An Estimation of the Health Implications of Chemical Contaminants in Food and Water a Total Diet ("Market Basket") Study

H O Fourie

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AN ESTIMATION OF THE HEALTH IMPLICATIONS OF CHEMICAL CONTAMINANTS IN FOOD AND WATER A TOTAL DIET ("MARKET BASKET") STUDY

by

H O FOURIE

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**Faculty of Medicine
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EXECUTIVE SUMMARY

Chemicals used in agricultural activities, could possibly be the most potent group of compounds used on a regular basis by employees representing a significant fraction of the unskilled, economically active, labour market of a country. Certainly such a statement will hold true for South African and probably for most Third World and developing states. All chemical compounds contain the inherent property of being toxic and/or hazardous. However, pesticides are chemicals *intentionally* used to *kill*. They are therefore not avoidable and in contrast to other chemicals are used only because of their ability to kill.

As in most other countries in the world, poisoning in the Republic of South Africa is to be expected due to the use of pesticides. In the handling of pesticides, statistics show South Africa to be vulnerable to an appreciable number of deaths and poisoning cases. There could be a number of reasons for this phenomenon, two of them probably being ignorance and negligence on the part of officers in charge of handling pesticides, and perhaps the most important, the exploitation of unskilled labour in applying and handling pesticides. It is believed that the South African agricultural industry represents both the First and Third World and should thus be ideally suited for investigating:

- **Acute intoxication due to chemicals used in the agricultural industry.**

  It was found that the annual consumption of pesticides in the Republic of South Africa results in a dose of approximately 250 mg/m^2 which compares very favourably with consumption rates of developed countries. An analysis of the products registered for use in the RSA indicates a total of 1 211 products containing 359 different active ingredients. The three chemical groups responsible for 73% of the poisoning cases (organophosphates 55%, carbamates 14%, organochlorines 4%) are with the exception of pyrethroids, also the chemicals most frequently formulated. Products containing these three chemical groups constitute only 41% of all formulated products, but are responsible for 73% of all intoxications. It is concluded that the poisoning rate by pesticides is appreciably higher than officially notified, and that the fatality rate could be two orders of magnitude higher than that of developed countries. A compendium - the first of its kind in South Africa - for use by hospitals and clinical practitioners and containing trade names, chemical classification, active ingredients, toxicology, symptomatology and proposed treatment procedures for each product, is presented as an appendix.

- **Chronic exposure to residues of agricultural products in the diet of South Africans.**

  Food intake data was calculated from 24-hour dietary recall studies. Residues of only 4 compounds were present in 33 composite, ready-to-eat foods, consisting of 5 538 foodstuffs sampled over a period of one year country wide, and representing 142 different food items categorised into 11 food groups. The residues found were well within acceptable levels and compare very favourably with those found in the diets of developed countries. It has to be concluded that possible chronic exposure due to agricultural chemical contaminants, to the white population at least, does not exist, and emphasises a sound regulatory policy towards the use of these chemicals in South Africa.

- **A hypothesis of this study that it is not possible that neither the inherent toxicities of pesticidal compounds, nor a paucity of knowledge about the toxicological, chemical and physical properties of these compounds could be mainly responsible for the numerous intoxications recorded annually.**

  An epidemiological 400 case study (descriptive design), investigated the contribution by occupational, environmental, cultural and socio-economic variables to poisoning. The numerous effects by these variables are described and amongst many others, it is concluded that the recommendations of the World Health Organization to classify pesticides by hazard, is confusing to illiterate and semi-educated users and should not be recommended to developing countries.

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INTRODUCTION

National authorities have the responsibility and obligation to ensure that toxic chemicals such as pesticides and other contaminants are not present in food and water at levels which may adversely affect the health of consumers.

The public as well as workers may be exposed to hazardous chemicals through emissions to air, water and soil from industrial plants, through accidents and spillage during transport, storage and use, through inadequate waste disposal methods, or by ingestion of contaminated water and food. Consumers are exposed to a wide range of chemical products in the home and elsewhere.

Chemicals are indispensable commodities for the survival of mankind, and for all forms of life for that matter. We acknowledge the fact that chemical compounds make up the air we breathe, the food we eat and the energy we use. Scientific literature is literally a vast body of data on the necessity of chemicals for survival on the one hand, and of disasters and effacement on the other hand. If not used correctly, responsibly, with care and respect, chemicals can have a very serious detrimental effect on man and the ecology. Man is directly exposed to chemicals when the chemicals <u>per se</u> are consumed orally or through the skin and indirectly when consumed through the environment, such as air, water and foodstuffs. Ingesting chemicals through foodstuffs, for

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example, can be serious because many a chemical compound has a long effective life with the tendency to accumulate to extraordinary concentrations in the food chain. Many of these chemical compounds are also subjected to biochemical changes which could introduce a totally different compound with even more hazardous properties than the parent compound.

The effect of chemicals on the health of man depends on their chemical and physical properties, the duration and frequency of exposure, accumulation and metabolism and the ability of the human being to offer resistance. The embryo, foetus and certain segments of the general population such as children, the elderly and the sick are more susceptible to the toxic affect of chemicals. Accidental exposure to toxic compounds has reached epidemic proportions in the past two or three decades. An example of such an event is the mass poisoning by organo-mercury compounds in Japan. Chemicals can have a detrimental effect on fauna and flora such that species may be endangered, while chemicals could also influence local and global weather conditions. Examples are the effects of air pollution and of oxides of nitrogen and fluorocarbons on the ozone layer in the upper atmosphere. It is obvious to what extent chemicals can pollute fresh and marine water systems. Aquatic life is vulnerable to low concentrations of metal pollution and it is easy to pollute to the extent where aquatic life could be exterminated.

The modern chemical industry produces a large quantity of chemicals to be used in virtually every commodity and it would not be wrong to state that these chemicals should protect, prolong and enhance life. However, the indiscriminate use of such chemicals could achieve just the opposite. Although the literature differs (understandably) on the exact amount of chemicals produced worldwide, estimates are all within the same order of magnitude.

The following estimates which do not differ significantly with those published by the WHO, were reported by Leslie Roberts (1984): 5 000 000 known chemical substances of which only about 7 000 have been tested for carcinogenicity. Of these, 1 500 have been identified as being carcinogenic in animal studies, of which 30 have definitely been linked to cancer in humans. With reference to pesticidal chemicals in relation to total chemicals, the impact of pesticidal chemicals on environmental quality has received much more attention. This is an anomaly which should be rectified as <u>total chemicals, with an annual world production of several hundred million tons</u>, need to be considered (Korte, 1980). Studies in the aquatic environment on a worldwide basis have identified 2 221 different organic compounds of which 765 are in drinking water. Of these, 43 are suspected carcinogens, 56 are mutagenic contaminants and 18 are carcinogenic promoters (Bedding, N.D. <u>et al</u>, 1983).

The generation and disposal of wastes are a major problem for the chemical industry. Through (1) dispersion in air and water, (2) the relative ease of environmental degradation and (3) the often resultant toxicity of the degraded chemicals, waste disposal could be <u>the</u> major disaster to ecosystems and to man and his environment. The fact that such wastes are:

1. usually dumped in enormous amounts in a confined area;
2. usually in drums or other containers which inhibit degradation and facilitate a continuous release; and
3. usually of a mixed and very complex chemical nature,

emphasizes the much greater possibility of local contamination rather than an evenly dispersed, less densely concentrated phenomenon.

Thus, chemical wastes generated by domestic, agricultural and industrial activities would ultimately contaminate natural waters and therefore affect survival, growth and reproduction of organisms. Recreational and agricultural interests in aquatic ecosystems will likewise not only be negatively affected by the release of wastes but could also affect the health detrimentally through toxic contaminants in drinking water. Wastes must therefore be regarded as potential pollutants with poisoning properties. In fact, it has been suggested that from an environmental and ecotoxicological point of view, a waste should be regarded as a poison causing pollution and that a waste could be defined as a substance or material which falls into disuse and differs in its chemical or physical properties from its natural or original occurrence in nature, or which, due to synthetic preparation, does not naturally occur in nature.

The extent to which waste is generated worldwide is not known. For some reason such data, as far as volumes are concerned, are also not dealt with in scientific literature. It is, however, dealt with in the day-to-day press, from which it is possible to get some idea of the magnitude of the problem:-

1. "The Canadian federal government estimated in 1982 that at least 3,2 million tons of hazardous wastes are generated in Canada each year" (Jackson, 1982).

2. "State and federal officials have filed a $40 million lawsuit against 31 defendants who owned, operated or disposed of toxic wastes at the notorious Stringfellow acid pit in riverside country" (Los Angeles Times, 1983).

3. "The EPA has identified at least 11 000 additional sites that remain active as toxic wastes continue to pour in. Other estimates place the figure as high as 50 000" (Washington Post, 1983).

4. "In 1980, according to EPA figures, US industry generated more than 400 pounds of hazardous waste for every man,

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woman and child in the country. It all went to an incinerator, as landfill or some other storage facility. EPA has estimated that 90% of these facilities have inadequate environmental safeguards and 75% of the landfill sites are close to wetlands, aquifers or flood plains" (Washington Post, 1983).

5. "... about 200 drums had identifying marks. Asked how many drums were removed during that phase, he replied: 'Somewhere between 4 400 and 4 700'" (Washington Post, 1983).

6. "At the Seymore recycling dump near Seymore, 24 firms ... to pay $7,7 million to clean up ... more than 50 000 drums and 500 000 gallons of liquid waste" (Washington Post, 1983).

7. "... and made a ghost town of Times Beach, Missouri, permanently evacuated in 1983. Dusty dirt roads there had been sprayed a decade earlier with oil contaminated by dioxin" (National Geographic, March 1985).

8. "EPA lists 786 Superfund sites nationwide, has fully cleaned 12 and expects eventually to purge 1 500 to 2 500 at a cost of as much as 23 billion dollars" (National Geographic, 1985).

Although these citations are only representative for the United States of America and for Canada, there is no reason why they should differ from other industrialized countries. On the other hand, many other countries, of which the Republic of South Africa is one, will become heavily industrialized in the near future and it would be grossly irresponsible not to take cognizance of the problems encountered by the developed countries when industrialization take place without a firm national policy on waste management.

WATER AND FOOD

A relatively small surface area in the RSA is available for agricultural production of food. Thus for a fast growing population, more food has to be produced per unit area to provide in domestic needs. This means that use have to be made of agricultural chemicals and it should be expected that this volume would grow substantially towards the year 2000.

To ascertain whether a consumer is at risk or not, it is necessary to estimate the actual intake (dietary intake) of a contaminant for comparison with acceptable daily intakes. The acceptable daily intake (ADI) of a chemical is the intake which, through an entire lifetime, will be without appreciable risk on the basis of all known facts at the time.

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The process of determining the exposure of a population to chemical residues in the diet is thus indispensable for risk assessment. Also would the providing of information on environmental levels of pollutants in food, water and air aid in the determining of priorities for the selection of pollution control strategies and develop a basis for taking sound environmental management and regulatory decisions.

Dietary intake studies provides the information needed to assess potential health problems and the exposure to environmental pollutants. The consumption of "contaminated" food and beverages, constitutes only a variable part of total food and water consumption. Likewise, cooking and preparation of foods may change the concentration of contaminants. The individual habits in food preparation and the choice of various foods and beverages is thus of the utmost importance.

With reference to the intake as well as preparation of foods, water must always be included in the dietary intake study. Not only is water <u>per se</u> consumed, but it is used for cooking and for making beverages. It is used in the reconstitution of dehydrated foods and in the cooking of food which is typical of that used by the population group under study. As an example, in a typical USA total diet, beverages including water, (but excluding water used for cooking and with evaporated milk powder, as well as beer, wine, ale etc.) forms 22.5% of the total diet. When carbonated and non-carbonated soft drinks, beer, ale and orange juice is included, (but cooking excluded), water forms 40% of their diet.

Intake of drinking water varies significantly between communities and between individuals. Should the intake of water <u>per se</u> be calculated from the literature, then it would amount to approximately an average of 1,2 liters per day (0,1 to 9,8) for adults, and 800 ml/day for babies and small children. For healthy people the water intake from all sources closely matches the amount lost by the urine, faeces, etc., maintaining a state of equilibrium. Between individuals this varies widely, but on average amounts to 2,5 liters per day.

All food derived from living or dead material contains water, which in their metabolism has much the same functions as in humans. Foods, such as fruits and vegetables, can be regarded as living organisms until cooked. For many fresh animal foods (milk, meat, fish, eggs) the water content ranges from about 65 to 87%, the largest content being in meat, poultry, fish, fruit, leafy brassicas, potatoes, however but in meat and fish, the water content depends greatly on the fat content; e.g., herring (fatty) holds more water than cod or haddock. Water makes up from two to nearly seven times the quantity by weight of dry solids present and in fruit and vegetables, 75 to 98% is water. Some foods (sugar, chocolate and cooking

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oil) contain less than 1% water; starches, flour and biscuits contain from 5 to 15%. The water content of foods which come direct from animals, such as milk and eggs, is fairly constant because the functioning of these products in their natural state requires close control of this component. In others, e.g., fruit and vegetables, there is less close biological control; so much depends on various factors, such as weather and species. The water content of apples varies from 75 to 85%, of potatoes from 65 to 85%, of spinach from 85 to 95%. The water content of plant tissues changes after harvesting because of physical water losses and metabolic changes. Losses in stored foods, such as fruit, potatoes, eggs, in contact with air depends on storage temperature, humidity and air movement (British Food Journal, October 1978).

The significance of trace concentrations of organic contaminants in drinking water to public health is largely inconclusive and controversial, since there is a general paucity of information concerning human health effects from which to draw conclusions. Exposure to such toxic organic compounds in drinking water is only a small percentage of the total exposure to these substances. Other routes of intake include food and air. A survey of pesticide levels in water in the United Kingdom revealed that even in the worst case the human intake of organochlorine insecticides from drinking water would not exceed 0.5% of the total dietary intake of such substances. Polynuclear aromatic hydrocarbons (PAH) ingested from drinking water may only amount to 0.1% of the intake from food sources. Many medical preparations contain a relatively large proportion of chloroform; a few spoonsful of such medicines is equivalent to a lifetime ingestion of chloroform from drinking water. The toxicity of a compound could depend upon its mode of ingestion (whether food or water, etc.) and also on whether or not it is adsorbed on particles. Perspective is, therefore, required in evaluating the problems posed by trace amounts of organic compounds in water (N.D. Bedding et al, 1983).

RISK ASSESSMENT

It is not possible to draw a line between safe chemicals and toxic chemicals. Toxicity is relative and is described as a relationship between dose and effect. Primarily an amount (dose) of a chemical is able to respond to some or other effect, an effect which could be either harmful or beneficial. What is important is that the effect is directly related to the dose and that the response to such a dose is a graded one i.e. related to progressive changes in dose and ultimately to a frequency distribution for the individual responders as a function of dose.

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Assessment of possible hazards once a compound has been released can be a complicated matter. Acute toxicity, which occurs rapidly often from a single dose, is of relatively little concern. Such an effect is cognizable in a short time after introduction and can be dealt with accordingly. Repeated small doses of a chemical can, however, lead to chronic effects which are usually more difficult to identify. Such effects, to make any assessments more difficult, can have one of the following characteristics (Bedding, 1983): (1) it might disturb metabolic systems in the long term, which could have important effects on disease patterns or susceptibility to diseases, or (2) it could have irreversible damage to deoxyribonucleic acid (DNA), an effect which may not be manifested within a human life span.

Health risk evaluation is the evaluation of the biological changes which are caused by chemicals. Risk is a statistical concept which measures the frequency of such undesirable effects and it forms the basis of regulatory control of exposure to such substances. However, risk as an absolute measure could never be the only criterion in the regulatory process. The beneficial qualities of a compound are as important and therefore risk assessment involves a risk/benefit ratio. In toxicology the risk/benefit ratio is not a controversial matter but is associated with conflicts of interest or even perhaps conflicts of necessity. In risk/benefit the people who enjoy the benefits are not always those that run the risks; for example the Eskimos in Alaska are exposed to Strontium-90 fallout through food-chains but do not gain anything by nuclear explosions.

Typical toxicological tests involves laboratory animals using large doses administered over short time intervals. This is in direct contrast to the situation in real life where small amounts of compounds are ingested over a human lifetime, and it is known that toxicity is dependent upon dose and period of exposure. There is therefore considerable uncertainty in estimating the magnitude of the risk to human health from the extrapolation of laboratory experiments. The possibility also exists that one compound can modify the toxicological effect of another. Synergism, antagonism and addition between two or more compounds can occur. Cocarcinogens or carcinogenic promoters are prime examples of synergism. Nevertheless, animal experimentation has to be relied on.

In order to assess potential health problems from the presence of toxic contaminants in the food supply, the extent to which actual dietary intakes approach or exceed a toxicologically acceptable daily intake (ADI) should be determined.

The acceptable daily intake of a chemical is the daily intake which, during an entire lifetime, appears to be without appreciable risk on the basis of all the known facts at the time. It is expressed in milligrams of the chemical per

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kilogram of body weight (mg/kg). It is calculated by the application of safety factors - compensation for factors influencing extrapolation - to the observed no adverse effect level (NEL) in animal studies (interpreted as a threshold level), on which risk assessment is based. There is controversy surrounding the presence or absence of a threshold level, particularly for carcinogens. A threshold level assumes that there is a minimum level below which no toxic or carcinogenic effect is realized. The general consensus is that there are no threshold limits for carcinogens. The threshold dose would in principle not be such a controversial matter if this principle was only to be used to demonstrate the existence of toxic effects. The threshold concept, however, is not only used to demonstrate the existence of a toxic effect but is widely applied to estimate the limits of safety by relying on laboratory experiments conducted on a limited number of animals over a relatively short period of time, and the results then extrapolated to man. Although these problems are dealt with statistically to be acceptable, it has to be admitted that in tests large doses are administered over a short period of time which is in direct contrast to the real life situation, where usually small amounts of a contaminant are ingested over a human lifetime.

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SUBACUTE AND CHRONIC EXPOSURE TO PESTICIDES IN SOUTH AFRICA

Toxicological tests for the determination of the toxicology of chemicals fall mainly into 3 categories, namely acute toxicity, subacute toxicity and chronic toxicity. Subacute tests, usually using animals of two species, and being continued for about 3 months by exposure on a daily basis, provides information on the toxic effects of the compound and the target organs affected. In chronic toxicity tests, the test animals are usually exposed for their entire lifetime to repeated doses, to establish the long term toxicological effect of the chemical. One of the main aims of these tests is to establish the no effect level used in setting acceptable daily intakes for man. It has to be appreciated that generally speaking, man is exposed most of his lifetime to low levels of many different chemicals. Usually these exposures occur at such low doses that signs of toxicity and dose-effect relationships are not easily established, and although epidemiological studies do assist in this respect, the degree of hazard due to low level exposure in man is not easy to assess. Thus subacute and chronic testing of chemicals by using animals to assess long term effects is unavoidable.

Pesticides in agriculture and public health are used to control insects harmful to man and animals. The problem of malnutrition in an ever growing world population, which necessitates the use of pesticides to maintain food production

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at an adequate level, is generally beyond dispute. Simultaneously however, it has to be fully acknowledged - also beyond dispute - that the many pesticidal chemicals used daily give rise to metabolites and degradation products with similar toxicological properties to the parent compounds. These residues are xenobiotics which can be more potent than the majority of chemicals encountered daily, and the fact that such a chemical is deliberately used to "contaminate" foodstuffs and animal feeds, is relevant to the concern expressed by the general public on the possible presence of such chemicals in foods. The general public is not wrong in regarding pesticides as a specific group of chemicals which they call poisons, and they should not be blamed for being suspicious about possible detrimental effects on their health. After all, as man is not infallible, history and literature is repleted with morbidity and mortality statistics due to agricultural chemicals, in one way or another.

It is therefore the obligation of a national authority to ensure that contaminants such as pesticides residues are not present in food at levels which may adversely affect the health of consumers. In the registration procedure of such a chemical, two parties are involved, i.e. the manufacturer and the government.

The contribution of the manufacturer is twofold:

(i) experiments are to be carried out to assess the safety of the compound. Such experiments could involve several years of work and may involve 80 separate parameters in hematology, clinical chemistry, urine analysis, electrocardiography, opthalmoscopy, organ weighing at death and extensive histopathology. A chronic study in rats, for example, will involve about 130 000 separate measurements and will comprise several volumes (Turnbull, 1984); and

(ii) experiments are to be carried out to determine the residues which may occur in crops when the product is used as recommended.

The contribution of the government is also twofold:

(i) The toxicity and residue data must be evaluated and reviewed in depth, to ascertain that the product will not be a health hazard when approved. A statutory maximum residue limit, determined by Good Agricultural Practice for a specific food commodity, has to be established and be used to establish an Acceptable Daily Intake (ADI).

(ii) It is also the responsibility of government to instigate residue monitoring programs to determine whether the approved residue levels in commodities are not being exceeded in practice.

Some perspective, however, has to be given to the intake of residue contaminants as a measure of exposure. When a maximum

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residue level is established by government, the established level is kept at the minimum and consistent with the use by good agricultural practice, which in most cases is far below the level considered to possibly give rise to toxicological effects. Thus a large margin of safety exists between level of consumption and a hazardous level. In contrast to this highly geared mechanism to nullify any possible detrimental effects due to consuming pesticide residues, two examples could be mentioned to illustrate the possibility of similar, if not much more serious, risks by chemicals commonly used. One such example is the use of chlorinated hydrocarbons. Most of these compounds, such as DDT and Dieldrin, have been prohibited for use in agriculture. However, many commercial halogenated derivatives are being extensively utilized as solvents, aerosol propellants, degreasing agents, dry-cleaning agents and in the production of plastics (British, 1984). Secondly, although natural, large numbers of mutagens and carcinogens are available in every meal and it has been emphasized that no human diet can be entirely free of such natural substances (Ames, 1983).

In many countries, governments have programs for the analysis of residues in crops (Duggan, 1983; GEMS, 1982; GEMS, 1983; GIFAP, 1984). In the Republic of South Africa residue determinations in raw agricultural commodities, are also being executed on a regular basis by health officials from local authorities, municipalities and State Departments. However, these studies are mostly done for surveillance purposes; samples being selected for infringement purposes, therefore not representative of total food supply or dietary habits of the general public. Generally, where diet studies have been carried out, the level of ingestion of residues has been lower than the recommended acceptable daily intakes (GIFAP, 1984), which emphasizes that caution must be taken in the interpretation of such data for any purpose other than those necessary for infringement studies.

It is also important to bear in mind that an individual is not only exposed to contaminants by food consumption. Exposure to heavy metals for example could be via ingestion or inhalation, and should such a contaminant be the object of concern, then the total risk in comparison to the ADI must take into account both sources of exposure.

OBJECTIVES OF STUDY

The main objective of this project was to obtain estimates of the intake of pesticide residues via food consumption and to correlate such data with acceptable daily intakes. Comparison of such results with the legal limits set per food contaminant will disclose whether the individual or population is exposed to chronic exposure and therefore indicate whether current regulatory practices are adequate to protect all consumers.

The Republic of South Africa also exports foodstuffs and therefore have to comply with the regulatory pesticidal residue limits of the importing countries. It is also believed that initiating such a project would stimulate regulatory authorities to adopt a coordinated official food safety program from which the monitoring data could be effectively utilized to (1) evaluate the current situation of dietary intakes of contaminants; (2) predict potential exposures to residue contaminants; and (3) create an awareness of responsibility to utilize the existing resources of manpower, facilities and finance to maximum advantage of the population as a whole.

METHODS AND DESIGN OF STUDY

It was not the object of this study to make food intake assessments. It was the aim of this project to derive intakes of contaminants, and therefore all available data on food consumption patterns in the Republic of South Africa have been used to develop a sampling program. In fact not much consumption data representative of an entire ethnic population in the RSA was available, nor was it possible to determine the absolute validity of such dietary survey data. It is also realized that existing surveillance data, accumulated for infringement purposes, is inadequate for the current objectives and that the daily intake of a contaminant must be based on available food consumption data.

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Food data intake was calculated from 24-hour dietary recall studies which were undertaken in the Cape Peninsula and three rural towns (Rossouw, 1983; Steyn, 1985). Although the studies by Rossouw and Steyn were undertaken for totally different objectives, the data presented could be used for the present study. The interviewers used in their study were graduated dieticians familiar with such techniques and therefore the data is regarded as reliable.

Normally, the 24-hour recall method is only suitable when several 24-hour recalls per person are undertaken (GEMS, 1983). However, it has been established that a single 24-hour recall within a large population does reflect reliable average long-term intakes since the group mean values obtained by this approach do not vary significantly on a day-to-day basis (GEMS, 1983).

Three approaches (GEMS, 1983), based on food consumption data, were available for the estimation of the daily intake of a contaminant:

(1) Total diet ("Market Basket") studies;

(2) selective studies of individual foodstuffs; and

(3) duplication portion studies.

Only one of these approaches (total diet) was used, but it should be realized that, because this study had not been done before in South Africa and because a single study to reflect the average intake of a contaminant for the population as a

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whole is not feasible due to the diversity of ethnic groups in South Africa, it might be necessary in future to use the total diet as well as the selective studies of individual foodstuffs, approaches.

The market basket approach entails table-ready prepared foods of a defined total diet consumption. Food commodities are combined in food group composites in proportions based on consumption data, and each group analyzed separately for the different contaminants selected. Such analyses allow calculations for each composite group - which will reflect the distribution of contaminants amongst composite groups - as well as for the diet as a whole.

The individual foodstuffs approach involves the separate analysis of each food component of a food group in its unprocessed state. This method will not only allow daily intakes to be calculated, but will also (1) allow the calculation of daily intakes for any ethnic group if consumption data are available; and (2) allow assessment of possible contamination of foods as well as possible losses of contaminants due to the table-ready preparation of commodities. If no consumption data is available for a particular ethnic group, theoretical consumption data could be used in combination with those from the individual foodstuffs approach to calculate the probable daily intake of contaminants.

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Sampling sites chosen were representative of all the geographically important cultural regions within the country, These were the major cities from the four provinces including six rural towns:

Cities

Cape Town plus one rural town
Port Elizabeth plus one rural town
Durban plus one rural town
Kimberley plus one rural town
Bloemfontein plus one rural town
Johannesburg
Pietersburg plus one rural town

Sampling was done during the months of July, October and January/February, from supermarkets and butcheries normally available to the public.

A standard shopping list was developed describing the food item and quantity to be supplied. The 142 food items were arranged according to the following 11 food classes:

	Food class	Number of items
1.	Vegetables	13
2.	Fruit	8
3.	Meat, meat products and poultry	24
4.	Cereals	33
5.	Eggs	1
6.	Fish	6
7.	Soup	7
8.	Fat and oils	3
9.	Milk and milk products	18
10.	Sugars and sweets	12
11.	Beverages	17
	TOTAL	142

Sampling was done on the same day at the 13 locations during summer, spring, winter/autumn and transported by air, under refrigerated conditions to the analyzing laboratories in Cape Town. Thus for each sampling, 1 846 food items from the 13 locations were sampled, which totalled 5 538 food items for the three calendar periods.

One of the laboratories was established as a kitchen facility. On receipt of each batch of 1 846 samples, samples were categorized and prepared according to flow-diagrams 1 to 11. Samples to be prepared as ready-to-consume foods, were processed according to a pre-prepared cookbook to standardize all methods used, which consisted of typical, normal household recipes consistent with cultural habits. Mixing, blending and homogenization of samples were done carefully to obtain representative samples. Although all possible care was taken not to contaminate any samples, equipment and containers used were those typical of a South African kitchen so that normal contamination or loss of contaminants, if any, would be reflected in the analytical results. Prepared samples were frozen in large mouth glass containers until analysis could be done.

Analyses were done at the Chemical Health Laboratories of the Department of National Health and Population Development in Cape Town. After food preparation and composition into the 11 groups, each group was analyzed separately by multi-residue procedures, covering a wide range of contaminants. All samples, composite and individual, were analyzed for organochlorine, organophosphate and polychlorinated biphenyl (PCB) residues, cadmium and lead. For this specific study, however, only the results of organochlorine and organophosphate residues on the composite samples of the market basket study will be reported on, being those residues from pesticides to indicate possible chronic exposure of the population at large.

Analyses of organochlorine and organophosphate residues were done by gas/liquid chromatography after extraction and cleanup procedures. Because diet samples contain fat, fat assays of each food or food group were done in advance to facilitate calculations of results and to ensure compatibility with established analytical methods. For the determination of organochlorine compounds, two gas/liquid chromatography systems were used employing stationary phases of different polarities and fitted with electron-capture detectors. Residues were separated from fat extracts by gel permeation chromatography. For the determination of organophosphate residues, two gas/liquid chromatography systems with columns of different polarities were used. Instruments used were equipped with flame-photometric detectors operating in the phosphorous mode. Confirmations were carried out on a third gas chromatograph with different columns.

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RESULTS AND DISCUSSION

Most countries where maximum pesticide residues are regulated in food commodities, routinely use quantitative, multi-residue, gas-liquid chromatographic methods in either surveillance or total diet monitoring programs. More than 300 pesticide residues are being analyzed using these methods, although their limits of detection could differ substantially due to matrixes (fatty and non-fatty foods), recoveries and analytical capabilities. The limits of quantification for the residues determined in this study (Table 13) typically varied between 0,01 to 0,03 ppm and may even be better using larger sample aliquots after cleanup procedures.

The distribution of items in the food consumption survey are given in Tables 1 to 11, while the total diet consumption for the white population is given in Table 12. Tables 1 to 11 also include the daily consumption of each food item, the amounts purchased, and whether cooking preparation was required or not. In order to obtain a large enough sample for duplicate analysis, a seven day sample was composited from each food group. The schematic sequences of the preparation of the different food groups are given in the flow-diagrams 1 to 11.

The eleven food groups contained 142 food items sampled at 13 locations country wide. The total diet of the white

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population compared favorably with those from other countries (GEMS, 1982; GEMS, 1983):

	Austria	Canada	Guata-mala	Japan	New Zealand	U.K.	USA	South Africa
Consumption g/day	1 650	1 034	1 553	1 400	3 310	1 500	2 900	1 995
Population group	Adult	Average person	-	Average Male	Young Man	Average Person	Teenage Male	Adult
Number of food items	-	120	41	90	-	78	117	142
<u>Beverages</u>: Alcoholic	Yes	-	No	Yes	Yes	No	No	Yes
Drinking Water	Yes	No	No	Yes	-	No	Yes	No
Number of composites	8	11	12	14	8	9	12	11

Residues were found in 8 (73%) of the diet groups (Table 14), with no residues found in soups, sugars and beverages. DDT, dieldrin and dicloran were present in 7 groups, while the organophosphate mercaptothion was only present in cereals. It is somewhat surprising to find residues of mercaptothion in grains and not in fruits and vegetables as this compound is extensively used in the latter, although the maximum residue levels allowed in fruits and vegetables are much lower (2 to 4 mg/kg) than in grain (8 mg/kg). It is also surprising to find mercaptothion residues at a concentration of 0,05 mg/kg in ready-to-eat cereals. Duggan (1983) reported malathion residue levels of 0,234 to 0,790 mg/kg in grain for human consumption for the years 1970 to 1976 in the USA, but also reported the concentration to be only 0,020 mg/kg in their cereal products. However, although 0,05 mg/kg mercaptothion in the RSA cereals seems to be at a marginally higher level than in the USA, the daily intake of 11,1 ug/day due to this compound (Table 14) results in only 0,000 19 mg/kg body weight/day, which is only 0,9% of the acceptable daily intake (Table 15).

Tables 14 and 15 also indicate the levels of DDT, dieldrin and dichloran found in the diet study. DDT and dieldrin are persistent organochlorines and occur at low levels, i.e. 0,6% and 6% of the acceptable daily intakes, respectively. Although total dichloran results in only 0,5% of the acceptable daily intake, residues of this compound should not be present in the vegetable group (Table 14), being only permitted for use on peaches (Bot, 1985).

SUMMARY

Residues of only 4 compounds were present in 33 composite, ready-to-eat foods, consisting of 5 538 foodstuffs sampled over a period of one year country wide, and representing 142 different food items categorized into 11 food groups. The residues found were well within acceptable levels and compare

very favourably with those found in the diets of developed countries. It has to be concluded that possible cronic exposure due to agricultural chemical contaminants, to the white population at least, does not exist, and implies a sound regulatory policy towards the use of these chemicals in South Africa.

The community in South Africa consists of Black, Coloured and White population groups with different cultures and socio-economic standards. Therefore, this market basket study was duplicated to include ready-to-eat foods as well as selective studies of individual foodstuffs which, due to the analysis of each unprocessed individual food component will allow the calculation of daily intake for any ethnic group, if consumption data are available. The individual food components are currently being analysed and the results will be used to calculate daily intakes of contaminants for all population groups concerned.

TABLE 1

TOTAL DIET STUDIES - ADULT

GROUP I : VEGETABLES					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Beans fresh	200 gram	20,5	X		143,5
Beetroot fresh	100 gram	5	X		35
Beetroot bottled	1 bottle	2,8		X	19,6
Cabbage fresh	100 gram	0,51		X	3,6
Cabbage fresh	-	4,4	X		30,6
Carrot fresh	1 bunch	7,3		X	51
Carrot fresh	-	8,3	X		57,9
Peas canned	250 gram	9,1	X		63,8
Lettuce fresh	1 head	1,9		X	13,3
Pumpkin fresh	100 gram	8,9	X		62,6
Squash fresh	100 gram	8,9	X		62,6
Sweet potato fresh	100 gram	8,2	X		57,7
Potato fresh:	1 000 gram				
roasted		25,4	X		177,8
chips		7,3	X		51,1
mashed		19,8	X		138,9
peeled		41,2	X		289,1
Tomato fresh	500 gram	31		X	217,2
Tomato canned	250 gram	2,6		X	18,2

TABLE 2

TOTAL DIET STUDIES - ADULT

GROUP II : FRUIT					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Apples fresh	500 gram	25,9		X	419,3
Pear fresh	200 gram	19,7		X	137,9
Pear canned	250 gram	0,72		X	5,04
Grapes fresh	500 gram	59,6		X	417,2
Orange fresh	100 gram	4		X	28
Peach fresh	300 gram	38,2		X	267,4
Peach canned	250 gram	3,8		X	26,3
Peach dried	100 gram	6,2		X	43,5

TABLE 3

TOTAL DIET STUDIES - ADULT

GROUP III : MEAT					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Bacon	100 gram	0,46	X		3,2
Ham smoked	100 gram	0,37		X	2,6
Brawn	100 gram	0,36		X	2,5
Polony	100 gram	3,1		X	21,7
Pork sausage	100 gram	0,59	X		4,1
Pork chops	100 gram	4,5	X		31,2
Mutton stew	100 gram	5,9	X		41,3
Mutton chops	100 gram	8,9	X		62,2
Mutton leg chops	400 gram	38,2	X		267,6
Beef sirloin	100 gram	11	X		76,9
Beef rump steak	200 gram	11,1	X		77,7
Beef stew meat	100 gram	4,9	X		34
Beef mince meat	500 gram	18,7	X		130,7
Beef liver	100 gram	2,6	X		18,5
Beef sausage	200 gram	11,7	X		81,9
Vienna sausage canned	250 gram	1,4		X	9,8
Frankfurters	100 gram	1,2	X		8,4
Sausage roll/meat pie	1	1,2		X	8,4
Beef patties	100 gram	0,86	X		6,0
Steak and kidney pie	1	0,71		X	5,0
Corned beef canned	250 gram	1,2	X		8,4
Chicken	100 gram	11,0	X		76,7
Chicken pie	1	0,36		X	2,5

TABLE 4

TOTAL DIET STUDIES - ADULT

GROUP IV : CEREALS					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Bread white	1 loaf	47,1		X	330
Bread brown	1 loaf	49,4		X	346
Bread whole wheat	1 loaf	17		X	119
Crisp bread whole wheat	1 pkt	0,59		X	4,1
Rusks whole wheat	1 pkt	3,4		X	23,8
Rusks white	1 pkt	9,1		X	63,8
Cookies commercial	1 pkt	2,3		X	16,4
Biscuits commerial	1 pkt	0,11		X	0,8
Cake homemade	1 cake	3,2		X	22,4
Cake chocolate	1 cake	1,1		X	7,9
Cake flour (vetkoek)	1 pkt	2	X		14
Swiss roll	1	0,24		X	1,7
Tart/pie: apple	1	1,4		X	9,8
jam	1	0,54		X	3,8
caramel	1	1		X	7,0
coconut	1	0,29		X	2,0
lemon	1	0,13		X	0,9
milk	1	2,7		X	18,9
savory	1	1,2		X	8,4
fruit	1	0,59		X	4,1
Oats	500 gram	10,8	X		75,6
Tastee wheat	500 gram	0,19		X	1,3
Maltabella	1 tin	1,5	X		10,5
All-bran	1 pkt	0,51		X	3,6
Corn flakes	1 pkt	0,83		X	5,8
Wheatbix	1 pkt	2,1		X	14,7
Pro-nutro	1 pkt	2,2		X	15,4
Rice crispies	1 pkt	0,27		X	1,9
Rice white	500 gram	39,9	X		279,1
Rice brown	500 gram	0,07	X		0,49
Maize meal	1 000 gram	13,7	X		95,9
Mealie/samp	500 gram	1,7	X		11,9
Gravy (Bisto)	1 pkt	1,9	X		13,3
Gravy beef powder	1 pkt	2,1	X		14,7

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TABLE 5

TOTAL DIET STUDIES - ADULT

GROUP V : EGGS					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
eggs large	1 dozen	24,3	X		170

TABLE 6

TOTAL DIET STUDIES - ADULT

GROUP VI : FISH					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Pilchards	1 can	0,31		X	2,2
Tuna	1 can	0,96		X	6,7
Sardines	1 can	0,11		X	0,8
White fish fresh	200 gram	17,9	X		125,7
Fish fingers	1 pkt	0,09	X		0,6

TABLE 7

TOTAL DIET STUDIES - ADULT

GROUP VII : SOUP					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Bean	2 pkts	18,5	X		129,5
Pea	1 pkt	10,1	X		70,7
Lentil	100 grams	0,59	X		4,1
Vegetable	1 pkt	10,6	X		74,2
Tomato	1 pkt	0,21	X		1,5
Chicken	1 pkt	0,27	X		1,9
Asparagus	1 pkt	0,23	X		1,6

TABLE 8

TOTAL DIET STUDIES - ADULT

GROUP VIII : FATS AND OILS					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Oil vegetable	750 ml	0,24		X	1,7
Mayonnaise	120 ml	1,2		X	8,4
Orley whip	1 pkt	0,09		X	0,6

TABLE 9

TOTAL DIET STUDIES - ADULT

GROUP IX : MILK AND MILK PRODUCTS					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Whole milk	2 liters	236		X	1 652
Skim milk	1 liter	18,5		X	129,5
Evaporated milk	1 can	0,31		X	2,2
Skim milk powder	100 gram	0,89		X	6,2
Whole milk powder	100 gram	0,26		X	1,8
Melkkos/snysels	100 gram	0,21		X	1,5
Malted milk powder	100 gram	0,04		X	0,3
Cheddar cheese	100 gram	8,5		X	59,5
Sweetmilk cheese	100 gram	3,7		X	25,9
Cheese spread	1 bottle	0,21		X	1,5
Non-dairy creamers	1 bottle	0,59		X	4,1
Butter	100 gram	2,2		X	15,4
Cream fresh	125 ml	0,34		X	2,4
Margarine hard	250 gram	10,2		X	71,4
Margarine poly-unsaturated	250 gram	7,3		X	51,1
Ice cream	100 gram	2,6		X	18,2
Ice cream (sorbet)	100 gram	1,7		X	11,9
Custard	500 gram	9,7		X	68,2

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TABLE 10

TOTAL DIET STUDIES - ADULT

GROUP X : SUGARS AND SWEETS					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Jelly dessert	1 pkt	4,1	X		28,7
Honey	1 bottle	1,6		X	11,2
Jam	1 bottle	9,9		X	69,3
Sweets, jelly	1 pkt	1,1		X	7,7
Milk chocolate plain	1 pkt	0,27		X	1,9
Fudge/caramel/toffee	1 pkt	0,83		X	5,8
Chocolate assorted	1 pkt	0,53		X	3,7
Chocolate sauce	1 pkt	0,16		X	1,1
Chocolate coated nuts	1 pkt	0,21		X	1,5
Chocolate coated bar	1	0,63		X	4,4
Peppermints	1 pkt	0,10		X	0,7
White sugar	500 gram	41		X	287

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TABLE 11

TOTAL DIET STUDIES - ADULT

GROUP XI : BEVERAGES					
		24-hour consumption	Cooking required		7-day composite
Food item	Purchase	gram	Yes	No	gram
Beer	1 can	14,9		X	104,3
Sherry	50 ml	0,84		X	5,9
White wine	750 ml	20,4		X	142,7
Spirits	2 x 50 ml	6,6		X	46,2
Coffee instant	1 tin	412		X	2 884
Tea	1 box	230		X	1 610
Soft drink carbonated	2 tins	61,6		X	431,2
Soft drink non-carbonated	1 bottle	23,2		X	162,4
Crapefruit juice	1 can	1,3		X	9,0
Guava juice	1 can	0,61		X	4,3
Orange juice	1 can	0,39		X	2,7
Apple juice	1 can	0,61		X	4,3
Apple juice fresh	1 pkt	0,40		X	2,8
Orange juice fresh	2 pkts	6,3		X	44,1

TABLE 12

FOOD GROUPS AND CONSUMPTION DATA OF TOTAL DIET STUDY

COMPOSITION (DAILY BASIS) FOR ADULT DIET			
Food group		Average grams/day	% by weight of Total Diet
I	Vegetables	213,2	10,7
II	Fruit	192,1	9,6
III	Meat	140,3	7,0
IV	Cereals	221,1	11,1
V	Eggs	24,3	1,2
VI	Fish	19,4	0,97
VII	Soup	40,5	2,0
VIII	Fats and oils	1,53	0,08
IX	Milk	303,2	15,2
X	Sugars	60,4	3,0
XI	Beverages*	779,2	39,1
		1 995,2	100,0

*excluding drinking water

TABLE 13

ACCEPTABLE DAILY INTAKE FOR COMPOUNDS ANALYZED

Compound	WHO/FAO mg/kg/day	Codex Alimentarius mg/kg/day
Cabtab	0,1	0,01
Captofol	-	0,01
Chlorobenzilate	-	0,02
Chlorothalonil	-	0,005
Chlorpyriphos	-	0,01
DDT	0,005	0,005
Diazinon	0,002	0,002
Dicofol	0,025	0,025
Dichloran	0,03	0,03
Dieldrin	0,000 1	-
Endosulfan	0,007 5	0,008
Fenitrothion	-	-
Fenthion	-	0,001
Gamma-BHC	-	0,01
Mercaptothion	0,02	0,02
Parathion	0,005	0,005
Phosalone	0,006	0,006
Pirimiphos-Ethyl	-	-
Pirimiphos-Methyl	-	0,01
Procymidone	-	0,05
Prothiophos	-	-
Triazophos	-	0,000 2
Vinclozolin	-	-

TABLE 14

POSITIVE RESULTS OF RESIDUES AMONG FOOD GROUPS OF TOTAL DIET SAMPLES

Food Group	Compound	Residues mg/kg			Mean Daily	Intake
		July 1985	November 1985	February 1986	mg/kg	ug/day
Vegetables	Dichloran	- *	0,03	-	0,03	6,3
Fruit	Dichloran	0,02	-	0,01	0,015	2,9
Meat	DDT (total) Dieldrin	0,006 -	0,005 0,000 7	- -	0,005 5 0,000 7	0,77 0,098
Cereals	Mercaptothion (Malathion)	0,05	0,05	-	0,05	11,1
Eggs	DDT (total) Dieldrin	0,002 -	0,003 4 0,000 3	0,003 4 0,000 3	0,002 9 0,000 3	0,07 0,007
Fish	DDT (total) Dieldrin	0,002 0,000 9	0,008 -	0,003 0,001	0,004 3 0,000 95	0,08 0,017
Fats & Oils	DDT (total)	-	0,007	-	0,007	0,011
Milk	DDT (total) Dieldrin	- 0,001	0,002 4 0,000 7	0,002 8 0,000 7	0,002 6 0,000 8	0,788 0,243

* means not found

TABLE 15

DIETARY INTAKE OF PESTICIDE CHEMICALS IN READY-TO-EAT FOODS

Compound	Total Daily Intake		Acceptable Daily Intake WHO/FAO/Codex	Accepted Daily Intake
	ug	mg/kg/day	mg/kg/day	%
DDT	1,72	0,000 029	0,005	0,6
Dieldrin	0,365	0,000 006	0,000 1	6,0
Dichloran	9,2	0,000 15	0,03	0,5
Mercaptothion (Malathion)	11,1	0,000 19	0,02	0,9

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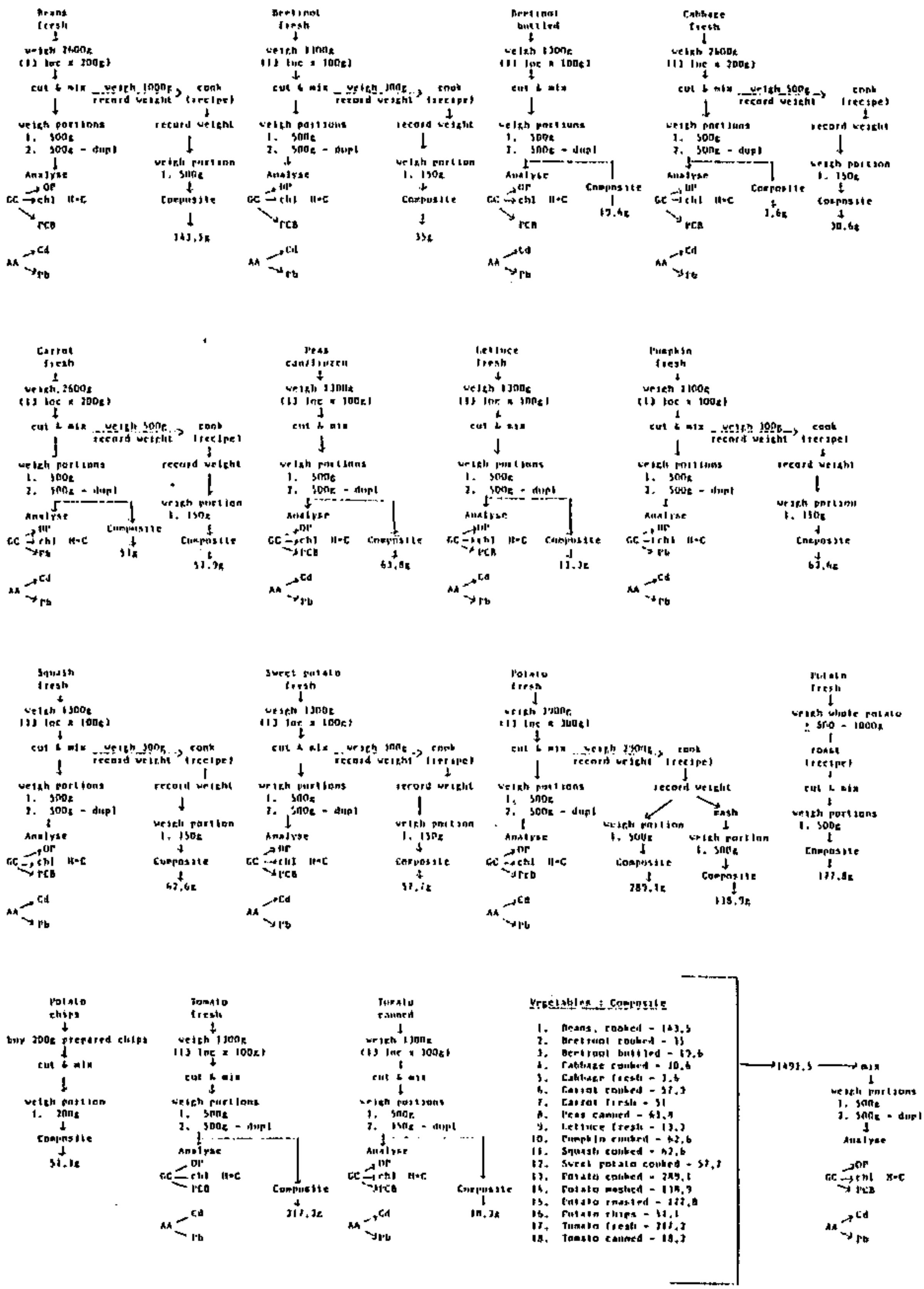
GROUP 1 : VEGETABLES



GROUP 2 : FRUIT

Apple Fresh
weigh 2600g
(13 loc x 200g)
cut and mix
weigh portions
1. 500g
2. 500g
3. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
419,3g

Pear Fresh
weigh 1300g
(13 loc x 100g)
cut and mix
weigh portions
1. 500g
2. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
137,9g

Pear Canned
weigh 1300g
(13 loc x 100g)
cut and mix
weigh portions
1. 500g
2. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
5g

Grape Fresh
weigh 2600g
(13 loc x 200g)
cut and mix
weigh portions
1. 500g
2. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
417,2g

Orange Fresh
weigh 1300g
(13 loc x 100g)
cut and mix
weigh portions
1. 500g
2. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
28g

Peach Fresh
weigh 2600g
(13 loc x 200g)
cut and mix
weigh portions
1. 500g
2. 500g
3. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
267,4g

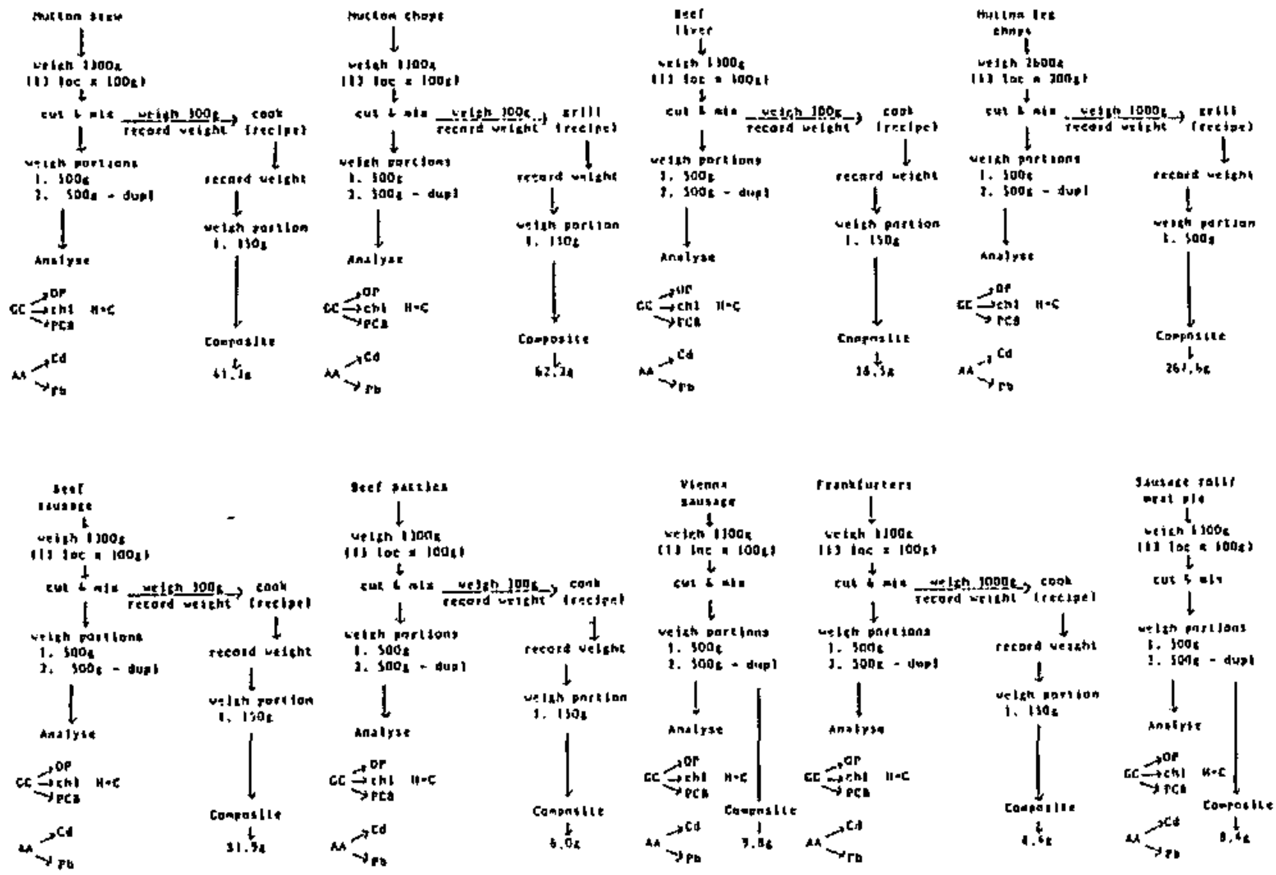
Peach canned
weigh 1300g
(13 loc x 100g)
cut and mix
weigh portions
1. 500g
2. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
26,3g

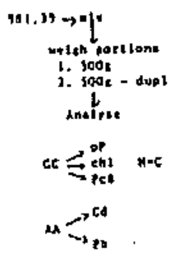
Peach dried
weigh 1300g
(13 loc x 100g)
cut and mix
weigh portions
1. 500g
2. 500g -dupl.
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb
Composite
43,5g

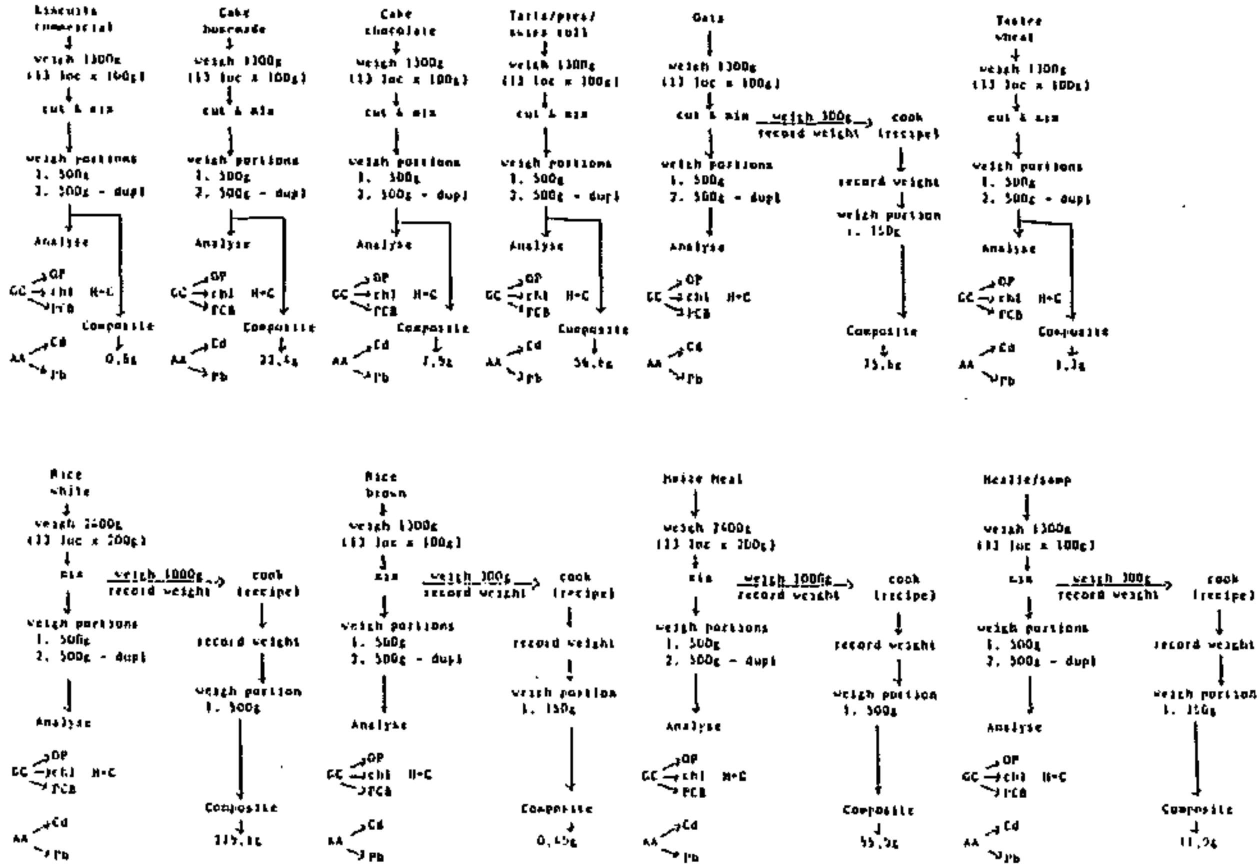
Fruit : Cmposite

1. Apple fresh - 419,3
2. Pear fresh - 137,9
3. Pear canned - 5,0
4. Grapes fresh - 417,2
5. Orange fresh - 28,0
6. Peach fresh - 267,4
7. Peach canned - 26,3
8. Peach dried - 43,5

→ 1344,6 → mix
weigh portions
1. 500g
2. 500g - dupl
Analyse
GC → OP, chl, PCB   H=C
AA → Cd, Pb


Mutton stew
Mutton chops
Beef liver
Mutton leg chops
Beef sausage
Beef patties
Vienna sausage
Frankfurters
Sausage roll/ meat pie
weigh 1300g
(13 loc x 100g)
weigh 2600g
(13 loc x 200g)
cut & mix
weigh 300g
weigh 1000g
record weight
cook (recipe)
grill (recipe)
weigh portions
1. 500g
2. 500g - dupl
record weight
weigh portion
1. 150g
1. 500g
Analyse
GC
OP
chl
PCB
H+C
AA
Cd
Pb
Composite


mix
weigh portions
1. 500g
2. 500g - dupl
Analyse
GC
OP
chl
PCB
H+C
AA
Cd
Pb



Biscuits commercial
Cake homemade
Cake chocolate
Tarts/pies/swiss roll
Oats
Teff wheat
weigh 1300g
(13 loc x 100g)
cut & mix
weigh portions
1. 500g
2. 500g - dupl
Analyse
GC
OP
chl
PCB
H+C
AA
Cd
Pb
Composite
weigh 300g
record weight
cook (recipe)
record weight
weigh portion
1. 150g
Rice white
weigh 2600g
(13 loc x 200g)
mix
weigh 1000g
record weight
weigh portion
1. 500g
Rice brown
Maize Meal
Mealie/samp

GROUP 5 : EGGS

Eggs

↓

weigh 1300g

(13 loc x 100g)

↓

mix (scramble) → weigh 300g, record weight → scramble (recipe) → record weight → Save entire portion for analysis

↓

weigh portions

1. 500g
2. 500g - dupl.

↓

Analyse

GC → OP

GC → chl H=C

GC → PCB

AA → Cd

AA → Pb

GROUP 6 : FISH

Pilchards Canned

↓

weigh 1300g
(13 loc x 100g)

↓

cut and mix

↓

weigh portions
1. 500g
2. 500g -dupl.

↓ Analyse

GC → OP / chl / PCB H-C

AA → Cd / Pb

→ Composite ↓ 2.2g

Tuna Canned

↓

weigh 1300g
(13 loc x 100g)

↓

cut and mix

↓

weigh portions
1. 500g
2. 500g -dupl.

↓ Analyse

GC → OP / chl / PCB H-C

AA → Cd / Pb

→ Composite ↓ 6.7g

Sardines Canned

↓

weigh 1300g
(13 loc x 100g)

↓

cut and mix

↓

weigh portions
1. 500g
2. 500g -dupl.

↓ Analyse

GC → OP / chl / PCB H-C

AA → Cd / Pb

→ Composite ↓ 0.8g

White fish fresh/frozen

↓

weigh 1300g
(13 loc x 100g)

↓

cut and mix → weigh 300g / record weight → fry (recipe) ↓ record weight ↓ Composite ↓ 125.7g

↓

weigh portions
1. 500g
2. 500g -dupl.

↓ Analyse

GC → OP / chl / PCB H-C

AA → Cd / Pb

Fish Fingers

↓

weigh 1300g
(13 loc x 100g)

↓

cut & mix → weigh 300g / record weight → Fry (recipe) ↓ record weight ↓ Composite ↓ 0.6g

↓

weigh portions
1. 500g
2. 500g - dupl.

↓ Analyse

GC → OP / chl / PCB H-C

AA → Cd / Pb

Fish : Composite

1. Pilchards - 2.2
2. Tuna - 6.7
3. Sardnies - 0.8
4. White fish - 125.7
5. Fish fingers - 0.6

→ 136 → mix

↓

weigh portion
1. 136g

↓

Analyse

↓

GC → OP / chl / PCB H-C

AA → Cd / Pb

GROUP 7 : SOUP

Bean Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 129,5g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Pea Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 70,7g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Vegetable Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 74,2g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Tomato Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 1,5g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Chicken Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 1,9g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Asparagus Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 1,6g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Lentil Soup
weigh 650g (13 loc x 50g)
mix → weigh 50g, record weight → Cook (recipe) 600ml H_2O → record weight → weigh portion 1. 400g → Composite → 4.1g
mix → weigh portions 1. 300g 2. 300g - dupl. → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

Soup : Composite

1. Bean soup - 129,5
2. Pea soup - 70,7
3. Vegetable soup - 74,2
4. Tomato soup - 1,5
5. Chicken soup - 1,9
6. Asparagus soup - 1,6
7. Lentil soup - 4,1

→ 283,5 → mix → weigh portion 1. 283,5g → Analyse
GC → OP, chl, PCB H=C
AA → Cd, Pb

GROUP 8 : FATS AND OILS

Oil Vegetable

↓

weigh 1300g

(13 log x 100g)

↓

mix

↓

weigh portions

1. 400g
2. 400g

Analyse: GC → OP, chl, PCB; H=C; AA → Cd, Pb

Composite ↓ 1,7g

x 10

= 17g

Mayonnaise

↓

weigh 1300g

(13 log x 100g)

↓

mix

↓

weigh portions

1. 400g
2. 400g

Analyse: GC → OP, chl, PCB; H=C; AA → Cd, Pb

Composite ↓ 8,4g

x 10

= 84g

Orley Whip

↓

weigh 1300g

(13 log x 100g)

↓

mix

↓

weigh portions

1. 400g
2. 400g

Analyse: GC → OP, chl, PCB; H=C; AA → Cd, Pb

Composite ↓ 0,6g

x 10

= 6g

Fats and Oils : Composite

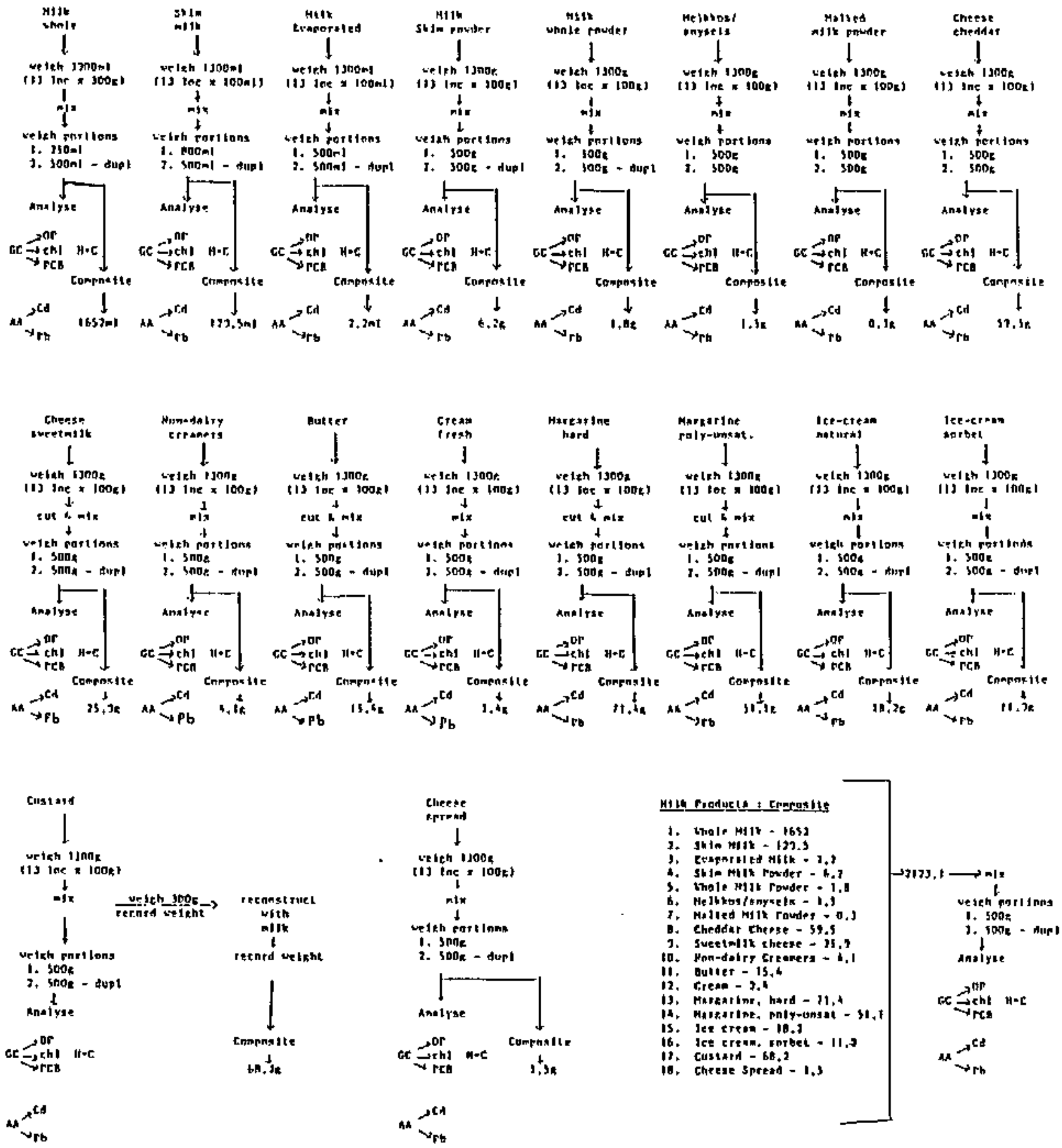
1. Vegetable oil - 1,7 x 10 =17g
2. Mayonnaise - 8,4 x 10 = 84g
3. Orley whip - 0,6 x 10 = 6g

→ mix

↓

Keep entire weight for analysis (107g)

GROUP 9 : MILK PRODUCTS



GROUP 10 : SUGAR AND SWEETS

Jelly Dessert
↓
weigh 1040g
(13 loc x 80g)
↓
mix → weigh 40g, record weight → reconstruct (recipe) ↓ record weight ↓ Composite ↓ 28,7g
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb

Honey
↓
weigh 1300g
(13 loc x 100g)
↓
mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 11,2g

Jam
↓
weigh 1300g
(13 loc x 100g)
↓
mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 69,3g

Sweets Jelly
↓
weigh 1300g
(13 loc x 100g)
↓
mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 7,7g

Milk chocolate
↓
weigh 1300g
(13 loc x 100g)
↓
cut & mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 1,9g

Fudge/caramel or toffee
↓
weigh 1300g
(13 loc x 100g)
↓
cut & mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 5,8g

Chocolate assorted
↓
weigh 1300g
(13 loc x 100g)
↓
cut & mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 3,7g

Chocolate sauce
↓
weigh 1300g
(13 loc x 100g)
↓
mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 1,1g

Chocolate nuts
↓
weigh 1300g
(13 loc x 100g)
↓
cut & mix
↓
weigh portions
1. 500g
2. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 1,5g

Chocolate bar
↓
weigh 1300g
(13 loc x 100g)
↓
cut & mix
↓
weigh portions
1. 500g
2. 150g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 4,4g

Peppermints
↓
weigh 650g
(13 loc x 50g)
↓
cut & mix
↓
weigh portions
1. 500g
2. 150g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 0,7g

Sugar white
↓
weigh 2600g
(13 loc x 200g)
↓
mix
↓
weigh portions
1. 500g
2. 500g
3. 500g - dupl
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb
Composite ↓ 287g

Sugar and Sweets : Composite

1. Jelly dessert - 28,7
2. Honey - 11,2
3. Jam - 69,3
4. Sweets Jelly - 7,7
5. Milk chocolate - 1,9
6. Fudge/caramel/toffee - 5,8
7. Chocolate assorted - 3,7
8. Chocolate sauce - 1,1
9. Chocolate nuts - 1,5
10. Chocolate bar - 4,4g
11. Peppermints - 0,7
12. Sugar white - 287

→ 423 → mix
↓
weigh portion
423g
↓
Analyse
GC → OP, chl, PCB
H=C
AA → Cd, Pb

GROUP 11 : BEVERAGES