covering liquid is added (Smit et al., 1961). Usually, sugar syrup at about 30° Brix or fruit juice at about 20° Brix is added to the peach halves. Water then moves from the fruit to the more concentrated liquid phase. This decreases the actual mass of the peach halves and thus the

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[13] As Measured By The Standard Deviation
[14] Tolerable Negative Error
[15] At The Packing Stage: DrndWt = Ingoing Mass = Target Mass
[16] Filled Peaches Cost (cents); Excluding Can (Oosthuizen, 1991)
[17] At Nominal 500 g Ingoing Mass
[18] For 1200 t Season (Oosthuizen, 1991)

drained mass of the pack. These changes are due to differences in osmotic pressure. However, when the fruit is cooked as part of the canning process, the fruit cells plasmolise and adsorption forces take over to eventually equilibrate the concentrations of fruit and liquid phases. This final state of equilibration is only reached approximately three months after canning and determines the cut-out mass of the peach half. For peaches Smit et al. (1961) found that the drained mass could increase to more than 100 % of the original fruit ingoing mass. On the other hand, with apricots the percentage retention of the fruit originally packed, can vary from as low as 80 % to about 90 % (Stiekema et al., 1960) and is due to the tendency of canned apricots to soften (Van Der Merwe et al., 1966) possibly due to the removal of structural calcium from the cell wall by chelating organic acid anions (French et al., 1989). These changes in fruit mass also vary between different fruits and with variety, the maturity, the growing area and the actual water content of the fruit, amongst others.

Data pertaining to changing drained masses are not available for modern peach and other fruit varieties grown in different areas and canned for local and export sales. This complicates accurate forward estimates of drained masses and corresponding adjustments to target ingoing masses.

Statistical content control and Shewart-charts were first introduced in South Africa by Goosen (1961) at a Tulbagh fruit canning plant and at a Paarl fruit cannery by Van der Merwe (1963). These systems were based on statistical methods recommended by the National Canners' Association (1956) and Kramer & Twigg (1961) and depend on transforming many figures into graphs permitting hand packers to respond appropriately. Kock (1984) extended the techniques to piece sorting during pineapple canning at an East London operation.

Shewart-charts have however, inherent limitations if applied to high speed filling operations with multihead fillers, because of the vast amount of manual data transfer and associated computations. Such difficulties were overcome through the development of the Mettler Filling Process Control (1983) system which linked one or more manually operated balances to data processing units varying from simple calculators to computers with sophisticated software. These systems are costly and although excellent statistical record keeping is maintained, the hand packer is precluded from on-line immediate action, thus reacting to an after-the-event activity. The use of Shewart-charts produces excellent results (Van der Merwe, 1987) in the hands of trained supervisors who are also versed in management by objective techniques for improving productivity (Riggs & Felix, 1983).

In order to maintain vigilant content control, high speed check weighers were designed and operated to divert over-mass and under-mass filled cans from the main stream. Mechanical mass determination limits line speeds to around 250 cans per minute (cpm) (Hi-Speed Check Weigher Co., 1983), while the use of low level gamma rays to measure fill volume (Peco, 1989) coupled to computerised control and data acquisition systems permit much improved line speeds of up to 2200 cpm and certainly has application with liquids. These mass control machines can be seen as a necessary affirmation for maintaining mass standards.

The application of advanced statistical methods like Duncan's multiple range test by Maxcy & Lowry (1984) to multihead fillers, provides valuable information, but its implementation is limited by the vast number of calculations.

The use of linear programming (LP) in optimising food unit operations was discussed at a symposium chaired by Saguy & Karel (1982). These subjects were largely influenced by the use of LP in animal feed applications designed to establish minimum cost formulations (Bender et al., 1976). Recently De Kock (1988) developed a computer program for feed mixtures which runs on less sophisticated PC installations and thus brings about significant cost savings to the industry. Using LP techniques, Norback & Evans (1983) studied food mix formulations like ice cream, processed meat products, and cereal based foods.

These systems are suitable for net mass control, but do not lend themselves to effective peach half mass control and thus the requirements of ingoing mass control of canned peach half packs. A system to sort peach halves according to individual masses is needed, but not yet available for the high speeds of 1500 to 2000 peach halves per minute per packing line of 250 cpm.

1.4 **Size Sorting**

Peach half uniformity control has not been studied in any great detail. In the literature almost nothing is available, apart from an effort made by Kotze & Smit (1961) who, in co-operation with a fruit canner, addressed the importance of Kakamas peach halves in respect to production costs, canning capacity of factories and the attainment of certain quality grades. They subsequently investigated the size and number of fresh whole peaches per hundred pounds (45.36 kg) of fresh mass. It was found that the average coefficient of variation was as low as 3.84 % and concluded that once the number of peaches per mass unit of 100 lbs (45.36 kg) is known, it will be possible to estimate the average size of Kakamas peaches accurately. This meant counting peach halves per 100 lb (45.36 kg) lot and reading it off a graph produced through regression analysis. They warned that this information cannot be applied to peaches of different varieties[19] because of inherent shape differences.

The most prevailing method for quantitative shape description involves calculations of similarity to a sphere (Peleg & Bagley, 1987). The higher the number, the greater the similarity to a sphere. Oblong shaped products such as rice, will exhibit a low value of sphericity[20]. Published values for the sphericity of fruits are of the order of 89 % to 97 % (Peleg & Bagley, 1987). The geometry of a fresh peach as received at the canning factory is round and its sphericity probably close to 97 %. During the process of peach canning the geometrical properties of the fresh whole peach change from a round to an oblate shape (Peleg & Bagley, 1987). The influence of ambient temperature on size variations of peaches could be quite large during the last few weeks of growth on the tree (Bergh, 1991).

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[19] Variety Details In Appendix A-9

[20] Defined in glossary of terms

1.5 **Problem Statement**

A reciprocating sieve stack consisting of sieve plates each with holes of different diameter is currently the only technology available to sort prepared peach halves into mass classes for the purpose of controlling count and ingoing can masses. The sieve diameters are customarily selected manually with varying success.

The problem at hand is to improve on the efficiency of the manual methods presently employed for the selection of sieve diameters.

2 **Materials And Methods**

2.1 **Peach Canning**

A synopsis of salient peach canning operations is presented here while a flow sheet, in the next section of the various processes employed in the plant where this study was conducted, completes the description. During the canning operation fresh peaches are dumped into a water dump washer from where they are elevated through a roller elevator which also evens out material flow to an even string. From here the round peaches are conveyed on a roller sorter which grades them into four nominal selected different sizes according to the distance the rollers are varied from start to the end of this conveyor. Again the peaches are dumped into water holding bins from where they are roller elevated to the pitting machines. Two kinds of pitting machines were used: The first type is the twist pitter[21] with automatic suture aligner feeding the pitting head. In the pitting process the peach is cut along the suture line and the pit held together by the two clamping dividing knives. Two cup hands on either side of the peach half twist the halves in opposite directions, breaking them loose from the pip. The net result is a clean pip cavity. The second kind of pitter used is the knife pitter[22]. These pitters are also equipped with suture aligners. The peach is grabbed by mechanical hands and moved to be sawn in half and transferred to the scooping knife which then scoops out the pip

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[21] Atlas Pacific Corporation.

[22] Food Machinery Corporation.

section from both peach halves. Because knives break when they are too small for the pip diameter, the tendency is to fit slightly larger knives to scoop clearly and cleanly around the pip. Claims are made that this cutting operation brings about greater losses of peach flesh material than would be the case with the twist pitter (Molenaar, 1989). The difference in appearance resulting directly from the use of two types of pitters influences product uniformity, but this has not deterred from the general buyers' appeal of the peaches produced at this factory (Oosthuizen, 1991).

All mispitted halves are then sent to the mispit-pitter, which orientates the peach half with its pip uppermost and feeds this into the depipping head relying on circular knife action. These knives are of greater diameter than described earlier and fairly big pip cavities are characteristic of halves pitted in the mispit-pitter. Peach halves having passed this operation were excluded from this study.

Subsequent to pitting all halves go through an inspection station upon which they are orientated cup down onto the belt feeding the continuous lye peeler where caustic soda chemically removes the peel at a temperatures of about 90° C. Peach halves are subsequently washed and graded for defects before they are pumped in water flume onto the reciprocal sieve stack. This sieve stack is used to sort the peach halves into sizes as determined by the diameter of the openings of the sieve through which halves will or will not pass.

During peach preparation pip and peel removal accounts for 25 % of the total mass, while trimmings reduce the yield by an additional 4 % (Canning Fruit Board, 1991). Thus only 71 % of the peaches actually accepted for processing is utilized in the end product. Pip losses for the knife pitters were found to be between 10 % and 12 % for Kakamas peaches (Van Der Merwe, 1961).

2.2 **Flow Sheet**

PEACH CANNING FLOW LINE

Weigh Bridge - Grade For Defects And Size To Affect Payment. Directly To Processing Line Or Cold Storage Until Required

Empty Bulk Bin By Hydraulic Tilting Into Water Dump-washer - Roller Elevator To Roller Feed Size Distributor/Sorter - Into Four Feed Balancing Water Dump Tanks - Roller Elevator To Belt Conveyer And Belt Turn-table Feeding Pitting Machines

Pitting - Pit-out Shaker - Cup-up Shaker Visual Inspection And Defect Removal - Cup-down Shaker - Continuous Lye Peeling In Steam Box - Peel Scrubber/Spray Washer - Manual Defect Inspection - Water Pump Flume Elevator To Size Sorting Sieve Stack

Belt Conveyer Distributor To Half Slicers And Cup-up And Cup-down Shakers With Final Quality Grading And Hand Packing From Belt Into Cans On Chain Conveyers -Fill Covering Liquid With Vacuum-fillers - Steam-flow Closer - Continuous Cooker And Cooler

Palletise - Bright Can Stack Warehouse - Inspection - Automatic Machine Labelling - Palletise And Containerise For Rail And Sea Freight To Export Destination

GROCERY TRADE

2.3 **Sieve Sorting**

Present technology sorts peaches halves into classes according to their diameter. A series of seven sorting sieves (Fig. 2-2) mounted one above the other in a reciprocating shaking machine was employed. These were mounted in such a way that each screen overlaps the other by about half its length. The undersized peach halves of the upper screen which become the oversize fruit of the screen immediately underneath, were diverted via exit ducts and spouts to the respective packing lines. The average diameter of the upper and the lower screens thus represented the arithmetic average diameter (Brennan et al., 1979) of the two screen apertures and thus of the diverted peach halves. This average diameter value best described the diameter of the peach halves in that particular sieve interval. Figure 2-1 shows peach halves being sorted on the sieve stack from which peach half data were gathered for this investigation. Peach halves sorted into such diameter classes were accepted as having been sorted into mass classes and this operation formed the basis for controlling fruit ingoing mass according to pack specifications.

Thus, seven screens with diameters usually varying between 70 mm and 35 mm at 2 - 5 mm intervals have to be selected in accordance with the masses of peach halves demanded for the different pack configurations ordered. This sieve stack configuration would be quite different in the beginning of the season to that demanded a few weeks later as effects of variety and sales requirements of finished products evolve during the production period.

Although widely used for sorting peach halves, this method has considerable disadvantages, because it will separate the units according to the narrowest dimension (Brennan et al., 1979). It is appropriate for products with a high sphericity value, but the sphericity of a halved peach according to the formula[23] of (Pelag & Bagley, 1987), calculates to approximately 50 % and about half that of the whole fruit.

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[23] sphericity = d_c/d_e; defined in glossary of terms

Fig. 2-1 Peach Halves Being Size Sorted

2.4 Sieve Stack

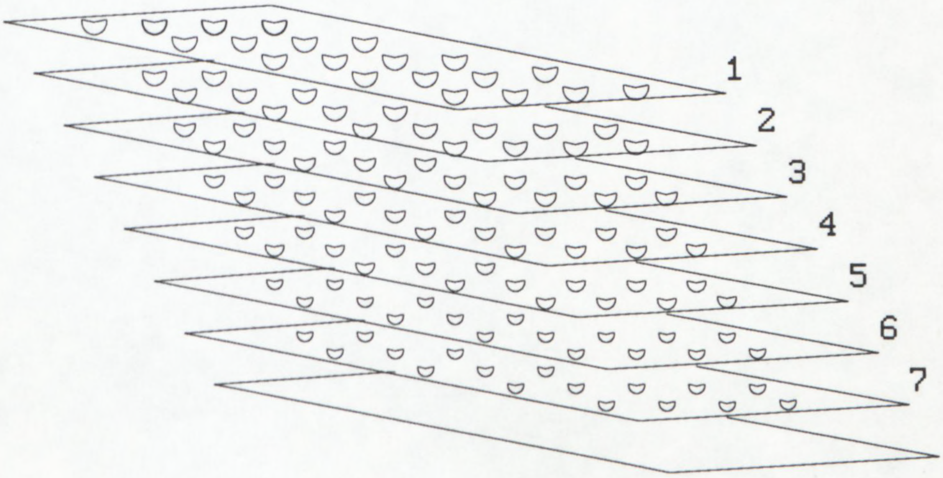

Fig. 2-2 Schematic Diagram Of Peach Sorting Sieve Stack

2.5 **Peach Varieties**

The Kakamas cling peach and the Keimoes, Goosen and Walgant were the major varieties[24] available to canners during the Second World War period when re-armament provided a major impetus to the canning industry of the RSA (Canning Fruit Board, 1991).

These varieties ripened in short succession in the summer months of January to February in the Boland. A need to lengthen the fruit ripening season and to utilise plant and machinery over a longer period encouraged plant breeders to produce new varieties which would extend the season with fruit of both earlier and later ripening dates (Canning Fruit Board, 1991). The culmination of these efforts led to the introduction of some very successful canning cling peach varieties and the extension of the peach canning season to about four months from late December to early April. A total of 87167 t with a value of R42,119,254 was canned and sold in 1990 (Canning Fruit Board, 1990). Clingstone peach tree plantings in the RSA for 1989 are presented in Table 2-1. (Apricot Peach Growers Association, 1990).

Table 2-1. Clingstone Peach Tree Plantings

Cultivar[25]	Total(Ha)
Kakamas	2201
Prof Neethling	2004
Oom Sarel	1546
Woltemade	824
Prof Malherbe	673
Prof Black	274
Walgant	183
Goudmyn	NA[26]

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[24] Details Of South African Peach Varieties Can Be Found in Appendix A-9

[25] Variety Details In Appendix A-9

[26] New Variety; Not Available

2.6 **Choice Of Peach Varieties**

Because the ripening dates of the different cling peach varieties available to a factory overlap it is difficult to separate varieties during a production run. This is so because fresh peaches are utilised both directly from the field and from cold storage on a first-in-first-out basis and as production requirements demand. Table 2-2 shows the micro climatic influences on ripening dates of different varieties, even in neighbouring areas as observed during the experimental period.

Table 2-2. Ripening Dates Of Neighbouring Production Areas

	Growing Area	
Variety	Ashton	Montagu
Oom Sarel	14 Dec, 88	27 Dec, 88
Malherbe	14 Dec, 88	2 Jan, 89
Neethling	9 Jan, 89	19 Jan, 89
Keimoes	31 Jan, 89	8 Feb, 89
Kakamas	13 Feb, 89	15 Feb, 89

As a consequence it was decided to conduct sieve sorting tests with only the most important varieties and only on days when they were available in sufficient quantities to ensure variety processing and the reliability of the data gathered. Four of the commercially important varieties in terms of available tonne and their consecutive ripening dates were selected for this study. They were Oom Sarel, Neethling, Woltemade and Kakamas.

A brief description of their origin (Canning Fruit Board, 1990) is presented in Table 2-3 while Table 2-4 presents physical detail of the experimental material (Canning Fruit Board, 1990). Further detail can be found in Appendix A-9.

Table 2-3. Origin Of Peach Varieties[27]

Variety	Ripening	Origin
Oom Sarel	mid-Dec	RSA; Kakamas & Early Dawn cross; FFRI
Neethling	mid-Jan	RSA; Kakamas & Early Dawn cross; FFRI
Woltemade	late-Jan	RSA; Kakamas seedling; Nel-Brothers
Kakamas	mid-Feb	RSA; Kakamas seedling; Reinecke & Collins

Table 2-4. Physical Properties Of Peach Varieties[28]

Variety	Mass[29]	Shape	Released	Flesh Colour
Oom Sarel	125g	round	1961	yellow
Neethling	130g	round	1961	yellow
Woltemade	140g	ovate with point	-	orange-yellow
Kakamas	140g	round to ovate	1938	yellow

2.7 **Sampling**

Peach halves were sampled for four different varieties during the 1989/90 and 1990/91 summer fruit seasons. Because the factory uses two kinds of peach pitting machines, samples from each type were collected separately. Each sample consisted of 100 peach halves. A sample was taken at each of the spout streams in use, respectively. The final number of halves actually used for mass determination per spout varied according to the number of sieves and the kinds of pitters employed at the time of sampling. This resulted in differences in the

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[27] Variety Details In Appendix A-9

[28] Variety Details In Appendix A-9

[29] Average For Canners Grade Fruit (Canning Fruit Board, 1990)

final number of halves available per variety as indicated in Table 2-4. The masses of halves were determined on a top loading balance and recorded to the nearest gram.

Varieties were sampled separately for each observation series on the dates summarised in Table 2-5. Masses of 2440 peach halves were determined, recorded and statistically analysed.

Table 2-5. Sampling Dates For Size Sorted Peach Halves

Varieties	Date	STSC file	n
Mixed	15 Feb 89	PSRT89MD	320
Kakamas	8 Mar 89	PSRT89KD	280
Oom Sarel	8 Jan 90	PSRT90OD	520
Neethling	24 Jan 90	PSRT90ND	520
Woltemade	7 Feb 90	PSRT90WD	560
Kakamas	7 Mar 90	PSRT90KD	240
		Total	2440

2.8 **Computer Ware**

For economic reasons the computer-aided system had to be limited to an AT and application software to that available commercially. A central processing unit with 1000 Mb RAM and a 20 Mb hard drive was considered appropriate. The application required an integrated program for database and spreadsheet linking together with word processing capabilities. The program Framework III[30] was selected. The various databases and spreadsheet were suitably programmed, using the FRED programming language. The Statgraphics[31] application program was used for statistical analyses. Print-outs of tables and figures therefore vary according to software. Where appropriate, files were exported and imported via ASCII as needed.

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[30] A registered trade mark of Ashton-Tate Corporation

[31] Registered Trade Mark Of The Statistical Graphics Corporation.

2.9 **FRED Language**

The FRED[32] language is a relatively complete program language that contains functions to perform the common operations of input, output, assignment, decision, looping and string manipulation. In addition, FRED contains a number of functions to access and manipulate the various types of frames. Individual statements in the FRED language are function calls. The syntax of the FRED function is: @<function name>(parameter list).

The function may be predefined as a part of the FRED language, or may be defined as required. The parameter list will contain zero or more parameters. If there are more than one parameters in a list, then the parameters will be separated by comma's (,). Some FRED functions have an optional parameter list. When FRED function is executed, it returns a value. The value may be a number, a character, or a system constant (Dinerstein, 1986; Hergert and Kamin, 1987; Simpson, 1985).

2.10 **Data Recording And Reporting**

Raw data were punched into STSC version 3.01 data files with file names as listed in Appendix A-4. All subsequent data reduction and statistical analyses were carried out using STSC routines as detailed in Appendix A-3. Organised raw data are contained on the enclosed 1.2 Mb floppy disk. These STSC files are arranged for frequency distribution analyses and the file names are listed in Appendix A-5.

To study frequency distribution all data, including masses obtained at the overflow spout No. 8, were included. The data files for Oom Sarel (PSRT90OD), Neethling (PSRT90ND), Woltemade (PSRT90WD) and Kakamas (PSRT90KD) for the 1989/90 season were joined to investigate the overall frequency distribution curve for all four varieties sampled during that season (PSRJ90DV). Data for the Kakamas varieties for the two seasons, 1988/89 and 1989/90 were also joined to compare the distribution of this variety over two seasons (PSRJ89DV). The frequency distributions were determined using the

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[32] FRED is a registered trade mark of the Ashton-Tate Corporation.

STSC distribution fitting option. Appendix A-5 tabulates the different data files together with appropriate descriptive annotation.

Spout No. 8 delivered units which pass through the holes of the last sieve and end up on the final sieve stack plate. The nominal hole diameter of such a plate equals zero and as such provides units of nondescriptive average diameter. Unit mass data obtained from spout No.8 were therefore only included in studies of the population frequency distribution, but omitted from all other statistical analyses. Data files were accordingly modified and renamed. These are distinguished by the letter "R" as the last identifying digit of the file name. Appendix A-7 and A-8 list these files.

2.11 **Statistical Analyses**

Frequency distributions of peach half masses were determined with STSC and subjected to the Kolmogorov-Smirnov one sample test[33] (STSC, 1988).

Multifactor analyses of variance (STSC, 1988), were used to test the difference between mean masses. For this purpose the data files containing mass data for the four different varieties were joined to form file PSRTJ90 for the purpose of multifactor analysis of variance to study the influence of the factors of sieve diameter, peach pitter type and varieties. The data obtained for the Kakamas variety over the season 1990 and 1989 were joined to form the file PSRTJ89 for multifactor analysis of variance to test the effect of sieve diameter and season. The Scheffe range test was used to test for significance between means (STSC, 1988; Snedecor & Cochran, 1987).

Regression of peach half mass on sieve diameter was computed using the simple regression analyses option (STSC, 1988) to establish the model of best fit.

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[33] Comparison of empirical and hypothesised distributions.

3 **Results**

3.1 **The Market**

It was found that buyers' specifications (Table 4-2) are uniform with respect to the fact that all stipulated the number of peach halves per can (count) and the drained mass which should be attained on cutting of the container at the point of usage.

The count specifications of different buyers for particular can sizes are quite unlike (Table 4-2). These varied widely and were compared according to their respective coefficient of variation (CV) values. Buyers' specifications were in non-homogeneous population groups. In order to reduce the large divergent count requirements, specifications were modified to reduce variation between buyers, as measured by the CV.

3.2 **The Peach Crop**

3.2.1 **Overall View**

Figure 3-1 presents a three dimensional histogram of the relative frequencies[34] of peach halves distributed in each of the mass classes for four varieties of prepared peach halves during the 1990/91 peach season. The diagram indicates that peach halves of the same diameter yield different masses. Factors associated with these differences are presented in Tables 3-1 to 3-7.

3.2.2 **Mass Frequency Distribution**

The results show that the masses of prepared peach halves, ready for quality grading and packing followed the lognormal frequency distribution. These statistics are summarised in Table 3-1.

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[34] Expressed As A Percentage Of All Halves Measured

Fig. 3-1 Mass Distribution Of Peach

Halves During 1989/90

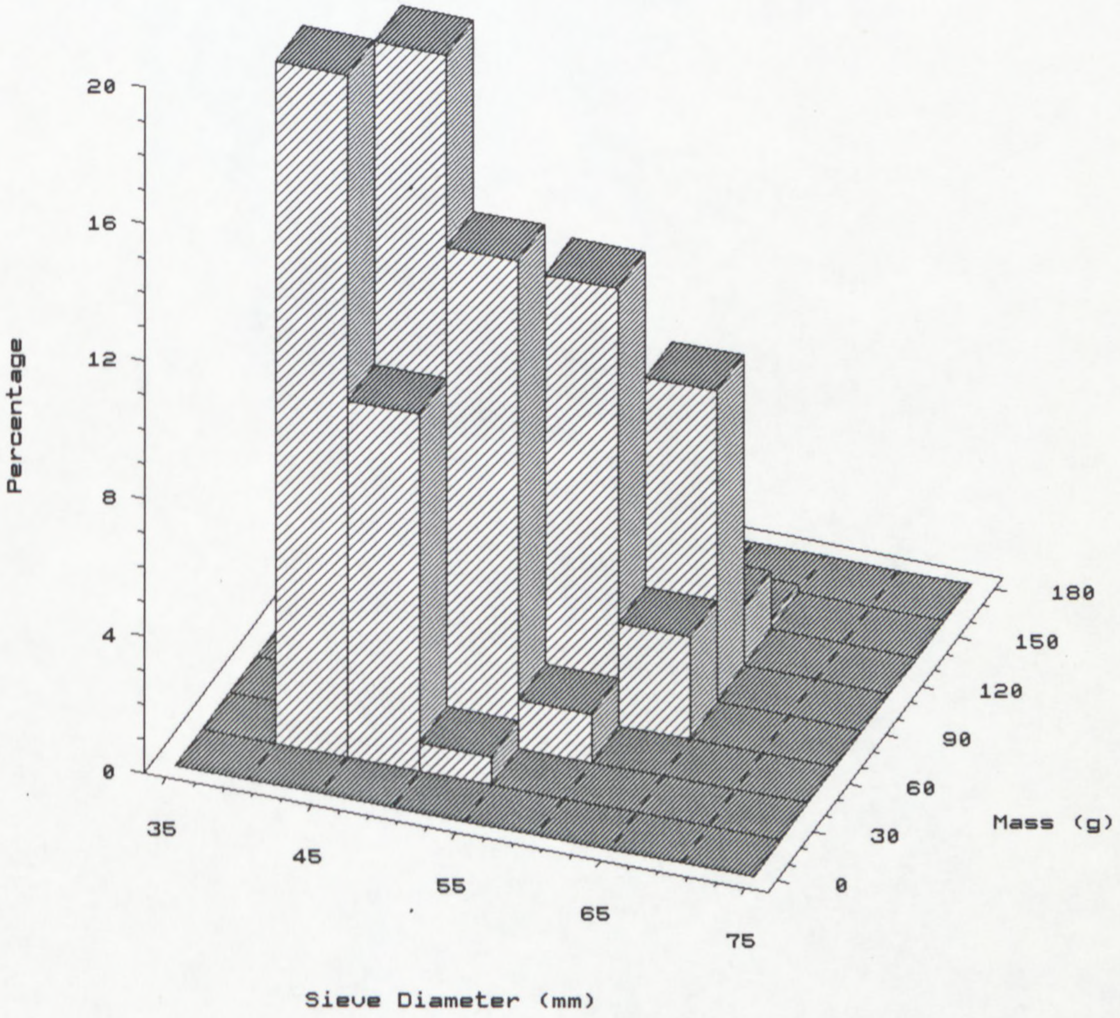

Table 3-1. Kolmogornov-Smirnov[35] Values For Peach Half Masses

File	Variety	Year	DN[36]	Significance[37]
PSRT89KDT	Kakamas	1989	.093228	.015390
PSRT90KDT	Kakamas	1990	.071381	.173211
PSRT90NDT	Neethling	1990	.059847	.048230
PSRT90ODT	Oom Sarel	1990	.054771	.088321
PSRT90WDT	Woltemade	1990	.060440	.033433

Figures 3-2 to 3-6 present the relative frequency[38] histograms of the mass distribution of peach halves for the four varieties studied. It is interesting to note that the lognormal distribution is scew towards a greater frequency of smaller peach halves with corresponding lighter masses. It follows that the quantity of smaller peach halves available for canning exceeds the number of larger units. Frequency distribution tables can be found in Appendix A-5, and provide further detail regarding average class masses of the differemt varieties.

3.2.3 **Variety**

Table 3-2 shows that the average masses of peach halves with the same diameter are significantly different between the four peach varieties investigated. Oom Sarel at 54 g had the lightest average mass while the Kakamas variety was found to be the heaviest at an average mass of 68 g; a difference of 14 g per peach half on average.

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[35] See Glossary Of Terms

[36] Overall Estimated Statistic

[37] Significant if >.01

[38] Expressed As A Percentage Of All Halves Measured

Fig. 3-2 Mass Distribution Of Kakamas Variety Peach Halves During 1988/89

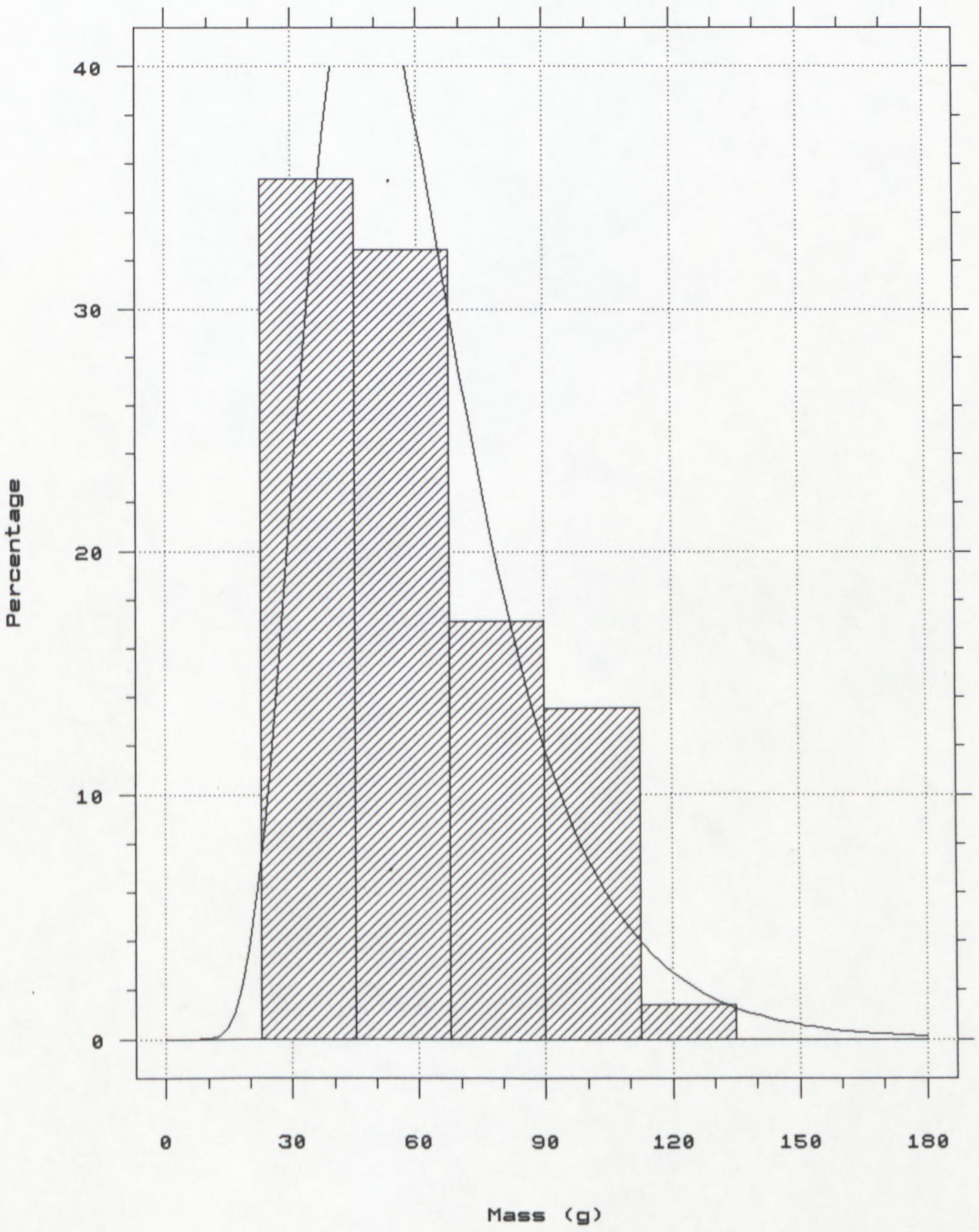

Fig. 3-3 Mass Distribution Of Kakamas

Variety Peach Halves During 1989/90

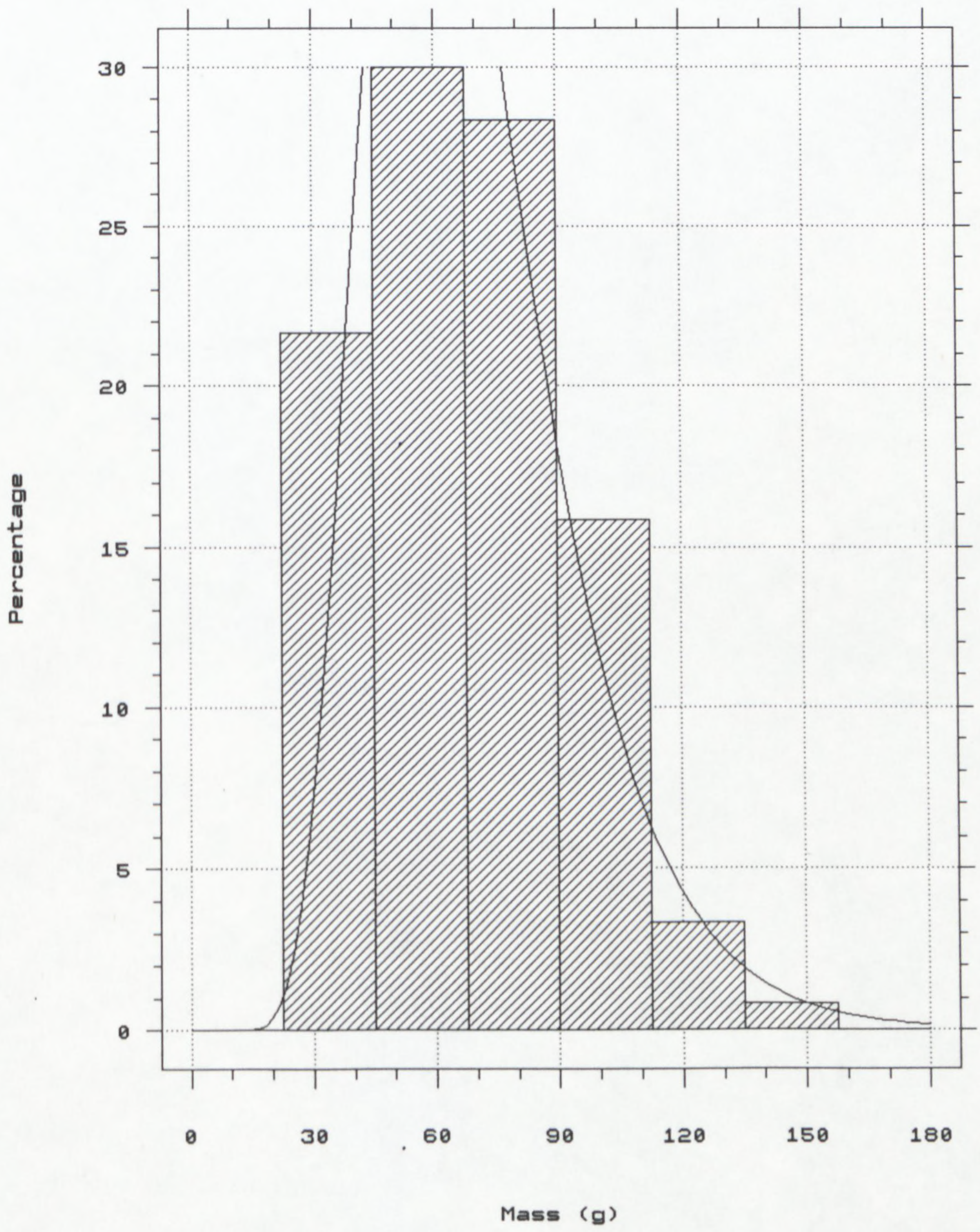

Fig. 3-4 Mass Distribution Of Oom Sarel

Variety Peach Halves During 1989/90

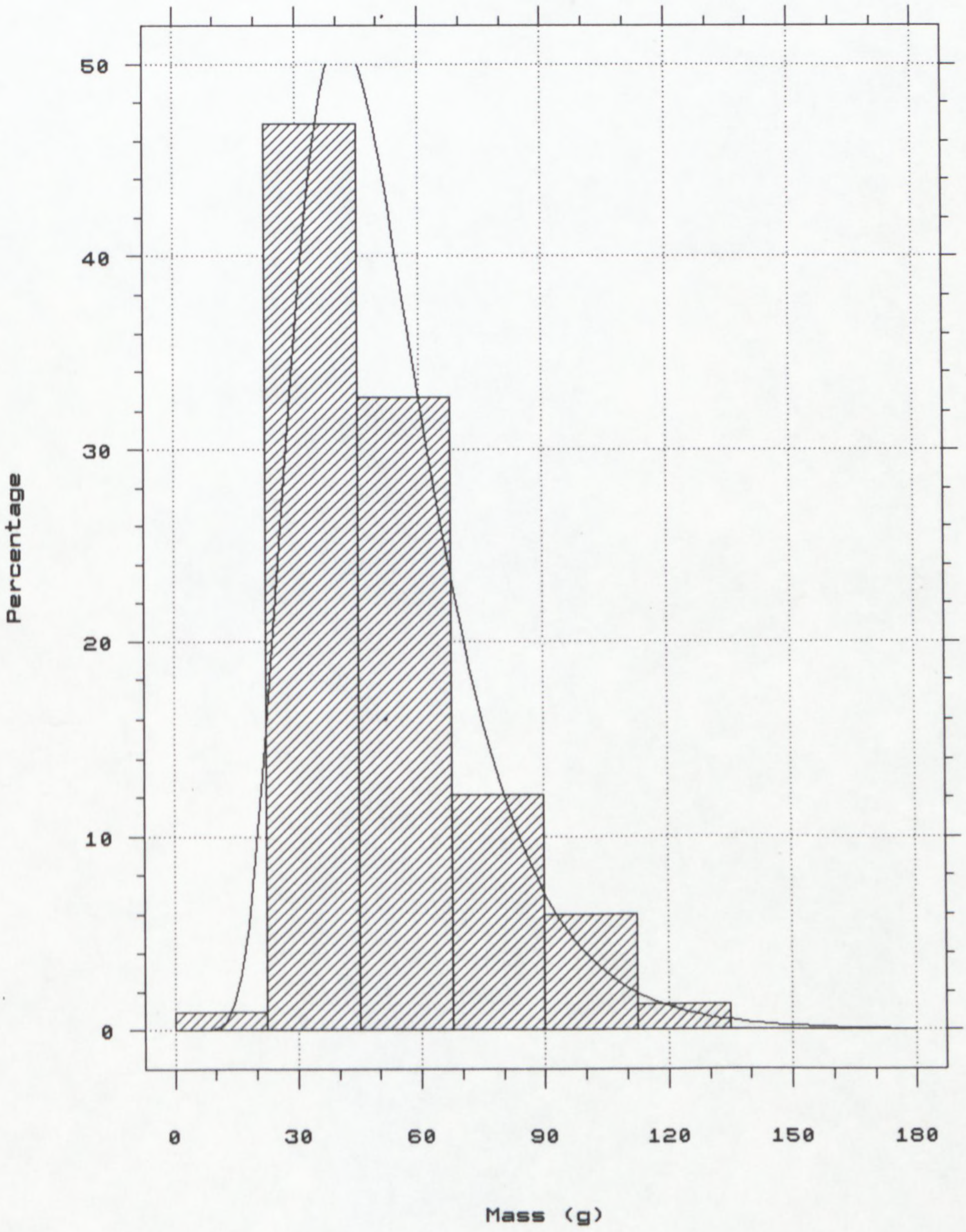

Fig. 3-5 Mass Distribution Of Neethling

Variety Peach Halves During 1989/90

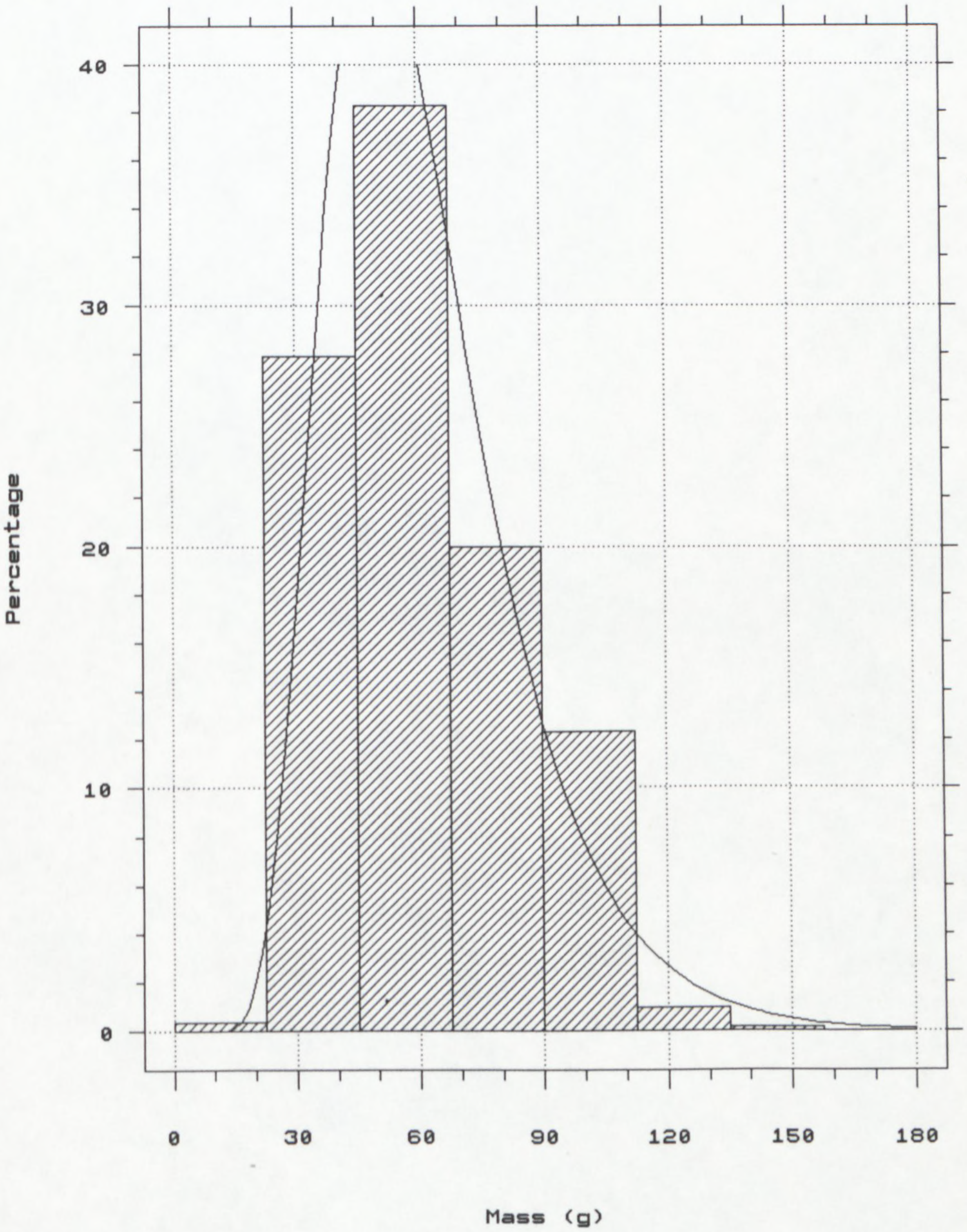

Fig. 3-6 Mass Distribution Of Woltemade

Variety Peach Halves During 1989/90

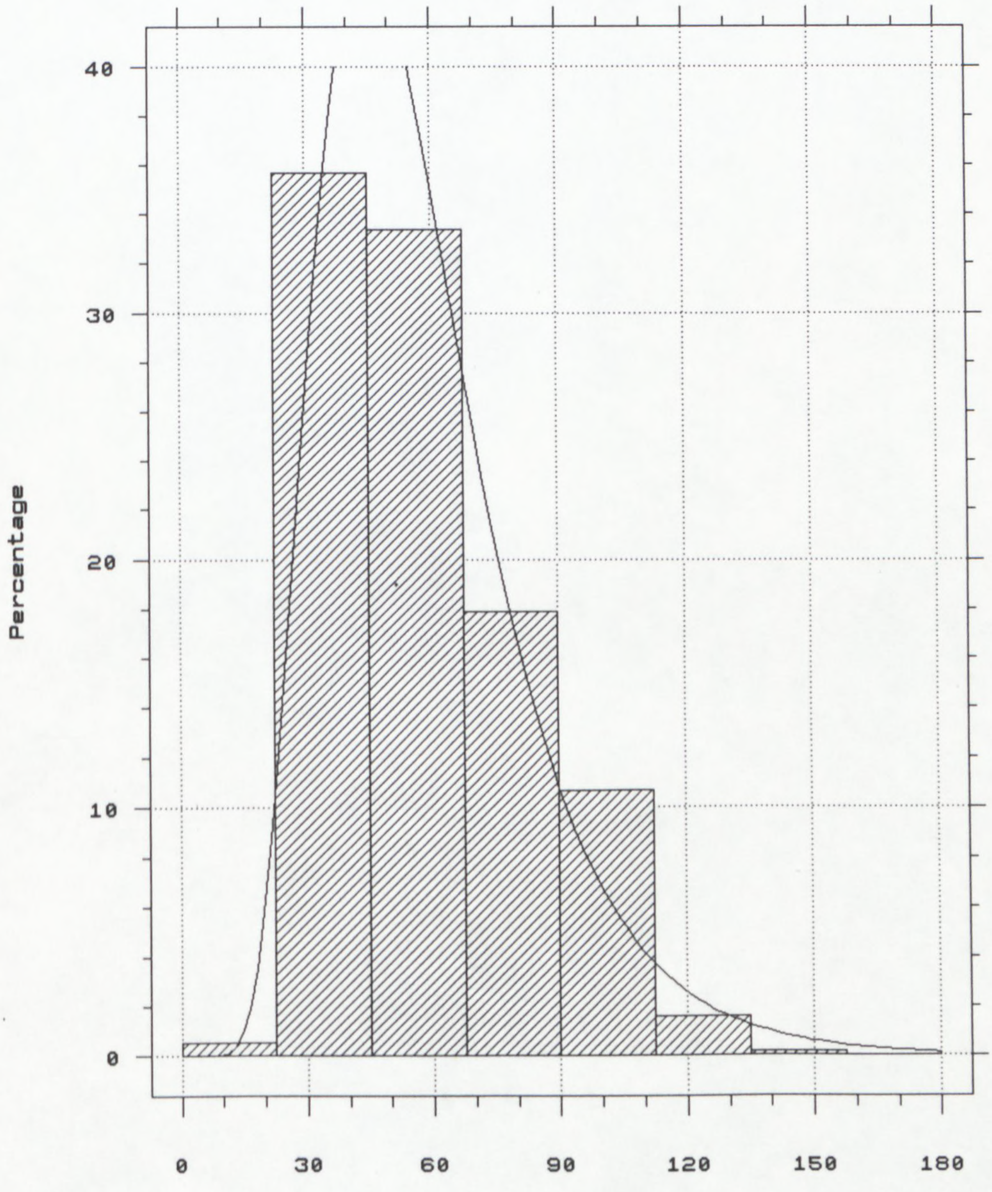

Table 3-2. Average Half Masses Of Four Peach Varieties

Level	Count	Average	Homogeneous Groups
Oom Sarel	480	54.193750	*
Woltemade	520	60.388462	*
Neethling	480	63.493750	*
Kakamas	240	68.412500	*

* Multiple Range Analysis For PSRTJ90.UNITWT by PSRTJ90.VARIETIES at 95 Percent Confidence Intervals (STC, 1988)

Means tables for different sieve diameters and varieties derived from the multiple ANOVA analyses provide further detail and are presented in Appendix A-7.

To illustrate the full meaning of the actual mass differences observed between peach halves of different varieties, Table 3-3 was prepared. The tabulated masses were estimated from the respective regression equations for the two nominal sieve diameters chosen. It was found that during the 1989/90 season, the mass of 40 mm diameter halves varied from 27 g for Kakamas to 34 g for Neethling; for 60 mm diameter halves the mass varied from 84 g for Kakamas to 87 g for the Oom Sarel varieties.

Table 3-3. Computed Peach Half Mass[39] For Different Peach Varieties At Two Diameters

					Diameters (mm)	
File	Variety	Year	Intercept	Slope	40	60
PSRT89MR	Mixed	1989	1.4701	.0475	29.12	75.33
PSRT90KR	Kakamas	1990	.9851	.0573	26.54	83.55
PSRT90NR	Neethling	1990	1.6766	.0461	33.85	85.17
PSRT90WR	Woltemade	1990	1.3577	.0518	30.86	86.97
PSRT90OR	Oom Sarel	1990	1.3877	.0514	31.28	87.41
PSRT89KR	Kakamas	1989	1.3308	.0525	30.92	88.37

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[39] $Y = \exp(a + bX)$; Y = Mass (g); X = Diameter (mm)

Peach varieties should be a major consideration in arranging size sorting sieve stacks.

3.2.4 **Seasons**

Data obtained on Kakamas peach halves for the 1989 and 1990 seasons indicate that the average peach half mass for the 1990 season was significantly higher at 68.42 g in comparison to the average mass of 64.17 g obtained during 1989 (Table 3-4).

Table 3-4. Comparing Kakamas Half Masses Over Two Seasons

Level	Count	Average	Homogeneous Groups
1989	240	64.170833	*
1990	240	68.412500	*

* Multiple Range Analysis For PSRTJ89.UNITWT by PSRTJ89.SEIVDIA at 95 Percent Confidence Intervals (STC, 1988)

As shown in Table 3-4, peach half masses change from one season to the next for the same diameter. Peach size is known to be influenced by ambient temperature, especially shortly after fruit-set and during the last few weeks before harvesting (Bergh, 1991).

3.2.5 **Relative Distribution**

Buyers' specifications for peach half masses could be adjusted to be between 28 g and 75 g (Table 4-10). For estimating purposes this portion of the peach crop was considered as having a normal distribution. The relative proportions of prepared peach halves falling within and outside these mass parameters can then be estimated using STSC (1988) techniques.

These results are summarised in Table 3-5 and detailed in Appendix A-5. It can be seen that during the 1990/91 peach crop most peach halves had masses varying between 25 g and 75 g. The relative proportions for this mass class varied between 68 % for Kakamas to 82 % for the Oom Sarel varieties. The proportion heavier than 75 g similarly varied from 13 % for Oom Sarel to 33 % in the case of Kakamas. The Kakamas variety is not expected to produce small peach halves suitable for canning.

Table 3-5. Relative Mass Distribution of Peach Halves

			Mass Distribution Classes		
File	Variety	Year	<25 g	25-75 g	>75 g
PSRF90OD	Oom Sarel	1990	4.81%	82.11%	13.08%
PSRF90WD	Woltemade	1990	2.68%	74.46%	22.86%
PSRF90ND	Neethling	1990	.96%	72.17%	26.92%
PSRF90KD	Kakamas	1990	.00%	67.50%	32.50%

Greater detail of the frequency distribution and a deeper insight into the actual distribution of peach half masses within the eight diameter classes sorted on a seven sieve stack can be found in the computed frequency distribution tables presented in Appendix A-5.

3.3 The Plant

3.3.1 Peach Pitters

The twist pitters as used in the plant gave significantly lighter average masses for the same peach half diameter as detailed in Table 3-6.

Table 3-6. Mean Masses Of Peach Halves Of Identical Diameter Obtained From Two Types Of Pitters

Pitter	Count	Average	Homogeneous Groups
Twist[40]	1000	59.456000	*
Knife[41]	720	62.298611	*

*Multiple Range Analysis For PSRTJ90.UNITWT By PSRTJ90.PITTERS At 95 Percent Confidence Intervals

3.3.2 **Regression Of Mass On Sieve Diameter**

The sieve stack forms the heart of the sorting operation and an understanding of the regression of peach half mass on sieve diameter is thus an imperative part to this study. The regression statistics are summarised in Table 3-7. These were all significant at $P_{.01}$ level. R^2-values obtained varied between 86.55 % and 90.78 %, indicating that mass variation was well described by differences in sieve diameter. The exponential model $y = \exp(a+bX)$ provided the best fit to the peach half mass data (STSC, 1988).

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[40] Atlas Pacific Twist Pitter

[41] Food Manufacturing Corporation Knife Pitter

Table 3-7. Summary Of Regression[42] Statistics For Four Varieties

File	Var[43]	Year	d.f	Intercept	Slope	R^2 %	F[44]	r[45]
PSRT89KR	K	1989	239	1.3308	.0525	89.6800	2068.4470	.9470
PSRT89MR	M	1989	279	1.4701	.0475	90.7800	2736.4260	.9528
PSRT90KR	K	1990	239	.9851	.0573	86.5500	1531.0460	.9303
PSRT90NR	N	1990	479	1.6766	.0461	88.7100	3755.7250	.9419
PSRT90OR	O	1990	479	1.3877	.0514	88.9800	3861.0490	.9433
PSRT90WR	W	1990	519	1.3577	.0518	89.7500	4536.4790	.9474

The detailed regression statistics are listed in Appendix A-8. The regression constants provide important information regarding the association of peach half mass and sieve diameter. These values were used to compute the sieve diameters and stack arrangement according to buyers' orders during the subsequent development of the computer-aided system.

To explain the exponential effects of mass change with increasing half diameter, the masses for peach halves of 40 mm and 60 mm diameters were calculated from the respective regression equations. The mass of a half was divided by its diameter to obtain the mass per millimetre of its diameter. These values are tabulated in Table 3-8. The estimated peach half masses varied from 0.7 g per mm for a half at 40 mm diameter to 1.5 g for a peach half at 60 mm diameter.

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[42] $Y = \exp(a + bX)$

[43] K=Kakamas; M=Mixed Varieties; N=Neethling; O=Oom Sarel; W=Woltemade

[44] Significant At $P_{.01}$

[45] Significant At $P_{.01}$

Table 3-8. Masses Per mm Of Peach Half Diameter At Two Sieve Sizes

					Sieve Diameter (mm)	
File	Variety	Year	Intercept	Slope	40	60
PSRT89MR	Mixed	1989	1.4701	.0475	.73	1.26
PSRT90KR	Kakamas	1990	.9851	.0573	.66	1.39
PSRT90NR	Neethling	1990	1.6766	.0461	.85	1.42
PSRT90WR	Woltemade	1990	1.3577	.0518	.77	1.45
PSRT90OR	Oom Sarel	1990	1.3877	.0514	.78	1.46
PSRT89KR	Kakamas	1989	1.3308	.0525	.77	1.47

The non-linearity of the mass to diameter relationship has to be considered an important factor when assembling the sieve stack. Appendix A-8 presents the detailed statistical results for the regression analyses of peach half mass on sieve diameter for the four varieties studied.

4 The Computer-aided System

4.1 Planning A System

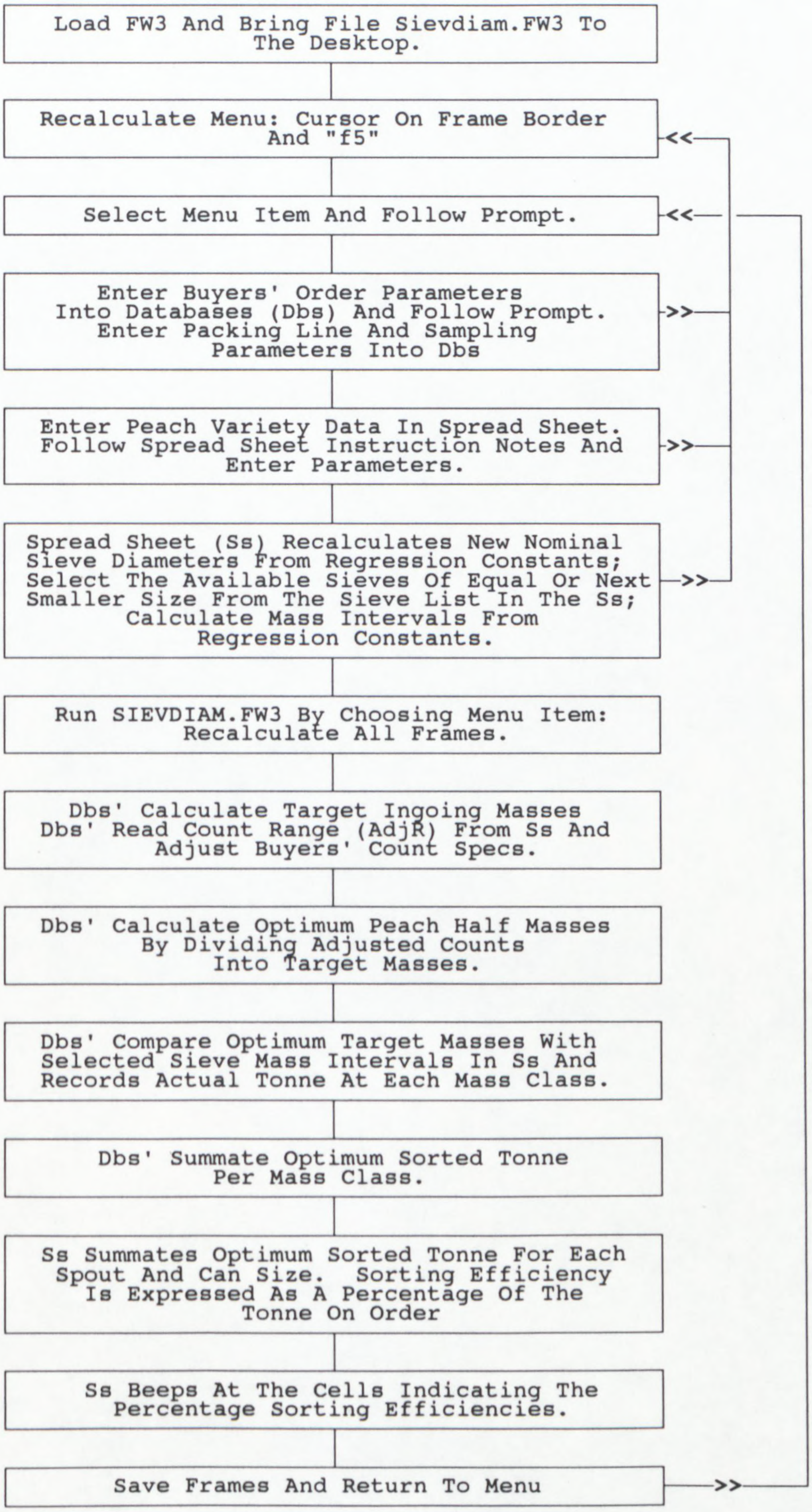
In the first instance, the computer-aided system should be able to select sieve diameters more efficiently than an experienced person is able to achieve manually. Furthermore, it has to include as variables constraints determined by buyers specifications, mandatory requirements, plant restrictions, the influences of peach characteristics and the skills of those operating it. It seems impossible to take accurate decisions based on detailed inputs from sales data together with the influences of fruit character and the need for the optimum balancing of materials flow in the factory, without modern computer aids. This is simply true because of the great number of calculations needed in a short space of time.

Optimising is one of the objectives to meet and linear programming (LP) with all its usefulness comes to mind. However, with changing target parameters and with undefined and varying peach attributes, this approach seems hypothetical. It also requires mathematical skills from the user which are not always available. A selection procedure using the high computation speed of modern computers appeared more appropriate. Also, applying user-friendly commercially available computer application software, allows practical and relevant technology transfer to this very important export industry.

A process of computer-aided selection was opted for. The RAM resident applications program Framework III with its FRED programming capability and interlinking database and spreadsheet facilities was chosen.

Consequently buyers' data were stored in databases, one for each can size, which in turn were inter-linked to a single spreadsheet for organising and controlling the computations. This configuration formed the basis of the computation system. FRED programs to compute and select the sieve stack diameter series most suited to the combined effects of the peach characteristics and a specific set of buyers' orders were written. The FRED programs are listed in Appendixes B, C and D. To avoid duplication in print-outs the FRED program for only one database was listed in Appendix C. The database for the A2½-can size, file SPECA2.FW3 was chosen. Details regarding buyers' specifications for the A2½-can are given in Appendix C. The FRED routine for the 1M and A10 can sizes are only available on the 1.2Mb floppy disks enclosed in the sub-frames named SPEC1M and SPECA10. The FRED programs handling the menu routine are listed in Appendix B while Appendix D lists the FRED programs for the spreadsheet computations. The program flow diagram is presented in section 4.2.

4.2 **Program Flow Diagram**



4.3 **Operating The Program**

This is a menu driven program and the operator should have the new input data at hand if updating is to be done, or accept the default. The objective is to obtain the highest percentage sorting efficiency (SE) for a particular can size, or of course, for a general improved overall SE or as may be otherwise required. There is also an option for recalculation which must be performed after each and every modification to the data in any of the databases or in the spreadsheet.

To execute the program select the file SIEVDIAM.FW3 from the disk in accordance with the usual Framework III procedures. Once the frame is on the desktop, open it and Table 4-1 with both Choices and SEL90A sub-frames will be displayed within the frame. Verify that the cursor is on the frame border and press "f5" to recalculate the menu. Only the "Choices" menu in zoomed view will now appear. By moving the "cursor" keys up or down select the menu item required and press the "return" key to execute the option. Alternatively menu items may also be selected by pressing the first letter of the item eg "R" for recalculate. The menu items are descriptive.

Table 4-1. Menu Of Program To Calculate Sieve Diameters

Choices
    1Mcan Edit
    A2.5can Edit
    No10can Edit
    Input Sieve Data
    Current Sieve Diameters
    Recalculate All And Quit
    Quit
SEL90A
    SPEC1M
    SPECA2
    SPECA10
    SIV
    DATA

Example: To update buyers' specifications merely select the can size demanded in the "Choices" menu and press "E" at the prompt. Select the database cell in accordance with usual Framework III procedures and enter data. Once data entry has been completed save the frame. If data entry to more than one frame (database or spreadsheet) is required, press "f5" between each operation to recalculate the menu. The item "Recalculate All And Quit", recalculates all the databases and spreadsheet twice in succession because they are linked and interdependent. A few minutes are taken. The item "Current Sieve Diameters" merely displays the sieve diameters in use.

4.4 **Databases**

4.4.1 **Main Functions**

Databases were selected because of their usefulness in storing data required for repetitive calculations. It is necessary to establish a database for each can size, because nominal masses and net masses are constant for a particular can size and forms the basis for the sieve diameter computation and selection system. Thus a database was developed for each of the three important can sizes under consideration.

Should it be required to include new can sizes, another database must be created. The database programs may be copied directly to the newly created database. However, fairly extensive modifications to the FRED programs are required to rename the new region references in the linked database spreadsheet system and to adjust for technical differences.

4.4.2 **Buyers' Orders**

Buyers' orders as detailed in Table 4-2, are always uniform in their statements, specifying can size, grade, the kind of covering liquid and its cut-out concentration. The maximum and minimum number of peach halves per can, commonly known as "count" specifications, are also given. The sum of the masses of the individual peach halves making up the count shall conform to a minimum ingoing mass which is representative of the drained mass stated on the label. In addition, the net mass is also declared on the label. These label declarations are mandatory statements intended to protect consumers against fraud and to promote fair trading. To complete the order, the quantity asked for is stipulated and is expressed in cartons, each containing 24 x A2½-cans.

Table 4-2. Detailed Buyers' Orders For A2½-Cans[46] at 825g NtWt[47]

Market	Grade	CovrLiqd[48]	Brix	MinCnt[49]	MaxCnt[50]	Cartns[51]
Austria	stndrd	syrup	17-19	5	18	15360
Austria	substd	syrup	17-19	5	18	22272
Germany	choice	syrup	17-19	14	18	1536
Germany	choice	syrup	17-19	12	14	17000
Libby	fancy	syrup	17-19	8	12	4654
PettyWood	fancy	syrup	17-19	5	6	1162
Swiss	choice	syrup	17-19	10	12	5720
Swiss	choice	syrup	17-19	8	10	6912
Taiwan	choice	syrup	18-20	7	8	17000
Taiwan	choice	syrup	18-20	8	10	6912

4.4.3 **Target Ingoing Mass**

The influence of natural variation due to fruit mass, can size and other packing line characteristics has to be considered. This variation is adequately represented by the standard deviation (s) around the mean for a particular line set-up. The importance of close control over the standard deviation of a line for achieving target mass and cost savings was explained (Van der Merwe, 1987).

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[46] Oosthuizen (1989)
[47] Net Mass
[48] Covering liquid
[49] Minimum count
[50] Maximum count
[51] Cartons each with 48 cans

It remains essential (Van der Merwe, 1987) to measure the standard deviation regularly, especially if modifications to unit operations affecting peach half masses and packing efficiency were made. New values should be entered into the respective databases in the same way as buyers' orders would be modified.

Tolerances associated with ingoing mass requirements are discussed in the detailed description of the current EEC mass system summarised in Appendix A-2. The application of this system was previously discussed in great detail by Van der Merwe (1987).

In order to be 95 % confident that the production conforms to the mandatory requirements the largest value of Rule 4 and Rule 5 shall be used as the target ingoing mass (DrndWt) for filling purposes. Table 4-3 provides the details contained in the database for A2½-cans. Although the nominal mass (NomWt) in this example is constant and typical of most orders for a particular can size, it may vary with changes in the covering liquid requirements. It is assumed that the standard deviations for all A2½-lines in use are the same, hence the constant DrndWt values.

Table 4-3. Target Ingoing Mass

Market	NomWt[52]	sw[53]	n[54]	TNE[55]	Rule4[56]	Rule5[57]	DrndWt[58]
Austria	500	14	8	15	510	483	510
Austria	500	14	8	15	510	483	510
Germany	500	14	8	15	510	483	510
Germany	500	14	8	15	510	483	510
Libby	500	14	8	15	510	483	510
PettyWood	500	14	8	15	510	483	510
Swiss	500	14	8	15	510	483	510
Swiss	500	14	8	15	510	483	510
Taiwan	500	14	8	15	510	483	510
Taiwan	500	14	8	15	510	483	510

The calculated target mass (DrndWt) is used for determining the different optimum peach half masses corresponding to the respective count values specified. The DrndWt is merely divided by the count.

4.4.4 **Count Analysis**

The count specified for a particular can size varies significantly between the different buyers as shown in Table 4-4.

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[52] Nominal Weight
[53] Standard Deviation For Line Ingoing Masses
[54] Number Of Units In Sample
[55] Tolerable Negative Error
[56] Appendix A; EEC Minimum Average Drained Mass Requirement
[57] Appendix A; EEC Minimum Single Unit Mass Requirement
[58] Target Ingoing Mass For Filling

Table 4-4. Counts For A2½-Cans

Market	Minimum Count	Maximum Count
Austria	5	18
Austria	5	18
Germany	14	18
Germany	12	14
Libby	8	12
PettyWood	5	6
Swiss	10	12
Swiss	8	10
Taiwan	7	8
Taiwan	8	10

The coefficient of variation (CV) (Snedecor & Cochran, 1987) describes the degree of variation in the population. The CV (CntCV) for the different counts specified varied from as low as 13 % to as much as 109 % in the case of A2½-can sizes (Table 4-5). In order to bring the populations closer together the count specifications were adjusted by the database program. A Range correcting factor (Rcor) was used for calculating the count correction factor (CntCorr). This value of Rcor may be changed up or down by changing the AdjR value in the linked spreadsheet during editing.

Because the target drained mass for a particular can size is usually the same, the net effect of a more homogeneous specification permits the selection of peach halves of more uniform masses. This rearrangement brings the count requirements closer to the reality of production capabilities, uniformity objectives and attainable sorting sieve stack arrangements. The buyers' count specifications as presented in Table 4-5, were subsequently adjusted by the database programs to the corresponding CntCorr values of a more homogeneous nature.

Table 4-5. Count Analysis Of A2½-Cans

Market	CntAv[59]	CntR[60]	CntCV[61]	RCor[62]	CntCorr[63]
Austria	12	13	109	9	4
Austria	12	13	109	9	4
Germany	16	4	25	0	0
Germany	13	2	16	0	0
Libby	10	4	40	0	0
PettyWood	6	1	17	0	0
Swiss	11	2	19	0	0
Swiss	9	2	23	0	0
Taiwan	8	1	13	0	0
Taiwan	9	2	23	0	0

The count correcting factors may be varied according to the size of the CV by modifying the AdjR value in the linked spreadsheet while in the edit mode and in accordance with the nature of trends in buyers' specifications. This section of the databases computes the preferred CV. Table 4-6 provides a typical example of specified counts in comparison with the adjusted counts as used in forward computations.

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[59] Count Average
[60] Count Range
[61] Count Coefficient Of Variation
[62] Range Corrector
[63] Count Corrector; Reads From Spreadsheet Input

Table 4-6. Adjusted Count Values For A2½-Cans

Market	CorMinCnt[64]	CorMaxCnt[65]	CorCntAv[66]	CorCntR[67]	CorCntCV[68]
Austria	13	14	14	1	8
Austria	13	14	14	1	8
Germany	14	18	16	4	25
Germany	12	14	13	2	16
Libby	8	12	10	4	40
PettyWood	5	6	6	1	17
Swiss	10	12	11	2	19
Swiss	8	10	9	2	23
Taiwan	7	8	8	1	13
Taiwan	8	10	9	2	23

4.4.5 **Optimum Mass Determination**

Buyers do not specify a constant count, but rather maximum and minimum values. This means that when the specified ingoing mass (drained mass) is divided by the counts specified for a particular can size, optimum peach half masses for each of the counts specified, are determined.

These masses are calculated in this section of the database under the respective heading of Wt 1, Wt 2, ... Wt 6. For example, one set of specifications could have respective ideal half masses of 36 g, 34 g, 31 g, 30 g, and 28 g for the A2½-can size with a target mass of 510 g as shown in Table 4-7. These values were used by the next database section as inputs to obtain the tonne of halves expected to be exiting each spout.

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[64] Corrected Minimum Count
[65] Corrected Maximum Count
[66] Corrected Count Average
[67] Corrected Count Range
[68] Corrected Count Coefficient Of Variation

Table 4-7. Optimum Masses[69] Required

Market	Wt1	Wt2	Wt 3	Wt4	Wt5	Wt6
Austria	39	36	.	.	.	.
Austria	39	36	.	.	.	.
Germany	36	34	31	30	28	.
Germany	42	39	36	.	.	.
Libby	63	56	51	46	42	.
PettyWood	102	85	.	.	.	.
Swiss	51	46	42	.	.	.
Swiss	63	56	51	.	.	.
Taiwan	72	63	.	.	.	.
Taiwan	63	56	51	.	.	.

4.4.6 **Spout Tonne**

This section of the database calculates the tonne (t) of peach halves expected to be selected according to the mass classes specified in the linked spreadsheet. The different W1, W2, ... W6 values are used by the next database section as inputs to obtain the tonne of halves expected to be exiting each spout. For example, the system compares each of the masses in Table 4-7 with that of the mass class in the spreadsheet. If the half mass is heavier than that for a mass class i.e. the peach half will not fall through the next sieve hole, it computes and enters the tonne on order for that count mass combination. This routine is repeated for each order. To illustrate from Table 4-8, 72 g in the Wt1 column was found to be heavier than class No2 (spout No2) and the corresponding quantity of 104 t was entered in the No2 column of Table 4-8. In this way Table 4-8 forms a matrix of tonne quantities corresponding to optimum masses for each order and at the same time indicates which spout will deliver the corresponding amount. This table shows that spout No6 will deliver halves of selected optimum mass against six different orders, while in comparison spout No2 is expected to output 104 t and spout

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[69] Wt1, Wt2, ... Wt6

No3, also 104 t against a Taiwanese order of 17000 cartons (Table 4-2). Thus, to obtain a near optimum ingoing mass of 510 g for the A2½-can size, 7 halves per can should be packed from spout No2 and 8 halves per can from spout No3 respectively, to complete the order.

Table 4-8. Tonne Of Sorted Peach Halves Exiting From Different Spouts According To Buyers Orders

Market	No1	No2	No3	No4	No5	No6	No7	No8	Opt	Exd	TonOpt	TonOvr	Tonne
Austr	.	.	.	.	.	188	.	.	2	1	94	94	188
Austr	.	.	.	.	.	272	.	.	2	1	136	136	273
German	.	.	.	.	.	9	9	.	5	2	7	11	19
German	.	.	.	.	.	208	.	.	3	1	69	138	208
Libby	.	.	14	14	14	14	.	.	5	4	45	11	57
PetWod	14	.	.	.	.	.	.	.	2	1	7	7	14
Swiss	.	.	.	23	23	23	.	.	3	3	70	0	70
Swiss	.	.	42	42	.	.	.	.	3	2	56	28	85
Taiwan	.	104	104	.	.	.	.	.	2	2	208	0	208
Taiwan	.	.	42	42	.	.	.	.	3	2	56	28	85

This next column of this section in Table 4-8 calculates and provides the operator with quantitative data on how effective the sieve stack selection was. The number of mass options are specified in the "Opt" column and the mass options for which suitable sieve diameters were available in the current sieve arrangement (Table 4-12), are shown in the "Exd" column. The next two columns provide the tonne optimally sorted (TonOpt) and the tonne that were not optimally sorted (TonOvr). The last column (Tonne) provides the tonne ordered by the specific buyer. By comparing these figures an estimate is made of the efficiency of any particular sieve stack arrangement.

A sorting bias towards smaller or larger can sizes can be readily monitored and adjusted. Adjustments are made by changing maximum and/or minimum peach half masses in the spread sheet. The tonne quantities for each can size are summated in the spreadsheet, Table 4-13 and expressed as the percentage of the quantity on order. This ratio describes the sorting efficiency (SE) of any particular sieve stack set-up.

4.5 **Spreadsheet**

4.5.1 **Data Entry**

When the spreadsheet is selected from the menu it zooms to display the section shown in Table 4-9. These directives guide data entry into the spreadsheet for subsequent computations.

Table 4-9. Data Entry Notes

ENTRY: 1. Set AdjR For Comparable AvgCV's
2. Heaviest And Lightest Masses
3. Regression Constants & Variety
4. Quantity Of Sieves

Entry 1, "AdjR" is needed to recalculate the maximum feasible Range permitted for counts specified by the buyers. If the difference between maximum and minimum count specified by buyers is too large the specification actually requires peach half masses not available in the population of prepared halves and can be considered unrealistic and is to be adjusted. The Range (R) is used to calculate the CV values for the different databases and the average values are displayed in the spreadsheet. This entry is only required when a new specification differs widely from those under consideration.

Entry 2, "Heaviest And Lightest Masses" must be stipulated in accordance with the minimum, maximum and average masses specified by the buyers and tabulated in the spreadsheet Table 4-10. These inputs are demanded to compute the largest and smallest screen diameters required for the sieve stack arrangement and then the screen interval.

Entry 3, "Regression Constants & Variety" should be adjusted as varieties change with the progression of the fruit season, but also when modifications to the pitting operation is made eg. a switch to a new type of pitter or to a different type of mechanical component of the pitting or sorting operations. Also important to consider are seasonal and variety changes which influence fruit size and mass relationships. The regression constants will require modification to ensure proper size sorting of the four varieties investigated. However, with mixtures of unknown character, regression constants should be estimated or ideally computed from new mass and diameter data.

Entry 4, "Quantity Of Sieves" may be modified according to the mass interval required. This value may be reduced when the maximum and minimum mass requirements are brought closer together for smaller Ranges in specifications. This value is not often changed and seven sieves describe the sieve stack well.

The program finds the lightest and heaviest optimum masses from the linked databases and displays the values in the cells corresponding to the rows marked "Lightest" and "Heaviest" of the columns labelled "1M", "A2½" and A10 of the spreadsheet (Table 4-10). Two of these values, or two others are chosen and entered into the cells "Lightest =" and "Heaviest =" (Table 4-10).

The count Ranges may be adjusted to achieve more consistent CV values between the counts specified by different buyers. This can be done by entering different Range values into the respective cells corresponding to a particular can size in row "AdjR" (Table 4-10). The Range of the maximum and minimum count specifications contained in the different linked databases will be modified accordingly to the values entered in these cells. This completes the entries required for subsequent computation.

Table 4-10 provides an example of a typical set of data for Neethling peach halves as entered into the spreadsheet.

Table 4-10. Typical Spreadsheet Data

			1M	**A2½**	**A10**
Y =	exp(a+bX)				
a =	1.6766				
b =	.0461				
Variety =	Neethling				
MinDia =	35				
MaxDia =	57				
Sieves =	7				
AvrgWt =	48				
			t	t	t
Lightest =	28 g		28	30	23
Heaviest =	75 g		64	102	67
AvSpecWt =	47 g		39	52	49
SieveCV =	98	AvgCV =	18	10	-4
WtIntervl =	8		6	12	8
		AdjR =	2	4	10
		Max R =	6	13	56
		Min R =	1	1	5

4.5.2 **Sieve Stack**

The available sieve plates were manufactured with hole diameters specified in inches and sixteenths of an inch in accordance with the imperial system. For cost saving reasons these were remarked to the calculated metric equivalent. Table 4-11 provides detail of the sieve plates available for selection.

Table 4-11. Sieve Plates Available

Siev	Nominal Diameter		Siev	Nominal Diameter	
mark	mm[70]	in[71]	mark	mm[72]	in[73]
28	28.58	$^{1}{}_{2/16}$	50	50.80	$^{2}{}_{0/16}$
	30.16	$^{1}{}_{3/16}$	52	52.39	$^{2}{}_{1/16}$
32	31.75	$^{1}{}_{4/16}$	54	53.98	$^{2}{}_{2/16}$
33	33.34	$^{1}{}_{5/16}$		55.56	$^{2}{}_{3/16}$
35	34.93	$^{1}{}_{6/16}$	57	57.15	$^{2}{}_{4/16}$
36	36.51	$^{1}{}_{7/16}$	58	58.74	$^{2}{}_{5/16}$
38	38.10	$^{1}{}_{8/16}$	60	60.33	$^{2}{}_{6/16}$
39	39.69	$^{1}{}_{9/16}$		61.91	$^{2}{}_{7/16}$
41	41.28	$^{1}{}_{10/16}$	63	63.50	$^{2}{}_{8/16}$
	42.86	$^{1}{}_{11/16}$	67	66.68	$^{2}{}_{10/16}$
44	44.45	$^{1}{}_{12/16}$		69.85	$^{2}{}_{12/16}$
	46.04	$^{1}{}_{13/16}$	74	73.03	$^{2}{}_{14/16}$
47	47.63	$^{1}{}_{14/16}$			
	49.21	$^{1}{}_{15/16}$			

Sieve hole diameters are calculated from the regression equation and displayed in the "mark" column. The program searches the sieve plate list (Table 4-11) and selects the diameter specified if available, else the next one smaller than specified is selected. The actual sieve diameter selected from the table of available sieves is displayed in column "mm" of Table 4-12.

Mass classes are then computed by substituting actual sieve diameters into the active regression equation. The computed mass classes are displayed in the section "Derived Values" of Table 4-12. These mass classes provide the input to the various databases when spout tonne values are computed (Section 4.4.6).

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[70] Metric
[71] Imperial
[72] Metric
[73] Imperial

Table 4-12. Typical Sieve Stack With Estimated Mass Classes

Selected Sieve Diameter		Derived Values				
mark	mm	Wt Classes g			AvrgWt g	Spout #
35	34.93	up	to	26		8
41	39.69	26	to	33	30	7
45	44.45	33	to	41	37	6
49	47.63	41	to	48	45	5
52	50.80	48	to	55	52	4
55	53.98	55	to	64	60	3
57	55.56	64	to	69	67	2
		69	and	larger		1

4.5.3 **Spout Outputs**

The mass interval based on the number of sieves in use is then calculated. Although the sieve stack can take a maximum of seven sieves, fewer may be used from time to time to suit the requirements. The number of sieves should be entered into the spreadsheet as demanded.

The last section of the spreadsheet summates the output of each spout for each of the can sizes packed. The output quantities optimally sorted for each can size is expressed as a percentage of that on order. These ratios indicate the sorting efficiency achieved for each can size, as well as that for the total operation.

For a particular can size the tonne peach halves optimally sorted in the assembled sieve stack were expressed as a percentage of that on order. This was termed Sorting Efficiency (SE). Table 4-13 shows that a 86 % SE was obtained for the 1206 t ordered for the A2½-can size, while an overall SE of 86 % was obtained for the total pack of 2291 t on order.

Table 4-13. Detail Of Tonne Sorted

Spout #	1M t	A2½ t	A10 t	Totals t
8	0	0	20	20
7	266	18	70	354
6	230	564	20	814
5	24	564	88	676
4	47	147	166	360
3	23	188	106	317
2	0	0	15	15
1	0	118	0	118
OptSort =	561	1036	365	1962
Requird =	596	1206	489	2291
% SE =	**94.15**	**85.91**	**74.63**	**85.64**

4.6 System Evaluation

4.6.1 System Efficiencies

The computer-aided system proved to be more efficient in specifying sieve diameters in a stack arrangement. Tables 4-14 compares the SE value of 86 % obtained with the computer-aided system sorting the Neethling variety to the SE of 72 % (Table 4-15) in a manually arranged sieve stack with regression constants not used for sieve diameter determination. This manually selected sieve stack was used for different varieties for most of the 1988/89 and 1989/90 seasons (Swart, 1991).

4.6.2 **Computer-aided Sieve Stack**

Table 4-14. Computer-aided Sorting Sieve Arrangement

Select Sieve Diam		Derived Values		
mark	mm	Wt Classes g	AvrgWt g	Spout #
35	34.93	up to 26		8
41	39.69	26 to 33	30	7
45	44.45	33 to 41	37	6
49	47.63	41 to 48	45	5
52	50.80	48 to 55	52	4
55	53.98	55 to 64	60	3
57	55.56	64 to 69	67	2
		69 and larger		1

Y =	exp(a+bX)	Spout #	1M	A2½	A10	Totals
a =	1.6766		t	t	t	t
b =	.0461	8	0	0	20	20
Variety=	Neethling	7	266	18	70	354
		6	230	564	20	814
MinDia =	35	5	24	564	88	676
MaxDia =	57	4	47	147	166	360
		3	23	188	106	317
Sieves =	7	2	0	0	15	15
		1	0	118	0	118
AvrgWt =	48	OptSort =	561	1036	365	1962
		Requird =	596	1206	489	2291
		% SE =	**94.15**	**85.91**	**74.63**	**85.64**

4.6.3 **Manually Arranged Sieve Stack**

Table 4-15. Manual Sorting Sieve Arrangement

Select Sieve Diam		Derived Values				
mark	mm					
		Wt Classes			AvrgWt	Spout
		g			g	#
	39.69	up	to	26		8
44	42.86	26	to	31	29	7
47	46.04	31	to	37	34	6
50	49.21	37	to	44	41	5
54	53.98	44	to	59	52	4
58	57.15	59	to	70	65	3
63	61.91	70	to	93	82	2
		93	and	larger		1
Y =	exp(a+bX)	Spout #	1M	A2½	A10	Totals
a =			t	t	t	t
b =		8	0	0	20	20
Variety=	Peaches[74]	7	45	18	70	133
		6	451	564	0	1015
MinDia =	40	5	24	564	20	608
MaxDia =	58	4	47	175	346	568
		3	23	188	30	241
Sieves =	7	2	0	111	0	111
		1	0	7	0	7
AvrgWt =	50	OptSort =	400	1015	243	1658
		Requird =	596	1206	489	2291
		% SE =	**67.13**	**84.16**	**49.69**	**72.37**

5 **Discussion**

The canning peach industry processed 87 167 t clingstone peaches during 1989/90 season (Canning Fruit Board, 1990) as opposed to the estimated 15 000 t sold on the fresh fruit market (Canning Fruit Board, 1991) and remains a major outlet to peach growers. Canned

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[74] Variety Characteristics Not Considered

peaches realised a steady increase in foreign exchange earnings currently exceeding R95 million per year (Canning Fruit Board, 1991). Between 74 % and 98 % of all canned peaches produced in the RSA since 1985 was sold abroad (Canning Fruit Board, 1991). As a result, foreign buyers' specifications dominate the standards to which canned peaches are produced in the RSA. In reality canners have to conform to both national and international statutory standards, but even more apt, they have to have tight control over manufacturing costs to meet price competition.

Canned fruit exported to the European Economic Countries require a statement of net mass, as well as a statement of drained mass on the label. The net mass is the sum of the mass of fruit packed (ingoing mass) and the mass of the covering liquid added. The ingoing mass of a can of peach halves is the sum total of the individual masses of each half contained in that can. The variation in ingoing masses is a direct result of differences between the mass of individual halves. This variation in mass between the individual peach halves influences the standard deviation (Van der Merwe, 1987). It also follows that the method used to sort halves into mass classes will have a major influence on the standard deviation of the average class mass. If it were possible to select halves with identical masses the contribution towards the standard deviation would be zero. Target ingoing masses will resultantly tend lower, with expected corresponding savings. This is so because the influence of the standard deviation in the target mass estimation is diminished. When the filling operation is characterised by a large standard deviation value of say 10.0 g and a small standard deviation of 0.5 g respectively, for two different powder filling lines, it is important to note that the calculated target masses to ensure 95 % confidence limits are quite different at 506 g and 500 g respectively for a declared nominal mass of 500 g and a sample size of 10 units (Van der Merwe, 1987). Target masses have to be calculated for each line and of course, recalculated when product attributes related to density, shape, size and other geometric properties change.

Checkweighers (Hi-Speed Check Weigher Co., 1983) are designed to determine the mass of filled cans. When applied to peach half canning it could be employed to check net masses. However, it cannot control the mass variation between individual peach halves and if used to control ingoing masses, only the group masses are measured.

No additional advantages are thus achieved. The only way to reduce the fluctuation of ingoing masses would be to reduce the mass differences between individual peach halves as expressed by the standard deviation (Table 1-2 and 1-3). This in turn can only be attained through an improved method of sorting peach halves into masses which when multiplied by the count, will yield the desired ingoing mass with its standard deviation tending to the hypothetical zero value (Table 1-3).

A system to sort peach halves according to individual masses is required, but not yet available for the high speeds of 1500 to 2000 peach halves per minute per A2½-packing line of 250 cpm at which canners operate.

Peach half uniformity control has not been studied in any great detail recently. In the literature almost nothing is available, apart from an effort made by Kotze & Smit (1961) who, in co-operation with a fruit canner, addressed the importance of Kakamas peach halves in respect to production costs, canning capacity of factories and the attainment of certain quality grades.

A reciprocating sieve stack consisting of sieve plates each with holes of different diameter is currently the only technology available to sort prepared peach halves into classes for the purpose of controlling ingoing can masses. The smaller the difference in diameter between two sieves, the less the expected standard deviation of the average mass in each of the classes would be.

The use of sieve plates with holes through which the product passes or does not pass is appropriate for products with a high sphericity value (Peleg & Bagley, 1987). Although the geometry of a fresh peach as received at the canning factory is round and its sphericity probably close to 97 % (Peleg & Bagley, 1987), it changes during the process of peach canning. The peach is cut along its suture line into two halves in order to remove the pip, thus changing its geometrical properties from a round to an oblate shape (Pelag & Bagley, 1987). The sphericity of a halved peach calculates to approximately 50 %, which is about half that of the whole fruit and will be separated according to its narrowest dimension with expected poor repeatability.

Peach halves sorted into these diameter classes are accepted as having been sorted into mass classes and form thus the basis for controlling fruit ingoing mass according to pack specifications. The sieve stack and its arrangement can be looked upon as the heart of the mass sorting operation. Accordingly, the most suitable screen diameters must be selected in relation to the masses of the peach half masses needed for the various count specifications.

Although it is well known that peach half masses vary with their diameter and also with the variety[75] of peach, with ambient temperature conditions (Bergh, 1991) and other uncontrollable factors, the exact nature of these relationships are not readily available to canners. This void in information has possibly led to the perception amongst some canners that it would be a futile exercise to endeavour an exact sieve stack set-up, due to the unpredictable variation in fruit properties (Swart, 1991). The sieve diameters are currently selected manually with varying degrees of success. The problem dealt with in this dissertation was directed towards increasing the efficiency of the manual methods presently employed for the selection of sieve diameters. It was visualised that such decisions could be greatly improved on with the aid of modern computer-aided systems having ready access to input data pertaining to both buyers' specifications and fruit characteristics.

In accordance with its objectives this study in the first place set out to develop a computer-aided system for improving the selection of screen diameters. It consequently compared and evaluated the nature of buyers' specifications. Secondly, it established the most important fruit attributes associated with peach half mass variation at a set diameter. In the third instance a computer-aided manufacturing system was developed and evaluated.

The results of this study show that the mass distribution of prepared peach halves ready for quality grading and packing followed the lognormal frequency distribution, scewed towards halves with smaller diameters (Table 3-1). Because peach halves are packed in specified multiples (count) to a target mass constraint, an understanding of the distribution of peach half masses available for canning from a

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[75] Variety Details In Appendix A-9

seasonal crop is necessary. Such information is invaluable in the assessment of the quantity of halves suitable for packing into small and large can sizes. It also assists in deciding which half masses should be packed as halves and which should be size reduced for sliced peach packs. Larger sized peach halves with masses greater than 76 g are usually size reduced to slices for sale in a different, but equally important sector of the market (Swart, 1991).

It was of interest to observe from Table 3-5, that the relative quantity of peach halves within the mass range of 25 g to 75 g specified by buyers, varied from 68 % for Kakamas to 82 % for the Oom Sarel varieties. The relative proportion found heavier than 75 g varied from 13 % for Oom Sarel to 33 % in the case of Kakamas accordingly. The quantity of large halves available for size reduction and slices packs can be gauged from Table 3-5. Oom Sarel variety had the greatest proportion of small halves (4.8 %) while the Kakamas variety is not expected to produce small peach halves suitable for canning (Table 3-5).

The significant regression of peach half mass on sieve diameter found in this study (Tables 3-8) was expected. This observation together with the significant differences in mean masses of halves with the same average diameter but from four different varieties (Table 3-2), suggests that for the same ingoing mass and count specifications altered sieve diameter configurations should be used when different varieties are to be sorted.

Contrary to the claims made by twist pitter machine suppliers (Molenaar, 1989), the twist pitters used in the plant gave significantly lighter average masses for the same peach half diameter than the knife pitters (Table 3-6). These machines were designed in the United States of America for their peach varieties and there are no reliable comparable data for USA and RSA peach varieties. Any attempt at an explanation will remain conjecture. It is worthwhile noting though that yield does not seem to be a good reason for replacing the old knife pitters with twist pitters.

To reduce mass variation between individual peach halves selected for a particular count and target mass combination the sieve interval should be kept as small as possible. Also the effect of variety, season, pitters and although not investigated, the growing locality, has to be constantly incorporated as important variables. This means that constant adjustments to the sorting sieve set-up is needed. With the acceptance of new buyers' orders as the season progresses the overall problem becomes even more complex and reliable sieve selection more impossible without computer assistance.

The computer-aided system required in this application had to incorporate input data of all the relevant variables and be more reliable in selecting the various sieve diameters required for assembling the sieve stack than an experienced operator was capable of achieving. In meeting this objective it was decided to store data pertaining to buyers' orders in different databases (one for each can size). These databases were linked to a spreadsheet which allowed the input of peach and plant attributes and parameters. The appropriate FRED programs were developed and used to calculate the sieve diameters for the stack arrangement. Incorporating the independent variables in the computations improved the estimated sieve sorting efficiency from 72 % to 86 % (Tables 4-14 and 4-15). In fact, the only difference in input data between the two sieve selecting procedures was that sieve diameters were calculated from the regression equation in the computer-aided sieve arrangement, shown in Table 4-14, while the sieve diameters in Table 4-15 were issued by an experienced operator (Swart, 1989).

In the process of developing this computer-aided sieve selection system the integrated applications program Framework III with its FRED language proved to be versatile and easily adaptable as the concepts of the system evolved. It also demonstrated adequate word processing capabilities during the preparation of this dissertation, permitting ready importation of STSC files in ASCII form to arrange tables in the text. It was not possible to handle graphs and graphic files in this way and these were consequently printed directly from Statgraphics (STSC, 1988).

Statistics play an important part in a research study dealing with biological materials and large samples. The Statgraphics[76] computer application program was found to be very suited to handle, reduce and analyse the data statistically.

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[76] STSC (1988)

The data shown in the tables associated with databases and the spreadsheet of this dissertation are those actually used to arrange the sieve stack set-up in January 1991 and were based on the results of this study obtained during the 1988/89 and the 1989/90 seasons.

Flexibility in adjusting the sieve stack arrangements is poor, because of the machine design. To change the sieve diameter a sieve plate has to be replaced. This requires stopping the plant and replacing the plate manually with resultant loss of production. It follows that there is great reluctance to use this procedure when operating at full capacity during the short summer fruit season. In practice thus, rearrangement of the stack is periodic and only when major changes in fruit variation becomes blatantly obvious.

Perhaps the most significant conclusion reached in this dissertation points to the inadequacies of the current practice of size sorting peach halves on horizontal plates with holes of a specific diameter. It does not permit quick adjustments for known changes in peach half attributes and is insufficiently reliable as it does not readily permit accurate sorting of peach half masses.

Although it was not the objective of this study to derive prediction models for all possible variations in fruit attributes, the data gathered provide a new approach to quantifying natural variation in the physical attributes of peach halves.

The results obtained and the subsequent computer-aided system developed here however, provide a reliable means for calculating sieve stack arrangements which could be effected during production down-time periods, despite the inflexibility of the operating machine. The timely use of this system is especially important in view of the significant influence of ambient temperature on fruit diameter during the last few weeks on the tree (Bergh, 1991).

There is a need to develop a new technique[77] for the accurate measurement of peach half masses and subsequent line process

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[77] There is danger in reckless change; but greater danger in blind conservatism - Henry George

controlled grouping of sorted halves into appropriate count-ingoing mass combinations.

6 Conclusions And Recommendations

The current practice of size sorting peach halves on a horizontal plate with holes of a specific diameter is ineffective as it does not readily permit continuous control of peach half masses. It is not sufficiently flexible to permit quick adjustments for known changes in peach half attributes. This size sorting operation is inaccurate, inefficient and counter-productive.

Considering the three prong approach for interdependence effects which buyers' specifications, peach crop attributes and sieve stack arrangement have on the mass classes into which peach halves are to be sorted, the following procedures are recommended to provide reliable input data to the computerised sieve selection system developed and described in this dissertation.

1. Select and store peaches received according to variety and origin where possible. Maintain location records to permit the drawing of peaches of a similar kind from cold store.

2. Determine regression constants for peach half mass on sieve diameter as often as possible for each kind of peach on hand. Enter regression data into spreadsheet for computation purposes.

3. Enter all buyers' specifications into the respective databases as they become available during the season.

4. Enter the appropriate constraints into spreadsheet to bias the sorting towards the pack size most important to the market. Run computer program to obtain highest sieve efficiency value.

5. Rearrange sieve stack with sieve plates of computed diameter as often as computed sieve stack arrangements change. This could be effected during down-time.

6. Regularly evaluate sieve efficiency against changing fruit and buyers' parameters and compute new sieve stack arrangements as often as appropriate.

7 **Suggested Future Research**

The results of this dissertation demonstrated the void in technology for high speed mass sorting of large units of food and the need for further research into the development of suitable machines.

In order to mass sort peach halves accurately, a completely new approach is called for. With the high sorting speed of 1500 - 2000 peach halves per minute needed to supply a 250 cpm canning line, single file mass determination of halves at such speeds is not possible. Multiple mass determination and filling machines as used in dried fruit and peanut filling and packaging in the RSA, have not been developed for peach half mass determination.

The determination of fruit diameter and height could be used as size sorting criteria, but to be effective, electronic devices utilising rapid optical dimension determination together with fast density measurements and line process control computers for directing diversion control and subsequent grouping, may be an approach to such a future upshot.

Research and development of appropriate methodologies for the rapid measurement of peach half density and volume is required. Line process controllers to compute the individual half masses for diversion purposes and subsequent re-grouping of halves into specified count and ingoing mass combinations need in depth attention.

Research has also been lacking in establishing data pertaining to changing drained masses for modern peach varieties grown in different areas and canned for local and export sales. This void in data complicates accurate forward estimates of drained masses and corresponding adjustments to target ingoing masses.

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APPENDIX[1]

A

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[1] In This Life We Want Facts, Sir; Nothing But Facts - Charles Dickens

Contents

1 Glossary Of Terms

Term	Meaning
Attribute:	any property, quality, or characteristic that can be ascribed to a foodstuff
Average Sieve Diameter:	mean of the diameters of the sieve passing a fraction and the next retaining it
Balance:	an instrument for mass determination
Computer Software:	programs and programming support needed to put a computer through assigned tasks
Content:	that which is contained, power of containing; capacity, volume, mass
Count:	the number of peach halves in a can
Covering Liquid:	liquid used to fill can after solid product has been packed
Deciduous Fruit:	falling off or shed at a particular season or stage of growth
Drained mass:	mass of solid product after separating off the covering liquid
Duncan's Multiple Range Test:	minimises the loss due to repeated decisions made from tests of significance
Ingoing Mass	mass of solid product packed into a can
Kolmogorov-Smirnov:	compares goodness of fit of a distribution against a hypothetical distribution
Linear Programming:	a mathematical technique designed to help in planning and decision making
Management:	the act of directing, using, treating, carrying on for a purpose
Multihead-filler:	filling machine having a number of filling heads
Net Mass	mass of can contents measured according to a standard method
Objective:	being the object of perception or thought
Optimising:	to make or arrange something in order to be highly functional or effective
Piece Count:	see unit count
Piece Sorted:	see size sorted
Residue Level:	that amount of substance which remains after a part is dealt with in some way
Scheffe Range Test:	test for significance > 5% level between means in multiple ANOVA unequal n_i
Sensory:	relating to the whole sensory apparatus of the body
Shewart-charts:	Dr Shewart (1920's) was the first to apply statistics to QC with control charts
Size Reduced:	to diminish in size like preparing slices from whole fruits
Size Sorted:	to arrange units according to classes of size
Unit Count:	to enumerate the units in a group
Unit Operation:	a process in food production bringing about physical changes
Sphericity: {	dc/de; where dc = diameter of sphere of same volume as test object and
{	de = diameter smallest circumscribing sphere

2 EEC Requirements

EEC "AVERAGE MASS" SYSTEM

The following rules (Robertshaw, 1989) are applicable to the "average mass" system[1] and will be adhered to when exporting to EEC members:

RULE 1: Average net mass = label declaration, QN,

RULE 2: At least 98% of net masses = QN - TNE,

RULE 3: Every net mass = QN - 2TNE,

RULE 4: Average drained mass = label declaration, QN,

RULE 5: Every drained mass = QN - 3TNE.

QN = Nominal quantity
TNE = Tolerable negative error.

---

[1] The Minimum Mass System Traditionally Used In The Uk Has Been Discontinued

3 STSC Applications

Objective	STSC Section	Ref	STSC Paragraph	Page	Command
Data Entry	Data Management	5-4	File Operations	5-14	FILE
File Export	Data Management	5-10	Export Data Files	5-47	EXPORT
Distribution Type	Distribution Functions	12-2	Distribution Fitting	12-1	DSTFIT
Analyses of Variance	ANOVA & Regression Analyses	14-3	Multifactor ANOVA	14-8	ANOVA
Regression Analyses	ANOVA & Regression Analyses	15-2	Simple Regression	15-2	REG
Distribution Tables	Descriptive Methods	10-3	Frequency Tabulation	10-5	FTAB

4 Contents Raw Data Files

4.1 Introductory Remark

The content of STSC raw data files before data reduction is summarised. The actual data is also available on the enclosed 1.2Mb floppy disk ID "HERMAN".

4.2 PSR89KRV

```
The following variables are currently in the file PSRT89KR:

Variable   Width Type Rank  Length      Date     Time  Comment
----------------------------------------------------------------------------------
UNITWT         7  0     1   240        1/20/91 07:04 peach half masses
SIEVES         7  I     1   240        1/20/91 07:04 sizes 1 to 8
VARIETIES      1  C     2   240 1      1/20/91 07:04 K=kakamas
SIEVDIA        7  I     1   240        1/20/91 07:04 screen size
SEASONS        7  I     1   240        1/20/91 07:04 89=1989;etc
PITTERS        1  C     2   240 1      1/20/91 07:04 M=mixed filper&fmc
```

4.3 PSR90ORV

```
The following variables are currently in the file PSRT90OR:

Variable   Width Type Rank  Length      Date     Time  Comment
----------------------------------------------------------------------------------
SIEVES         7  I     1   480        1/17/91 21:23 sizes 1 to 8
PITTERS        1  C     2   480 1      1/17/91 21:23 T=filper;C=FMC
UNITWT         7  I     1   480        1/17/91 21:23 peach half masses
VARIETIES      1  C     2   480 1      1/17/91 21:23 O=Oom Sarel
SEASONS        7  I     1   480        1/17/91 21:23 90=1990;etc
SIEVDIA        7  I     1   480        1/17/91 21:23 sieve diameter mm
```

4.4 PSR90NRV

```
The following variables are currently in the file PSRT90NR:

Variable   Width Type Rank  Length      Date     Time  Comment
----------------------------------------------------------------------------------
UNITWT         7  I     1   480        1/17/91 21:15 peach half masses
SIEVES         7  I     1   480        1/17/91 21:15 sieves 1 to 8
VARIETIES      1  C     2   480 1      1/17/91 21:15 N=Neethling
PITTERS        1  C     2   480 1      1/17/91 21:15 T=filper;C=FMC
SEASONS        7  I     1   480        1/17/91 21:15 90=1990;etc
SIEVDIA        7  I     1   480        1/17/91 21:15 sieve diameter mm
```

4.5 PSR90WRV

```
The following variables are currently in the file PSRT90WR:

Variable   Width Type Rank  Length      Date      Time  Comment
--------------------------------------------------------------------------------
SIEVES         7  I     1   520          1/17/91 21:26 sieves 1 to 8
PITTERS        1  C     2   520 1        1/17/91 21:26 T=filper;C=FMC
SEASONS        7  I     1   520          1/17/91 21:26 90=1990;etc
SIEVDIA        7  I     1   520          1/17/91 21:26 sieve diameter mm
UNITWT         7  I     1   520          1/17/91 21:26 peach half masses
VARIETIES      1  C     2   520 1        1/17/91 21:26 W=Woltemade
```

4.6 PSR90KRV

```
The following variables are currently in the file PSRT90KR:

Variable   Width Type Rank  Length      Date      Time  Comment
--------------------------------------------------------------------------------
UNITWT         7  I     1   240          6/28/91 17:40 kakamas peach half mass
VARIETIES      1  C     2   240 1        6/28/91 17:40 k=kakamas
SIEVES         7  I     1   240          6/28/91 17:40 sieve number
SEASONS        7  I     1   240          6/28/91 17:40 90=1990 etc
PITTERS        1  C     2   240 1        6/28/91 17:40 T=filper,C=FMC
SIEVDIA        7  I     1   240          6/28/91 17:40 sieve diameter mm
```

4.7 PSRJ89DV

```
The following variables are currently in the file PSRTJ89:

Variable   Width Type Rank  Length      Date      Time  Comment
--------------------------------------------------------------------------------
UNITWT         7  N     1   480          6/28/91 17:25
SIEVES         7  N     1   480          6/28/91 17:25
VARIETIES      1  C     2   480 1        6/28/91 17:25
SIEVDIA        7  N     1   480          6/28/91 17:25
SEASONS        7  N     1   480          6/28/91 17:25
PITTERS        1  C     2   480 1        6/28/91 17:25
```

4.8 PSRJ90DV

```
The following variables are currently in the file PSRTJ90:

Variable   Width Type Rank  Length      Date      Time  Comment
--------------------------------------------------------------------------------
UNITWT         7  N     1   1720         6/28/91 17:44
SIEVES         7  N     1   1720         6/28/91 17:44
VARIETIES      1  C     2   1720 1       6/28/91 17:44
PITTERS        1  C     2   1720 1       6/28/91 17:44
SEASONS        7  N     1   1720         6/28/91 17:44
SIEVDIA        7  N     1   1720         6/28/91 17:44
```

5 Frequency Distribution Tables

5.1 PSRF89KD

```
                           Frequency Tabulation
--------------------------------------------------------------------------------
        Lower     Upper                             Relative   Cumulative  Cum. Rel.
Class   Limit     Limit    Midpoint    Frequency   Frequency  Frequency   Frequency
--------------------------------------------------------------------------------
   at or below    25.00                       0      .0000          0      .0000
   1    25.00     33.50     29.25            25      .0893         25      .0893
   2    33.50     42.00     37.75            67      .2393         92      .3286
   3    42.00     50.50     46.25            45      .1607        137      .4893
   4    50.50     59.00     54.75            26      .0929        163      .5821
   5    59.00     67.50     63.25            27      .0964        190      .6786
   6    67.50     76.00     71.75            17      .0607        207      .7393
above   76.00                                73      .2607        280     1.0000
--------------------------------------------------------------------------------
Mean = 59.9143     Standard Deviation = 24.3343     Median = 52
```

5.2 PSRF900D

```
                           Frequency Tabulation
--------------------------------------------------------------------------------
        Lower     Upper                             Relative   Cumulative  Cum. Rel.
Class   Limit     Limit    Midpoint    Frequency   Frequency  Frequency   Frequency
--------------------------------------------------------------------------------
   at or below    25.00                      25      .0481         25      .0481
   1    25.00     33.50     29.25            66      .1269         91      .1750
   2    33.50     42.00     37.75           126      .2423        217      .4173
   3    42.00     50.50     46.25            82      .1577        299      .5750
   4    50.50     59.00     54.75            61      .1173        360      .6923
   5    59.00     67.50     63.25            59      .1135        419      .8058
   6    67.50     76.00     71.75            33      .0635        452      .8692
above   76.00                                68      .1308        520     1.0000
--------------------------------------------------------------------------------
Mean = 51.9731     Standard Deviation = 21.3656     Median = 47
```

5.3 PSRF90ND

```
                           Frequency Tabulation
--------------------------------------------------------------------------------
        Lower     Upper                             Relative   Cumulative  Cum. Rel.
Class   Limit     Limit    Midpoint    Frequency   Frequency  Frequency   Frequency
--------------------------------------------------------------------------------
   at or below    25.00                       5     .00962          5     .00962
   1    25.00     33.50     29.25            33     .06346         38     .07308
   2    33.50     42.00     37.75            74     .14231        112     .21538
   3    42.00     50.50     46.25            91     .17500        203     .39038
   4    50.50     59.00     54.75            89     .17115        292     .56154
   5    59.00     67.50     63.25            54     .10385        346     .66538
   6    67.50     76.00     71.75            34     .06538        380     .73077
above   76.00                               140     .26923        520    1.00000
--------------------------------------------------------------------------------
Mean = 61.1635     Standard Deviation = 22.2785     Median = 56
```

5.4 PSRF90WD

```
                                Frequency Tabulation
--------------------------------------------------------------------------------
         Lower    Upper                           Relative   Cumulative  Cum. Rel.
Class    Limit    Limit    Midpoint    Frequency  Frequency  Frequency   Frequency
--------------------------------------------------------------------------------
   at or below    25.00                   15        .0268        15         .0268
   1     25.00    33.50     29.25         65        .1161        80         .1429
   2     33.50    42.00     37.75         95        .1696       175         .3125
   3     42.00    50.50     46.25         74        .1321       249         .4446
   4     50.50    59.00     54.75         97        .1732       346         .6179
   5     59.00    67.50     63.25         44        .0786       390         .6964
   6     67.50    76.00     71.75         42        .0750       432         .7714
above    76.00                           128        .2286       560        1.0000
--------------------------------------------------------------------------------
Mean = 58.0054    Standard Deviation = 23.6695    Median = 53.5
```

5.5 PSRF90KD

```
                                Frequency Tabulation
--------------------------------------------------------------------------------
         Lower    Upper                           Relative   Cumulative  Cum. Rel.
Class    Limit    Limit    Midpoint    Frequency  Frequency  Frequency   Frequency
--------------------------------------------------------------------------------
   at or below    25.00                    0        .00000        0        .00000
   1     25.00    33.50     29.25          1        .00417        1        .00417
   2     33.50    42.00     37.75         34        .14167       35        .14583
   3     42.00    50.50     46.25         28        .11667       63        .26250
   4     50.50    59.00     54.75         37        .15417      100        .41667
   5     59.00    67.50     63.25         24        .10000      124        .51667
   6     67.50    76.00     71.75         38        .15833      162        .67500
above    76.00                            78        .32500      240       1.00000
--------------------------------------------------------------------------------
Mean = 68.4125    Standard Deviation = 23.507    Median = 66
```

6 Kolmogornov-Smirnov Statistics

6.1 Remarks

The Kolmogorov-Smirnov one sample statistic (STSC, 1988) tests the overall goodness of fit of a data set to determine if the data follow a specified distribution. This statistic compares the empirical cumulative distribution function with that of the hypothesised distribution, using the maximum absolute distance between the two to test for conformance of the two cumulative distribution functions (c.d.f.).

6.2 PSR89KDT

```
Estimated KOLMOGOROV statistic DPLUS = 0.0932275
Estimated KOLMOGOROV statistic DMINUS = 0.0692422
Estimated overall statistic DN = 0.0932275
Approximate significance level = 0.0153904
```

6.3 PSR90ODT

```
Estimated KOLMOGOROV statistic DPLUS = 0.0547709
Estimated KOLMOGOROV statistic DMINUS = 0.0311472
Estimated overall statistic DN = 0.0547709
Approximate significance level = 0.0883208
```

6.4 PSR90NDT

```
Estimated KOLMOGOROV statistic DPLUS = 0.0346763
Estimated KOLMOGOROV statistic DMINUS = 0.0598468
Estimated overall statistic DN = 0.0598468
Approximate significance level = 0.0482302
```

6.5 PSR90WDT

```
Estimated KOLMOGOROV statistic DPLUS = 0.0368393
Estimated KOLMOGOROV statistic DMINUS = 0.06044
Estimated overall statistic DN = 0.06044
Approximate significance level = 0.0334332
```

6.6 PSR90KDT

```
Estimated KOLMOGOROV statistic DPLUS = 0.0713814
Estimated KOLMOGOROV statistic DMINUS = 0.0502031
Estimated overall statistic DN = 0.0713814
Approximate significance level = 0.173211
```

7.2 Varieties and Pitters

7.2.1 PSRTJ90

```
                    Analysis of Variance for PSRTJ90.UNITWT
--------------------------------------------------------------------------------
Source of variation  Sum of Squares   d.f.   Mean square   F-ratio   Sig. level
--------------------------------------------------------------------------------
MAIN EFFECTS              773387.00     13     59491.307  1000.000        .0000
  PSRTJ90.SIEVDIA         717916.48      9     79768.498  1000.000        .0000
  PSRTJ90.VARIETIES         2007.35      3       669.116    11.886        .0000
  PSRTJ90.PITTERS           1014.65      1      1014.654    18.025        .0000

RESIDUAL                  96034.375   1706     56.292131

TOTAL (CORR.)             869421.37   1719
--------------------------------------------------------------------------------
0 missing values have been excluded.
```

7.2.2 PSRTJ90R

```
 Multiple range analysis for PSRTJ90.UNITWT by PSRTJ90.VARIETIES
--------------------------------------------------------------------------------
Method: 95 Percent Confidence Intervals
Level     Count      Average   Homogeneous Groups
--------------------------------------------------------------------------------
O          480    54.193750    *
W          520    60.388462     *
N          480    63.493750      *
K          240    68.412500       *
--------------------------------------------------------------------------------

 Multiple range analysis for PSRTJ90.UNITWT by PSRTJ90.PITTERS
--------------------------------------------------------------------------------
Method: 95 Percent Confidence Intervals
Level     Count      Average   Homogeneous Groups
--------------------------------------------------------------------------------
T         1000    59.456000    *
C          720    62.298611     *
--------------------------------------------------------------------------------
```

7.2.3 PSRTJ90T

```
                        Table of means for PSRTJ90.UNITWT
--------------------------------------------------------------------------------
                              Stnd. Error  Stnd. Error    95 Percent Confidence
Level     Count      Average  (internal)   (pooled s)           for mean
--------------------------------------------------------------------------------
PSRTJ90.SIEVDIA
 41        160      33.52500     .3752305     .5931491     32.36137     34.68863
 44        200      38.56000     .4053437     .5305287     37.51922     39.60078
 47        280      45.13929     .3421935     .4483786     44.25966     46.01891
 50        240      53.46250     .3388918     .4843042     52.51240     54.41260
 52         40      48.80000     .9508431    1.1862981     46.47274     51.12726
 54        280      62.87857     .4090294     .4483786     61.99895     63.75819
 57        120      77.10833     .8095020     .6849095     75.76469     78.45198
 58        160      81.40000     .7092826     .5931491     80.23637     82.56363
 63        200      98.63000     .8217615     .5305287     97.58922     99.67078
 65         40     105.10000    2.4077333    1.1862981    102.77274    107.42726
PSRTJ90.VARIETIES
K          240      68.41250    1.5173690     .4843042     67.46240     69.36260
N          480      63.49375     .9820368     .3424548     62.82193     64.16557
O          480      54.19375     .9462986     .3424548     53.52193     54.86557
W          520      60.38846    1.0027115     .3290199     59.74299     61.03393
PSRTJ90.PITTERS
C          720      62.29861     .8269281     .2796132     61.75007     62.84715
T         1000      59.45600     .7159306     .2372596     58.99055     59.92145
--------------------------------------------------------------------------------
Total     1720      60.64593     .1809088     .1809088     60.29103     61.00083
```

8 Regression Analyses

8.1 General remarks

The regression statistics according to STSC of mass on sieve diameter for peach halves from four varieties and one mixed lot for the 1988/89 and 1989/90 seasons are detailed in this Appendix.

8.2 PSRT89MR

```
Regression Analysis - Exponential model: Y = exp(a+bX)
------------------------------------------------------------------------------
Dependent variable: PSRT89MR.UNITWT        Independent variable: PSRT89MR.SIEVDIA
------------------------------------------------------------------------------
                              Standard              T                Prob.
Parameter         Estimate      Error             Value              Level
------------------------------------------------------------------------------
Intercept          1.47008    0.0468049          31.4087            .00000
Slope              0.04753    9.08606E-4         52.3109            .00000
------------------------------------------------------------------------------

                          Analysis of Variance
------------------------------------------------------------------------------
Source               Sum of Squares     Df   Mean Square    F-Ratio  Prob. Level
Model                      33.2539       1       33.2539   2736.426       .00000
Error                      3.37835     278        .01215
------------------------------------------------------------------------------
Total (Corr.)             36.63227     279

Correlation Coefficient = 0.952773          R-squared =  90.78 percent
Stnd. Error of Est. = 0.110238
```

8.3 PSRT89KR

```
Regression Analysis - Exponential model: Y = exp(a+bX)
------------------------------------------------------------------------------
Dependent variable: PSRT89KR.UNITWT        Independent variable: PSRT89KR.SIEVDIA
------------------------------------------------------------------------------
                              Standard              T                Prob.
Parameter         Estimate      Error             Value              Level
------------------------------------------------------------------------------
Intercept          1.33081    0.0612667          21.7216            .00000
Slope            0.0525117    1.15461E-3         45.4802            .00000
------------------------------------------------------------------------------

                          Analysis of Variance
------------------------------------------------------------------------------
Source               Sum of Squares     Df   Mean Square    F-Ratio  Prob. Level
Model                      27.7218       1       27.7218   2068.447       .00000
Error                      3.18974     238        .01340
------------------------------------------------------------------------------
Total (Corr.)             30.91158     239

Correlation Coefficient = 0.947001          R-squared =  89.68 percent
Stnd. Error of Est. = 0.115768
```

8.4 PSRT90OR

```
Regression Analysis - Exponential model: Y = exp(a+bX)
------------------------------------------------------------------------------
Dependent variable: PSRT90OR.UNITWT        Independent variable: PSRT90OR.SIEVDIA
------------------------------------------------------------------------------
                              Standard              T                Prob.
Parameter         Estimate      Error             Value              Level
------------------------------------------------------------------------------
Intercept          1.38774    0.0412182          33.6682            .00000
Slope            0.0513808    8.2689E-4          62.1373            .00000
------------------------------------------------------------------------------

                          Analysis of Variance
------------------------------------------------------------------------------
Source               Sum of Squares     Df   Mean Square    F-Ratio  Prob. Level
Model                      54.1637       1       54.1637   3861.049       .00000
Error                      6.70549     478        .01403
------------------------------------------------------------------------------
Total (Corr.)             60.86915     479

Correlation Coefficient = 0.943312          R-squared =  88.98 percent
Stnd. Error of Est. = 0.118441
```

8.5 PSRT90NR

```
Regression Analysis - Exponential model: Y = exp(a+bX)
---------------------------------------------------------------------------
Dependent variable: PSRT90NR.UNITWT       Independent variable: PSRT90NR.SIEVDIA
---------------------------------------------------------------------------
                               Standard               T             Prob.
Parameter        Estimate        Error              Value           Level
---------------------------------------------------------------------------
Intercept         1.67655      0.0397951           42.1296         .00000
Slope            0.046135      7.52807E-4           61.284         .00000
---------------------------------------------------------------------------

                           Analysis of Variance
---------------------------------------------------------------------------
Source                 Sum of Squares     Df  Mean Square    F-Ratio  Prob. Level
Model                         47.9254      1      47.9254   3755.725       .00000
Error                         6.09957    478       .01276
---------------------------------------------------------------------------
Total (Corr.)                54.02493    479

Correlation Coefficient = 0.941858          R-squared =  88.71 percent
Stnd. Error of Est. = 0.112963
```

8.6 PSRT90WR

```
Regression Analysis - Exponential model: Y = exp(a+bX)
---------------------------------------------------------------------------
Dependent variable: PSRT90WR.UNITWT       Independent variable: PSRT90WR.SIEVDIA
---------------------------------------------------------------------------
                               Standard               T             Prob.
Parameter        Estimate        Error              Value           Level
---------------------------------------------------------------------------
Intercept         1.35768      0.0400396           33.9085         .00000
Slope           0.0517976      7.69042E-4          67.3534         .00000
---------------------------------------------------------------------------

                           Analysis of Variance
---------------------------------------------------------------------------
Source                 Sum of Squares     Df  Mean Square    F-Ratio  Prob. Level
Model                         64.9366      1      64.9366   4536.479       .00000
Error                         7.41482    518       .01431
---------------------------------------------------------------------------
Total (Corr.)                72.35142    519

Correlation Coefficient = 0.947374          R-squared =  89.75 percent
Stnd. Error of Est. = 0.119642
```

8.7 PSRT90KR

```
Regression Analysis - Exponential model: Y = exp(a+bX)
---------------------------------------------------------------------------
Dependent variable: PSRT90KR.UNITWT       Independent variable: PSRT90KR.SIEVDIA
---------------------------------------------------------------------------
                               Standard               T             Prob.
Parameter        Estimate        Error              Value           Level
---------------------------------------------------------------------------
Intercept        0.985133      0.0817359           12.0526         .00000
Slope           0.0573384      1.46538E-3          39.1286         .00000
---------------------------------------------------------------------------

                           Analysis of Variance
---------------------------------------------------------------------------
Source                 Sum of Squares     Df  Mean Square    F-Ratio  Prob. Level
Model                         24.3946      1      24.3946   1531.046       .00000
Error                         3.79213    238       .01593
---------------------------------------------------------------------------
Total (Corr.)                28.18677    239

Correlation Coefficient = 0.930303          R-squared =  86.55 percent
Stnd. Error of Est. = 0.126227
```

9 Peach Varieties

9.1 Kakamas

Variety: Kakamas; Origin: RSA, originated by O.S.H.Reinecke and A.O.Collins as a chance seedling of St Helena peach; Released: 1938; Tree: Chilling Requirements: medium; Vigour: strong; Growth Habit: spreading; Full bloom Date: mid-September; Production: good; Fruit: Harvest Date: mid-January; Mass: 140 g; Shape: round to ovate; Skin Colour: yellow; Flesh Colour: yellow; Taste: good; Texture: non-melting, fine and firm; Stone: cling; Keeping Quality: 2 weeks at -0.5 °C; General: Good canning quality. Stone residues. Suitable for national fresh market

9.2 Prof Neethling

Variety: Neethling; Origin: RSA, bred by FFTRI as a cross between Kakamas and Early Dawn.; Released: 1961; Tree: Chilling Requirements: low; Vigour: strong; Growth Habit: spreading; Full Bloom Date: late-August; Production: good; Fruit: Harvest Date: mid-January; Mass: 130 g; Shape: round; Skin Colour: yellow; Flesh Colour: yellow; Taste: good; Texture: non-melting, fine and firm; Stone: cling; Keeping Quality: 2 weeks at -0.5 °C; General: Good canning quality. Suitable for national fresh market

9.3 Oom Sarel

Variety: Oom Sarel; Origin: RSA, bred by FFTRI as a cross between Kakamas and Early Dawn; Released: 1961; Tree: Chilling Requirements: low; Vigour: strong; Growth Habit: spreading; Full Bloom Date: late-August; Production: good; Fruit: Harvest Date: mid-December; Mass: 125 g; Shape: round; Skin Colour: yellow; Flesh Colour: yellow; Taste: good; Texture: non-melting, fine and firm; Stone: cling; Keeping Quality: 2 weeks at -0.5 °C; General: Good canning quality. Suitable for national fresh market

9.4 Woltemade

Variety: Woltemade; Origin: RSA, selected by Nel-Brothers from a chance seeding of Kakamas; Released: n/a; Tree: Chilling Requirements: medium; Vigour: strong; Growth Habit: spreading; Full Bloom Date: late-September; Production: good; Fruit: Harvest Date: late-January; Mass: 140 g; Shape: ovate with prominent point and suture; Skin Colour: yellow; Flesh Colour: orange-yellow; Taste: good; Texture: non-melting, fine and firm; Stone: cling; Keeping Quality: 2 weeks at -0.5 °C; General: Good canning quality. Some stone residues. Suitable for national fresh market

9.5 Prof Malherbe

Variety: Malherbe; Origin: RSA, bred by FFTRI as a cross between Kakamas and Early Dawn; Released: 1961; Tree: Chilling Requirements: medium; Vigour: strong; Growth Habit: spreading; Full Bloom Date: early-September Production: good; Fruit: Harvest Date: late-December; Mass: 135 g; Shape: round; Skin Colour: yellow; Flesh Colour: yellow; Taste: good; Texture: non-melting, fine and firm; Stone: cling; Keeping Quality: 2 weeks at -0.5 °C; General: Good canning quality. Suitable for national fresh market

9.6 Prof Black

Variety: Black; Origin: RSA, bred by FFTRI as a cross between Kakamas and Early Dawn; Released: 1961; Tree: Chilling Requirements: medium; Vigour: strong; Growth Habit: spreading; Full Bloom Date: late-August; Production: moderate; Fruit: Harvest Date: early-January; Mass: 130 g; Shape: round with prominent suture; Skin Colour: yellow; Flesh Colour: yellow; Taste: fair, but little flavour; Texture: non-melting, fine and firm Stone: cling; Keeping Quality: poor; General: Good canning quality. Suitable for national fresh market

9.7 Walgant

Variety: Walgant; Origin: RSA, bred by FFTRI by self-pollinating Kakamas; Released: 1959; Tree: Chilling Requirements: medium; Vigour: strong; Growth Habit: spreading; Full Bloom Date: early-September; Production: good; Fruit: Harvest Date: late-January; Mass: 140 g; Shape: ovate with prominent point; Skin Colour: yellow; Flesh Colour: orange-yellow; Taste: good; Texture: non-melting, fine and firm; Stone: cling; Keeping Quality: 2 weeks at -0.5 °C; General: Good canning quality. Stone residues. Suitable for national fresh market

9.8 Goudmyn

Variety: Goudmyn; Origin: RSA, Open-pollinated seed from 69-174 (Oom Sarel X 344); Released: 1989; Tree: Chilling Requirements: low; Vigour: strong; Growth Habit: semi-upright; Full Bloom Date: early-August Production: good; Fruit: Harvest Date: early-January; Mass: 160 g; Shape: round; Skin Colour: yellow; Flesh Colour: yellow; Taste: good; Texture: non-melting; Stone: cling; Keeping Quality: not-tested; General: Very good canning quality

APPENDIX[2]

B

---

[2] There Is Nothing Permanent Except Change - Heraclitus

```
Choices:
   ;  FRED to set menu
   @menu(choices)  ;set choices menu


Choices.[1Mcan Orders & Parameters]:
   ;  FRED to select and display/edit frame
   @local(cur),    ;set local variable cur
   cur:=@setselection, ;set variable to return frame name
   @setselection("Sievdiam.SEL90a.SPEC1M"),    ;store selected frame in variable
   @performkeys("{f9}"),  ;zoom frame
   @eraseprompt,   ;erase
   @prompt("""P"" To Input Parameters    "" Return"" To Continue ",15),    ;prompt
   @nextkey,   ;wait for any key to be pressed
   @if(@or(@key={P},@key={p}),     ;if P or p
   @quitmenu,      ;then quit menu
   @setselection(cur))     ;else return to origin




Choices.[A2.5can Orders & Parameters]:
   ;  FRED to select and display/edit frame
   @local(cur),    ;set local variable cur
   cur:=@setselection,     ;set variable to return frame name
   @setselection("Sievdiam.sel90a.SPECA2"),    ;store selected frame in variable
   @performkeys("{f9}"),  ;zoom frame
   @eraseprompt,   ;erase
   @prompt("""P"" To Input Parameters    ""Return"" To Continue ",15), ;prompt
   @nextkey,   ;wait fot key to be pressed
   @if(@or(@key={P},@key={p}), ;if P or p
   @quitmenu,  ;then quit menu
   @setselection(cur)) ;else return origin


Choices.[No10can Orders & Parameters]:
   ;  FRED to select and display/edit frame
   @local(cur),    ;set local variable cur
   cur:=@setselection, ;set variable to return frame name
   @setselection("Sievdiam.sel90a.SPECA10"),   ;store selected frame in variable
   @performkeys("{f9}"),  ;zoom frame
   @eraseprompt,   ;erase
   @prompt("""P"" To Input Parameters    ""Return"" To Continue ",15), ;prompt
   @nextkey,   ;wait fot key to be pressed
   @if(@or(@key={P},@key={p}), ;if P or p
   @quitmenu,  ;then quit menu
```

```
   @setselection(cur)) ;else return origin


Choices.[Peach & Sieve Parameters]:
   ;   FRED to select and display frame and input data
   @local(cur),    ;set local variable cur
   cur:=@setselection,     ;set variable to return frame name
   @setselection("Sievdiam.sel90a.siv"),   ;store selected frame in variable
   @performkeys("{f9}"),   ;zoom frame
   @performkeys("{Ctrl-Home}{Ctrl-PgDn}"), ;move curser to SS notes
   @eraseprompt,   ;erase
   @prompt("""P"" To Input Parameters    ""Return""  To Continue ",15),    ;prompt
   @nextkey,   ;wait fot key to be pressed
   @if(@or(@key={P},@key={p}), ;if P or p
   @quitmenu,      ;then quit menu
   @setselection(cur)) ;else return origin


Choices.Current Sieve Diameters:
   ;FRED to display current data used for sieve
   ;selection and recommended sieve diameters
   @local(cur), ;set local variable cur
   cur:=@setselection,   ;set variable to return frame name
   @setselection("Sievdiam.SEL90a.DATA"),  ;store selected frame in variable
   @performkeys("{f10}"), ;zoom frame
   @eraseprompt,   ;erase
   @prompt("Press Any Key To Continue",28),    ;prompt instruction
   @nextkey,   ;wait for a key
   @performkeys("{f10}"),  ;view
   @setselection(cur)   ;return to origin


Choices.Recalculate All Frames:
   ;   FRED to recalculate all frames
   @local(cal),    ;set local variable cur
   cal:=@setselection, ;set variable to return frame name
   @setselection("Sievdiam.SEL90A.SPEC1M"),    ;call frame
   @performkeys("{f9}"),   ;zoom frame
   @performkeys("{In}{ctrl-home}{f6}{end}"),   ;select all dbase programs
   @performkeys("{f5}{f5}{Out}"),  ;recalculate twice
   @performkeys("{Ctrl-return}"),  ;save frame
   @setselection( "Sievdiam.SEL90A.SPECA2"),   ;call frame
   @performkeys("{f9}"),   ;zoom frame
   @performkeys("{In}{ctrl-home}{f6}{end}"),   ;select all dbase programs
   @performkeys("{f5}{f5}{Out}"),  ;recalculate twice
   @performkeys("{Ctrl-return}"),  ;save frame
   @setselection("Sievdiam.SEL90A.SPECA10"),   ;call frame
   @performkeys("{f9}"),   ;zoom frame
```

```
   @performkeys("{In}{ctrl-home}{f6}{end}"),   ;select all dbase programs
   @performkeys("{f5}{f5}{Out}"),  ;recalculate twice
   @performkeys("{Ctrl-return}"),  ;save frame
   @setselection("Sievdiam.SEL90A.Siv"),   ;call frame
   @performkeys("{f9}"),   ;zoom frame
   @performkeys("{In}{ctrl-end}"), ;select final answer cell
   @performkeys("{f5}{f5}{Out}"),  ;recalculate twice
   @performkeys("{Ctrl-return}"),  ;save frame
   @setselection("Sievdiam.SEL90A.Data"),  ;call frame
   @performkeys("{f9}"),   ;zoom frame
   @performkeys("{In}{f5}{f5}{Out}"),  ;recalculate twice
   @performkeys("{Ctrl-return}"),  ;save frame
   @setselection(cal) ;return to origin


Choices.Quit:
   ;   FRED to quit menu
   @quitmenu   ;then quit menu
```

APPENDIX[3]

C

---

[3] Courage Consists In Equality To The Ploblem Before Us - Ralph Waldo Emerson

```
SPECA2.No:
   ;FRED program to calculate number of rows
   @fill(
   sel90a.spec1M.No,   ;specify region
   1,  ;start from 1
   1   ;increment = 1
   )   ;end
```

```
SPECA2.TNE:
   ;   FRED program to specify tolerable negative error(TNE) in
   ;accordance  with  buyers specifications and EEC rules
   @set(
   TNE,    ;set tolerable negative error
   @if(    ;if
   NomWt=500,  ;nominal weight = 500g
   15, ;then enter 15g
   @if(    ;if
   NomWt=250,  ;nominal weight = 250g
   9,  ;then enter 9g
   @if(    ;if
   NomWt=1815, ;nominal weight = 1815g
   27, ;then enter 27g
   @if(    ;if
   NomWt=510,  ;nominal weight = 510g
   15, ;the enter 15g
   @if(    ;if
   NomWt=1850, ;nominal weight = 1850g
   28, ;then enter 28g
   "?" ;else ?
   ))))))  ;end
```

```
SPECA2.Rule4:
   ;   FRED program to calculate target weight for rule4
   @set(   ;set
   Rule4,  ;average of n units > nominal weight
   @ceiling(   ;round upwards
   NomWt+2*s/n^.5) ;95% confidence limit for n units
   )   ;end
```

```
SPECA2.Rule5:
   ;   FRED program to calculate target weight rule 5
   @set(   ;set
   Rule5,  ;unit weight > nominal weight less 3TNE
   @ceiling(   ;round upwards
   (NomWt-(3*TNE)+2*s/1^.5))   ;95% confidence limit for n units rule 5
```

```
   )  ;end


SPECA2.DrndWt:
   ;  FRED program to select largest target weight
   @set(  ;set
   DrndWt, ;nominal drained weight declared
   @max(  ;select highest target weight of the
   Rule4,Rule5)   ;two target weights
   )  ;end


SPECA2.CntAv:
   ;  FRED program to calculate average count
   @set(  ;set
   CntAv,  ;calculate count average
   @ceiling(  ;round upwards
   @avg(  ;calculate average
   MinCnt,MaxCnt)) ;of parameters
   )  ;end


SPECA2.CntR:
   ;  FRED program to calculate count Range
   @set(  ;set
   CntR,  ;calculate Range
   MaxCnt-MinCnt  ;obtain difference
   )  ;end


SPECA2.CntCV:
   ;  FRED program to estimate
   ;coefficient of variation for unit count
   @set(  ;set
   CntCV,  ;count coefficient of variation
   @ceiling(  ;round upwards
   CntR*10^2/CntAv ;calculate count coefficient of variation
   ))  ;end


SPECA2.RCor:
   ;  FRED program to adjust count Range downwards
   RCor:=  ;set
   @if(   ;if
   CntR>siv.k32,   ;adjust counts with R>2
   @ABS(siv.k32-CntR), ;calculate new Range
   0  ;no change
   )  ;end
```

```
SPECA2.CntCorr:
   ;   FRED programme to narrow down unit count specifications
   CntCorr:=   ;set count correcting factor
   @floor( ;round downwards
   RCor/2  ;Range correction factor
   )   ;end


SPECA2.CorMinCnt:
   ;   FRED program to adjust minimum count upwards
   @set(   ;set
   CorMinCnt,  ;corrected minimum count
   @ceiling(   ;round uowards
   MinCnt+(2*CntCorr)  ;calculate new minimum count
   ))  ;end


SPECA2.CorMaxCnt:
   ;   FRED program to adjust maximum count downwards
   @set(   ;set
   CorMaxCnt,  ;corrected maximum count
   @ceiling(   ;round upwards
   MaxCnt-(CntCorr)    ;calculate new maximum count
   ))  ;end


SPECA2.CorCntAv:
   ;   FRED program to calculate new average count
   @set(   ;set
   CorCntAv,   ;corrected count average
   @ceiling(   ;round upwards
   @avg(CorMaxCnt,CorMinCnt))  ;calculate average
   )   ;end


SPECA2.CorCntR:
   ;   FRED program to calculate corrected count Range
   @set(   ;set
   CorCntR,    ;corrected count Range
   CorMaxCnt-CorMinCnt ;calculate
   )   ;end


SPECA2.CorCntCV:
   ;   FRED program to calculate smoothed CV
   @set(   ;set
   CorCntCV,   ;
   @ceiling(   ;round upwards
```

```
   CorCntR*10^2/CorCntAv   ;calculate smoothed CV
   ))  ;end


SPECA2.Wt1:
   ;   FRED program to calculate largest specified half weight
   Wt1:=   ;set
   @floor( ;round downwards
   DrndWt/CorMinCnt    ;calculated optimum half weight
   )   ;end


SPECA2.Wt2:
   ;   FRED program to calculate optimum half weights
   Wt2:=   ;set
   @if(    ;if
   (CorMinCnt+1)   ;new minimum count
   <=CorMaxCnt,    ;is less or equal to corrected maximum count
   @floor(     ;then round downwards
   DrndWt/(CorMinCnt+1)),  ;the calculated optimum half weight
   "sw"    ;else print sw
   )   ;end


SPECA2.Wt3:
   ;   FRED program to calculate optimum half weights
   Wt3:=   ;set
   @if(    ;if
   (CorMinCnt+2)   ;new minimum count
   <=CorMaxCnt,    ;is less or equal to corrected maximum count
   @floor(     ;then round downwards
   DrndWt/(CorMinCnt+2)),  ;the calculated optimum half weight
   "sw"    ;else print sw
   )   ;end


SPECA2.Wt4:
   ;   FRED program to calculate optimum half weights
   Wt4:=   ;set
   @if(    ;if
   (CorMinCnt+3)   ;new minimum count
   <=CorMaxCnt,    ;is less or equal to corrected maximum count
   @floor(     ;then round downwards
   DrndWt/(CorMinCnt+3)),      ;the calculated optimum half weight
   "sw"    ;else print sw
   )   ;end
```

```
SPECA2.Wt5:
   ;   FRED program to calculate optimum half weights
   Wt5:=   ;set
   @if(    ;if
   (CorMinCnt+4)   ;new minimum count
   <=CorMaxCnt,    ;is less or equal to corrected maximum count
   @floor(     ;then round downwards
   DrndWt/(CorMinCnt+4)),      ;the calculated optimum half weight
   "sw"    ;else print sw
   )   ;end


SPECA2.Wt6:
   ;   FRED program to calculate optimum half weights
   Wt6:=   ;set
   @if(    ;if
   (CorMinCnt+5)   ;new minimum count
   <=CorMaxCnt,    ;is less or equal to corrected maximum count
   @floor(     ;then round downwards
   DrndWt/(CorMinCnt+5)),      ;the calculated optimum half weight
   "sw"    ;else print sw
   )   ;end


SPECA2.No1:
   ;   FRED program to group half weights
   No1:=   ;set
   @if(    ;if
   @or(    ;or
   Wt1>SIV.j14,    ;optimum weights are
   Wt2>SIV.j14,    ;heavier than
   Wt3>SIV.j14,    ;a specified
   Wt4>SIV.j14,    ;value
   Wt5>SIV.j14,    ;for siev 1
   Wt6>SIV.j14),   ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else insert "."
   )   ;end


SPECA2.No2:
   ;   FRED program to group half weights
   No2:=   ;set
   @if(    ;if
   @or(    ;or
   @and(WT1>SIV.J13,Wt1<=SIV.L13),     ;optimum weights
   @and(WT2>SIV.J13,Wt2<=SIV.L13),     ;are within
```

```
   @and(WT3>SIV.J13,Wt3<=SIV.L13),      ;specified
   @and(WT4>SIV.J13,Wt4<=SIV.L13),      ;parameters
   @and(WT5>SIV.J13,Wt5<=SIV.L13),      ;for siev 2
   @and(WT6>SIV.J13,Wt6<=SIV.L13)),     ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else print "."
   )   ;end


SPECA2.No3:
   ;   FRED program to group half weights
   No3:=   ;set
   @if(    ;if
   @or(    ;or
   @and(WT1>SIV.J12,Wt1<=SIV.L12),          ;optimum weights
   @and(WT2>SIV.J12,Wt2<=SIV.L12),          ;are within
   @and(WT3>SIV.J12,Wt3<=SIV.L12),          ;specified
   @and(WT4>SIV.J12,Wt4<=SIV.L12),          ;parameters
   @and(WT5>SIV.J12,Wt5<=SIV.L12),          ;for sieve 3
   @and(WT6>SIV.J12,Wt6<=SIV.L12)),         ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else prinr "."
   )   ;end


SPECA2.No4:
   ;   FRED program to group half weights
   No4:=   ;set
   @if(    ;or
   @or(    ;optimum weights
   @and(WT1>SIV.J11,Wt1<=SIV.L11),      ;are within
   @and(WT2>SIV.J11,Wt2<=SIV.L11),      ;specified
   @and(WT3>SIV.J11,Wt3<=SIV.L11),      ;parameters
   @and(WT4>SIV.J11,Wt4<=SIV.L11),      ;for siev 4
   @and(WT5>SIV.J11,Wt5<=SIV.L11),      ;then
   @and(WT6>SIV.J11,Wt6<=SIV.L11)),     ;round downwards
   @floor(Tonne/Exd),                   ;calculated tonne
   "."     ;else print "."
   )   ;end


SPECA2.No5:
   ;   FRED program to group half weights
   No5:=   ;set
   @if(    ;if
   @or(    ;or
```

```
   @and(WT1>SIV.J10,Wt1<=SIV.L10),     ;optimum weightd
   @and(WT2>SIV.J10,Wt2<=SIV.L10),     ;are within
   @and(WT3>SIV.J10,Wt3<=SIV.L10),     ;specified
   @and(WT4>SIV.J10,Wt4<=SIV.L10),     ;parameters
   @and(WT5>SIV.J10,Wt5<=SIV.L10),     ;for sieve 5
   @and(WT6>SIV.J10,Wt6<=SIV.L10)),    ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else print "."
   )   ;end


SPECA2.No6:
   ;   FRED program to group half weights
   No6:=   ;set
   @if(    ;if
   @or(    ;or
   @and(WT1>SIV.J9,Wt1<=SIV.L9),       ;optimum weights
   @and(WT2>SIV.J9,Wt2<=SIV.L9),       ;are within
   @and(WT3>SIV.J9,Wt3<=SIV.L9),       ;specified
   @and(WT4>SIV.J9,Wt4<=SIV.L9),       ;parameters
   @and(WT5>SIV.J9,Wt5<=SIV.L9),       ;for siev 6
   @and(WT6>SIV.J9,Wt6<=SIV.L9)),      ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else print "."
   )   ;end


SPECA2.No7:
   ;   FRED program to group half weights
   No7:=   ;set
   @if(    ;if
   @or(    ;or
   @and(WT1>SIV.J8,Wt1<=SIV.L8),       ;optimum weights
   @and(WT2>SIV.J8,Wt2<=SIV.L8),       ;are within
   @and(WT3>SIV.J8,Wt3<=SIV.L8),       ;specified
   @and(WT4>SIV.J8,Wt4<=SIV.L8),       ;parameters
   @and(WT5>SIV.J8,Wt5<=SIV.L8),       ;siev 7
   @and(WT6>SIV.J8,Wt6<=SIV.L8)),      ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else print "."
   )   ;end


SPECA2.No8:
   ;   FRED program to class half weights
```

```
   No8:=   ;set
   @if(    ;if
   @or(    ;or
   Wt1<=SIV.L7,    ;optimum weight are
   Wt2<=SIV.L7,    ;less or eual than
   Wt3<=SIV.L7,    ;a specified
   Wt4<=SIV.L7,    ;value
   Wt5<=SIV.L7,    ;for siev 8
   Wt6<=SIV.L7),   ;then
   @floor(     ;round downwards
   Tonne/Exd),     ;calculated tonne
   "."     ;else print "."
   )   ;end


SPECA2.Opt:
   ;   FRED program to count size options specified
   Opt:=   ;set
   @count(     ;count
   Wt1:Wt6     ;range
   )   ;end


SPECA2.Exd:
   ;   FRED program to count options exersized
   Exd:=   ;set
   @count(     ;count
   No1:No8     ;range
   )   ;end


SPECA2.TonOpt:
   ;   FRED program to calculate proportion sorted out of optimum
   TonOpt:=    ;set
   @floor(     ;round downwards
   Tonne*Exd/Opt   ;calculate tonne
   )   ;end


SPECA2.TonOvr:
   ;   FRED program to calculate proportion sorted out of optimum
   TonOvr:=    ;set
   @floor(     ;round downwards
   Tonne*(Opt-Exd)/Opt     ;calculate tonne
   )   ;end
```

```
SPECA2.Tonne:
   ;  FRED program to calcalate tonnes per size
   @set(Tonne,     ;set
   DrndWt      ;target ingoing weight per can, rules 4 & 5
   *10^-6*24   ;calculate weight per carton of 24 cans
   *Cartns     ;number of cartons to be packed
   )  ;end
```

APPENDIX[4]

D

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[4] No Facts To Me Are Sacred; None Are Profane - Ralph Waldo Emerson

```
SIV.A4:
   28


SIV.B4:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C4+(D4/16)  ;decimalise inches
   )   ;end


SIV.C4:
   1


SIV.D4:
   2


SIV.B5:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C5+(D5/16)  ;decimalise inches
   )   ;end


SIV.C5:
   1


SIV.D5:
   3


SIV.A6:
   32


SIV.B6:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C6+(D6/16)  ;decimalise inches
   )   ;end


SIV.C6:
   1
```

```
SIV.D6:
   4


SIV.A7:
   33


SIV.B7:
   ;  FRED to convert inches to mm
   25.4*(  ;constant
   C7+(D7/16)  ;decimalise inches
   )  ;end


SIV.C7:
   1


SIV.D7:
   5


SIV.G7:
   ;  FRED program to calculate peach half weight(g)
   ;  from exponential regression of weight on diameter(mm)
   @floor(     ;round downwards
   (@LN($H$27)-$H$16)/$H$17    ;compute
   )  ;end


SIV.H7:
   ;  FRED program to select sieve
   @vlookup(   ;look up nominal diameter
   $G7,    ;sieve
   $B$4:$B$29,     ;range
   0  ;offset
   )  ;end


SIV.L7:
   ;  FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H7))     ;solve equation
   )  ;end
```

```
SIV.N7:
   8


SIV.A8:
   35


SIV.B8:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C8+(D8/16)  ;decimalise inches
   )   ;end


SIV.C8:
   1


SIV.D8:
   6


SIV.G8:
   ;   FRED program to calculate peach half weight(g)
   ;   from exponential regression of weight on diameter(mm)
   @floor(     ;round downwards
   (@LN($H$27+$H$31)-$H$16)/$H$17  ;compute
   )   ;end


SIV.H8:
   ;   FRED program to select sieve
   @vlookup(   ;look up nominal diameter
   $G8,    ;sieve
   $B$4:$B$29,     ;range
   0   ;offset
   )   ;end


SIV.J8:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H7))     ;solve equation
   )   ;end
```

```
SIV.L8:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H8))     ;solve equation
   )   ;end


SIV.M8:
   ;   FRED to calculate average weight
   ;of screen interval
   @sum(   ;sum lightest and heaviest weights
   J8,L8)/2    ;average


SIV.N8:
   7


SIV.A9:
   36


SIV.B9:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C9+(D9/16)  ;decimalise inches
   )   ;end


SIV.C9:
   1


SIV.D9:
   7


SIV.G9:
   ;   FRED program to calculate peach half weight(g)
   ;   from exponential regression of weight on diameter(mm)
   @floor(     ;round downwards
   (@LN($H$27+2*$H$31)-$H$16)/$H$17    ;compute
   )   ;end


SIV.H9:
   ;   FRED program to select sieve
```

```
   @vlookup(   ;look up nominal diameter
   $G9,    ;sieve
   $B$4:$B$29,     ;range
   0   ;offset
   )   ;end


SIV.J9:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H8))     ;solve equation
   )   ;end


SIV.L9:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H9))     ;solve equation
   )   ;end


SIV.M9:
   ;   FRED to calculate average weight
   ;of screen interval
   @sum(   ;sum lightest and heaviest weights
   J9,L9)/2    ;average


SIV.N9:
   6


SIV.A10:
   38


SIV.B10:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C10+(D10/16)    ;decimalise inches
   )   ;end


SIV.C10:
   1
```

```
SIV.D10:
   8


SIV.G10:
   ;   FRED program to calculate peach half weight(g)
   ;from exponential regression of weight on diameter(mm)
   @floor(     ;round downwards
   (@LN($H$27+3*$H$31)-$H$16)/$H$17    ;compute
   )   ;end


SIV.H10:
   ;   FRED program to select sieve
   @vlookup(   ;look up nominal diameter
   $G10,   ;sieve
   $B$4:$B$29,     ;range
   0   ;offset
   )   ;end


SIV.J10:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H9))     ;solve equation
   )   ;end


SIV.L10:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H10))        ;solve equation
   )   ;end


SIV.M10:
   ;   FRED to calculate average weight
   ;of screen interval
   @sum(   ;sum lightest and heaviest weights
   J10,L10)/2  ;average


SIV.N10:
   5
```

```
SIV.A11:
   39


SIV.B11:
   ;  FRED to convert inches to mm
   25.4*(  ;constant
   C11+(D11/16)    ;decimalise inches
   )  ;end


SIV.C11:
   1


SIV.D11:
   9


SIV.G11:
   ;  FRED program to calculate peach half weight(g)
   ;  from exponential regression of weight on diameter(mm)
   @floor(     ;round downwards
   (@LN($H$27+4*$H$31)-$H$16)/$H$17    ;compute
   )  ;end


SIV.H11:
   ;  FRED program to select sieve
   @vlookup(  ;look up nominal diameter
   $G11,  ;sieve
   $B$4:$B$29,     ;range
   0  ;offset
   )  ;end


SIV.J11:
   ;  FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H10))        ;solve equation
   )  ;end


SIV.L11:
   ;  FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
```

```
   @exp($H$16+($H$17*$H11))        ;solve equation
   )   ;end


SIV.M11:
   ;   FRED to calculate average weight
   ;of screen interval
   @sum(   ;sum lightest and heaviest weights
   J11,L11)/2  ;average


SIV.N11:
   4


SIV.A12:
   41


SIV.B12:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C12+(D12/16)    ;decimalise inches
   )   ;end


SIV.C12:
   1


SIV.D12:
   10


SIV.G12:
   ;   FRED program to calculate peach half weight(g)
   ;from exponential regression of weight on diameter(mm)
   @floor(     ;round downwards
   (@LN($H$27+5*$H$31)-$H$16)/$H$17    ;compute
   )   ;end


SIV.H12:
   ;   FRED program to select sieve
   @vlookup(   ;look up nominal diameter
   $G12,   ;sieve
   $B$4:$B$29,     ;range
   0   ;offset
```

```
   )   ;end


SIV.J12:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H11))        ;solve equation
   )   ;end


SIV.L12:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H12))        ;solve equation
   )   ;end


SIV.M12:
   ;   FRED to calculate average weight
   ;of screen interval
   @sum(   ;sum lightest and heaviest weights
   J12,L12)/2  ;average


SIV.N12:
   3


SIV.B13:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C13+(D13/16)    ;decimalise inches
   )   ;end


SIV.C13:
   1


SIV.D13:
   11


SIV.G13:
   ;   FRED program to calculate peach half weight(g)
   ;from exponential regression of weight on diameter(mm)
```

```
   @floor(     ;round downwards
   (@LN($H$27+6*$H$31)-$H$16)/$H$17    ;compute
   )  ;end


SIV.H13:
   ;   FRED program to select sieve
   @vlookup(   ;look up nominal diameter
   $G13,   ;sieve
   $B$4:$B$29,     ;range
   0   ;offset
   )   ;end


SIV.J13:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H12))        ;solve equation
   )   ;end


SIV.L13:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H13))        ;solve equation
   )   ;end


SIV.M13:
   ;   FRED to calculate average weight
   ;of screen interval
   @sum(   ;sum lightest and heaviest weights
   J13,L13)/2  ;average


SIV.N13:
   2


SIV.A14:
   44


SIV.B14:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
```

```
   C14+(D14/16)    ;decimalise inches
   )   ;end


SIV.C14:
   1


SIV.D14:
   12


SIV.J14:
   ;   FRED to calculate peach half weight(g)
   ;from diameter(mm) from regression constants
   @floor(     ;round downwards
   @exp($H$16+($H$17*$H13))        ;solve equation
   )   ;end


SIV.N14:
   1


SIV.B15:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C15+(D15/16)    ;decimalise inches
   )   ;end


SIV.C15:
   1


SIV.D15:
   13


SIV.A16:
   47


SIV.B16:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C16+(D16/16)    ;decimalise inches
   )   ;end
```

```
SIV.C16:
   1


SIV.D16:
   14


SIV.H16:
   .9


SIV.B17:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C17+(D17/16)    ;decimalise inches
   )   ;end


SIV.C17:
   1


SIV.D17:
   15


SIV.H17:
   .0461


SIV.J17:
   8


SIV.K17:
   ;   FRED to sum tonne sorted by sieve 8
   ;against requirement for 1M can size
   @sum(SPEC1M.No8)    ;summate tonne for sieve No8


SIV.L17:
   ;   FRED to sum tonne sorted by sieve 8
   ;against requirement for 1M can size
   @sum(SPECa2.No8)    ;summate tonne for sieve No8
```

```
SIV.M17:
   ;   FRED to sum tonne sorted by sieve 8
   ;                   against requirement for A10 can size
       @sum(SPECA10.No8)       ;summate tonne for sieve No8


SIV.N17:
   ;   FRED to obtain tonne /sieve

       @sum(K17:M17)       ;sum


SIV.A18:
   50


SIV.B18:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C18+(D18/16)    ;decimalise inches
   )  ;end


SIV.C18:
   2


SIV.D18:
   0


SIV.J18:
   7


SIV.K18:
   ;   FRED to sum tonne sorted by sieve 7
   ;against requirement for 1M can size
   @sum(SPEC1M.No7)    ;summate tonne for sieve No7


SIV.L18:
   ;   FRED to sum tonne sorted by sieve 7
   ;against requirement for A2.5 can size
   @sum(SPECA2.No7)    ;summate tonne for sieve No7
```

```
SIV.M18:
   ;  FRED to sum tonne sorted by sieve 7
   ;against requirement for A10 can size
   @sum(SPECA10.No7)   ;summate tonne for sieve No7


SIV.N18:
   ;  FRED to obtain tonne /sieve
   @sum(K18:M18)   ;sum


SIV.A19:
   52


SIV.B19:
   ;  FRED to convert inches to mm
   25.4*(  ;constant
   C19+(D19/16)    ;decimalise inches
   )  ;end


SIV.C19:
   2


SIV.D19:
   1


SIV.J19:
   6


SIV.K19:
   ;  FRED to sum tonne sorted by sieve 6
   ;against requirement for 1M can size
   @sum(SPEC1M.No6)    ;summate tonne for sieve No6


SIV.L19:
   ;FRED to sum tonne sorted by sieve 6
   ;against requirement for A2.5 can size
   @sum(SPECA2.No6)    ;summate tonne for sieve No6


SIV.M19:
   ;  FRED to sum tonne sorted by sieve 6
```

```
   ;against requirement for A10 can size
   @sum(SPECA10.No6)   ;summate tonne for sieve No6


SIV.N19:
   ;   FRED to obtain tonne /sieve
   @sum(K19:M19)   ;sum


SIV.A20:
   54


SIV.B20:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C20+(D20/16)    ;decimalise inches
   )   ;end


SIV.C20:
   2


SIV.D20:
   2


SIV.H20:
   ;   FRED program to calculate minimum peach half
   ;                 diameter (mm) from lightest weight (g) entered
   @floor(                              ;round downwards
       (@LN($H$27)-$H$16)/$H$17         ;solve regression equation
       )                                ;end


SIV.J20:
   5


SIV.K20:
   ;   FRED to sum tonne sorted by sieve 5
   ;against requirement for 1M can size
   @sum(SPEC1M.No5)    ;summate tonne for sieve No5


SIV.L20:
   ;   FRED to sum tonne sorted by sieve 6
```

```
   ;against requirement for A2.5 can size
   @sum(SPECA2.No6)    ;summate tonne for sieve No6


SIV.M20:
   ;   FRED to sum tonne sorted by sieve 5
   ;against requirement for A10 can size
   @sum(SPECA10.No5)   ;summate tonne for sieve No5


SIV.N20:
   ;   FRED to obtain tonne /sieve
   @sum(K20:M20)   ;sum


SIV.B21:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C21+(D21/16)    ;decimalise inches
   )  ;end


SIV.C21:
   2


SIV.D21:
   3


SIV.H21:
   ;   FRED program to calculate peach half weight(g)
   ;   from exponential regression of weight on diameter(mm)
   @floor( ;round downwards
   (@LN($H$28)-$H$16)/$H$17    ;
   )  ;end


SIV.J21:
   4


SIV.K21:
   ;   FRED to sum tonne sorted by sieve 4
   ;against requirement for 1M can size
   @sum(SPEC1M.No4)    ;summate tonne for sieve No4
```

```
SIV.L21:
   ;FRED to sum tonne sorted by sieve 4
   ;against requirement for A2.5 can size
   @sum(SPECA2.No4)    ;summate tonne for sieve No4


SIV.M21:
   ;-FRED to sum tonne sorted by sieve 4
   ;against requirement for A10 can size
   @sum(SPECA10.No4)   ;summate tonne for sieve No4


SIV.N21:
   ;   FRED to obtain tonne /sieve
   @sum(K21:M21)   ;sum


SIV.A22:
   57


SIV.B22:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C22+(D22/16)    ;decimalise inches
   )  ;end


SIV.C22:
   2


SIV.D22:
   4


SIV.J22:
   3


SIV.K22:
   ;   FRED to sum tonne sorted by sieve 3
   ;against requirement for 1M can size
   @sum(SPEC1M.No3)    ;summate tonne for sieve No3


SIV.L22:
   ;FRED to sum tonne sorted by sieve 3
```

```
   ;against requirement for A2.5 can size
   @sum(SPECA2.No3)    ;summate tonne for sieve No3


SIV.M22:
   ;FRED to sum tonne sorted by sieve 3
   ;against requirement for A10 can size
   @sum(SPECA10.No3)   ;summate tonne for sieve No3


SIV.N22:
   ;   FRED to obtain tonne /sieve
   @sum(K22:M22)   ;sum


SIV.A23:
   58


SIV.B23:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C23+(D23/16)    ;decimalise inches
   )   ;end


SIV.C23:
   2


SIV.D23:
   5


SIV.H23:
   7


SIV.J23:
   2


SIV.K23:
   ;   FRED to sum tonne sorted by sieve 2
   ;against requirement for 1M can size
   @sum(SPEC1M.No2)    ;summate tonne for sieve No2
```

```
SIV.L23:
   ;   FRED to sum tonne sorted by sieve 2
   ;against requirement for A2.5 can size
   @sum(SPECA2.No2)    ;summate tonne for sieve No2


SIV.M23:
   ;   FRED to sum tonne sorted by sieve 2
   ;against requirement for A10 can size
   @sum(SPECA10.No2)   ;summate tonne for sieve No2


SIV.N23:
   ;   FRED to obtain tonne /sieve
   @sum(K23:M23)   ;sum


SIV.A24:
   60


SIV.B24:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C24+(D24/16)    ;decimalise inches
   )   ;end


SIV.C24:
   2


SIV.D24:
   6


SIV.J24:
   1


SIV.K24:
   ;   FRED to sum tonne sorted by sieve 1
   ;against requirement for 1M can size
   @sum(SPEC1M.No1)    ;summate tonne for sieve No1


SIV.L24:
   ;   FRED to sum tonne sorted by sieve 1
```

```
   ;against requirement for A2.5 can size
   @sum(SPECA2.No1)    ;summate tonne for sieve No1


SIV.M24:
   ;FRED to sum tonne sorted by sieve 1
   ;against requirement for A10 can size
   @sum(SPECA10.No1)   ;summate tonne for sieve No1


SIV.N24:
   ;   FRED to obtain tonne /sieve
   @sum(K24:M24)   ;sum


SIV.B25:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C25+(D25/16)    ;decimalise inches
   )   ;end


SIV.C25:
   2


SIV.D25:
   7


SIV.H25:
   ;   FRED to calculate average weight
   ;   for selected sieve stack configuration
   @floor(     ;round downwards
   @avg(M8:M13))  ;calculate mean for sieve stack


SIV.K25:
   ;   FRED to sum tonne/can size
   @sum(SPEC1M.TonOpt)     ;sum


SIV.L25:
   ;   FRED to sum tonne/can size
   @sum(SPECA2.TonOpt)     ;sum
```

```
SIV.M25:
   ;   FRED to sum tonne/can size
   @sum(SPECA10.TonOpt)    ;sum


SIV.N25:
   ;   FRED to obtain tonne /sieve
   @sum(K25:M25)   ;sum


SIV.A26:
   63


SIV.B26:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C26+(D26/16)    ;decimalise inches
   )   ;end


SIV.C26:
   2


SIV.D26:
   8


SIV.K26:
   ;   FRED to sum required tonne
   @sum(SPEC1M.Tonne)      ;sum


SIV.L26:
   ;   FRED to sum required tonne
   @sum(SPECA2.Tonne)      ;sum


SIV.M26:
   ;   FRED to sum required tonne
   @sum(SPECA10.Tonne)     ;sum


SIV.N26:
   ;FRED to sum TOTAL required packing tonne
   @sum(SPEC1M.Tonne,SPECA2.Tonne,SPECA10.Tonne)   ;sum
```

```
SIV.A27:
   67


SIV.B27:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C27+(D27/16)    ;decimalise inches
   )  ;end


SIV.C27:
   2


SIV.D27:
   10


SIV.G27:
   34


SIV.H27:
   28


SIV.K27:
   ;   FRED to select lightest specified half
   @min(SPEC1M.Wt1:SPEC1M.Wt6)     ;minimum weight adjusted


SIV.L27:
   ;   FRED to select lightest specified half
   @min(SPECA2.Wt1:SPECA2.Wt6)     ;minimum weight adjusted


SIV.M27:
   ;   FRED to select lightest specified half
   @min(SPECA10.Wt1:SPECA10.Wt6)   ;minimum weight adjusted


SIV.B28:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C28+(D28/16)    ;decimalise inches
   )  ;end
```

```
SIV.C28:
   2


SIV.D28:
   12


SIV.H28:
   75


SIV.K28:
   ;   FRED to select heaviest specified half
   @max(SPEC1M.Wt1:SPEC1M.Wt6)     ;maximum weight adjusted


SIV.L28:
   ;   FRED to select heaviest specified half
   @max(SPECA2.Wt1:SPECA2.Wt6)     ;maximum weight adjusted


SIV.M28:
   ;   FRED to select heaviest specified half
   @max(SPECA10.Wt1:SPECA10.Wt6)   ;maximum weight adjusted


SIV.A29:
   74


SIV.B29:
   ;   FRED to convert inches to mm
   25.4*(  ;constant
   C29+(D29/16)    ;decimalise inches
   )   ;end


SIV.C29:
   2


SIV.D29:
   14


SIV.H29:
   ;   FRED to calculate mean weigt of specifications
```

```
   @floor(     ;round downwards
   @avg(SPEC1M.Wt1:SPEC1M.Wt6,     ;calculate mean
   SPECA2.WT1:SPECA2.Wt6,      ;from specifications
   SPECA10.Wt1:SPECA10.Wt6)    ;in database
   )  ;end


SIV.K29:
   ;  FRED to calculate mean specified weight
   @floor(     ;
   @avg(SPEC1M.Wt1:SPEC1M.Wt6)     ;maximum weight adjusted
   )  ;end


SIV.L29:
   ;  FRED to calculate mean specified weight
   @floor(     ;round downwards
   @avg(SPECA2.Wt1:SPECA2.Wt6)     ;mean weight adjusted
   )  ;end


SIV.M29:
   ;  FRED to select mean specified weight
   @floor(     ;
   @avg(SPECA10.Wt1:SPECA10.Wt6)   ;maximum weight adjusted
   )  ;end


SIV.H30:
   ;  FRED to calculate
   @ceiling(   ;round upwards
   ($H$28-$H$27)   ;Range
   *10^2/$H$25)    ;CV


SIV.K30:
   ;  FRED find max CV
   @ceiling(@avg(SPEC1M.CorCntCV))     ;mean count


SIV.L30:
   ;  FRED find max CV
   @ceiling(@avg(SPECA2.CorCntCV)) ;


SIV.M30:
   ;  FRED find max CV
   @ceiling(@avg(SPECA10.CorCntCV))    ;
```

```
SIV.H31:
   ;   FRED to calculate sieve stack weight interval
   @ceiling(($H$28-$H$27)/($H$23-1))   ;compute and round upwards


SIV.K31:
   ;   FRED to calculate weight interval
   @ceiling((K28-K27)/($H$23-1))   ;compute


SIV.L31:
   ;   FRED to calculate weight interval
   @ceiling((L28-L27)/($H$23-1))   ;compute


SIV.M31:
   ;   FRED to calculate weight interval
   @ceiling((M28-M27)/($H$23-1))   ;compute


SIV.K32:
   2


SIV.L32:
   4


SIV.M32:
   10


SIV.K33:
   ;   FRED to select maximum Range for count
   @max(SPEC1M.CntR)   ;select


SIV.L33:
   ;   FRED to select maximum Range for count
   @max(SPECA2.CntR)   ;select


SIV.M33:
   ;   FRED to select maximum Range for count
   @max(SPECA10.CntR)  ;select
```

```
SIV.K34:
   ;  FRED to select minimum Range for count
   @min(SPEC1M.CntR)   ;select


SIV.L34:
   ;  FRED to select minimum Range for count
   @min(SPECA2.CntR)   ;select


SIV.M34:
   ;  FRED to select minimum Range for count
   @min(SPECA10.CntR)  ;select


SIV.K35:
   ;  FRED to calculate percentage Sorting Efficiency (SE)
      @beep,       ;beep
      K25/K26*100 ;% SE 1M weights


SIV.L35:
   ;  FRED to calculate percentage Sorting Efficiency (SE)
   @beep,       ;beep
   L25/L26*100      ;% SE A2.5 weights


SIV.M35:
   ;  FRED to calculate percentage Sorting Efficiency (SE)
   @beep,       ;beep
   M25/M26*100      ;% SE A10 weights


SIV.N35:
   ;  FRED to calculate percentage Sorting Efficiency (SE)
   @beep(600,50),       ;beep
   N25*10^2/N26     ;% SE overall
```