Methods for assessing quality characteristics of non-grain starch staples. (Part 1. Introduction.)

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PART 1. INTRODUCTION

Natural Resources Institute

Overseas Development Administration

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Editors: Z. Bainbridge, K. Tomlins,
K. Wellings and A. Westby

NRI
Natural Resources Institute

Overseas Development Administration

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Cover illustration. Clockwise from top left. Banana (*Musa* spp.), cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*). *Drawings reproduced by kind permission of the Royal Botanic Gardens, Kew.*

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Andrew Westby
Root Crops Manager
Natural Resources Institute

Note

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Section 1.1 Introduction

SCOPE OF THE MANUAL

This manual sets out in a four-part publication the main methods necessary to evaluate the quality characteristics of non-grain starch staple (NGSS) food crops (cassava, sweet potato, banana, plantain, yam and cocoyam) and their processed products. It is designed to be a reference source and laboratory guide for food analysis laboratories and those concerned with the quality of NGSS.

It is hoped that the provision of this manual and its active promotion through workshops will assist in the uptake of quality assessment methodologies, the setting of quality standards and to the improved quality of fresh material and their processed products.

POTENTIAL USERS OF THE MANUAL

It is expected that the audience for this manual will be wide ranging and include:

- public sector research and development establishments such as universities, colleges and research institutes—this would include bodies responsible for NGSS breeding programmes and food and nutrition programmes;
- bureaux of standards/quality standards boards and other bodies responsible for setting and monitoring the standard of foods and raw materials within the NGSS sector; and
- private sector quality control laboratories wishing to implement quality assurance systems utilizing NGSS or their by-products as raw materials for food or industrial applications.

Different groups may wish to use different parts of the manual.

STRUCTURE OF THE MANUAL

The manual is divided into four parts:

- *Part 1* Introductory section;
- *Part 2* Field methods: methods that require a minimum of equipment and are suitable for use in situations where a laboratory is not readily available;
- *Part 3* Laboratory methods: this part brings together most of the standard laboratory methods for the analysis of NGSS food crops; and
- *Part 4* Advanced methods: in this part a diverse range of techniques is brought together. It includes methods of a more advanced nature and possibly requiring more sophisticated equipment than described in Part 3. This section may be used for research purposes.

Part 1 Introduction

It is recognized that the introduction will not be used on a day-to-day basis. Material that needs to be consulted less frequently has therefore been incorporated into this part.

Sampling is the preliminary process in any analysis. Information on statistically valid sampling schemes for NGSS food crops and their products is included in this part.

Safety is the most important issue in a laboratory and when laboratory techniques are being carried out. Whilst there is no substitute for professional training and common sense, a section on laboratory safety has been included. Safety comments specific to certain procedures have been incorporated into the text.

Part 2 Field methods

The field methods section was developed mainly from NRI's experience in field work. The methods are designed to use the minimum amount of equipment whilst giving the maximum amount of information. Few of the methods are recognized standard methods.

The potential uses of these methods are wide ranging. They are suitable for field surveys and potentially as part of needs assessment studies.

Part 3 Laboratory methods

The laboratory methods section brings together a wide range of laboratory-based methods suitable for NGSS. Where possible they are standard methods, but an attempt has been made to select methods that require the simplest of equipment.

The methods have been written with the general objective of giving the reader enough information to decide whether the technique will fulfil his requirements. The manual should then be suitable as a laboratory guide to be taken into the workplace and is designed so that the data obtained can be analysed. Where possible, guidance on the significance of results is given.

Part 4 Advanced methods

The fourth section of the manual brings together a variety of more advanced research topics. Advanced in this context either indicates that they are more suited for research or that more sophisticated equipment is required for the techniques described.

This section aims to guide the reader in the correct direction, to give general guidance on specific topics and, in some cases such as sensory analysis, to give more detailed protocols.

OTHER REFERENCES

This manual has been designed where possible to be a 'stand-alone' document. This is in recognition of the fact that the availability or otherwise of literature can be a limitation. However, references have been given in instances where the reader may need further information.

Section 1.2 Sampling

INTRODUCTION

When assessing any quality characteristics of NGSS, the first requirement is to define exactly what body of material or population is to be assessed. This may range in scale from very large, such as all the sacks of cassava chips stored in a particular region, to very small, such as a single cassava root subjected to a particular processing/storage treatment.

Once the population has been defined, a strategy can be formulated for assessing it. Occasionally it may be possible to assess the whole population if, for example, the variable being measured on a single cassava root is change in weight over the storage period. However, in almost all situations it will only be possible to assess part of the population or a sample and it is therefore necessary to decide how the sample should be selected.

FORMULATION OF THE SAMPLING STRATEGY

In devising a sampling strategy, the *main aim* is to ensure that the sample drawn should represent the population as closely as possible.

There are several *general principles* which can help to ensure this:

- making the sample as big as possible;
- drawing the sample from as wide a range as possible within the population; and
- organizing the collection of the sample in such a way that every part of the population has an equal chance of contributing towards the final sample collected. In this way bias is avoided.

In order to see, in practical terms, how the main aim of sampling and the general principles affect the selection of a sample, three examples will be considered.

Example 1: Sampling roots from a store

Aim To assess visually a population of sweet potatoes stacked in piles on the floor of a store.

Pitfalls to avoid The tempting approach would be to enter the store and select a sample from the most accessible part of the nearest pile. However, consideration must be given to whether this sample would satisfy the aim that it should represent the whole population as closely as possible.

There are various reasons why this is unlikely to be the case:

- different piles might have been in the store for different lengths of time, or might have been harvested from different fields; hence they would be of different qualities;
- the environment may vary within a pile so that the rate of deterioration in quality might differ between sweet potatoes at the bottom, in the middle and on the surface of a pile.

Therefore, for the sample to be representative, it needs to be taken from as wide a range as possible within the population by taking sweet potatoes from different parts of a number of piles.

Sample selection

There are two basic ways of deciding which piles are to be selected. In the first, piles are selected completely at random from within the store. This does not mean that a sample can be drawn from any particular pile at will because such selection might be biased. For example, small piles might be selected subconsciously because they will be easier to sample. For a truly random sample, all the piles must be numbered and a random selection taken from the numbers. However, this may be too time-consuming, so an acceptable alternative which will ensure that the sample is not biased by personal selection is to set up rules such as walking a specific number of steps in a particular direction and selecting the nearest pile of roots for sampling.

If information about the piles in the store is available, it may be more efficient to use the second method of pile selection, in which the population is divided up or stratified and each part sampled separately. For example, if it is known that certain piles have been in the store for several months and that the rest have been stored in recent months, it would be sensible to take

random samples from within these two groups. This improves the representativeness of the sampling by ensuring that each stratum is appropriately represented. To do this, as a general rule, the number of piles selected from each group should be proportional to the total number of piles in the group.

Sub-sample selection

Having selected the piles, a decision must be made about the selection of a sample of sweet potatoes from each. It would clearly be too time-consuming to select them using any formal method of randomization, so to make the sample as representative as possible the sweet potatoes should be taken from different parts of the pile. Rules should be devised to ensure that potatoes of a particular kind are not selected. For example, if they are being graded according to levels of insect damage, it may be tempting to select those that are obviously damaged. This must be resisted since they will not be representative of the whole population. One possibility would be to take a sample of, say five, that are close together and then to select one using a rule which would ensure that any of the five are equally likely to be chosen. For example, the sweet potatoes could be placed in a row, the left-hand potato being designated number one. A dice could then be thrown to make the selection. The dice should be re-thrown if the number six results.

Sample size

As well as deciding how to select the sample of sweet potatoes, it is necessary to decide how many are needed and how they should be split between and within piles. If information is available on the likely variability of the population and exactly what kinds are likely to be drawn, then there are formal statistical methods for working out necessary sample sizes. However, this information is frequently not available, and a compromise has to be reached between making the sample large enough and keeping it within reasonable bounds of cost. Clearly, provided the assessment to be made on the sweet potatoes is quite fast, it is easier to manage than if, for example, measurement of the area of the surface showing insect damage is required. A better idea of what sample size will be sufficient is likely to be developed when a number of stores have been sampled, so it will be best to begin with a large sample to ensure that the results will be satisfactory, and then reduce the sample size in later stores if the variability is found to be small. In general, to make the sample representative, it is usually better to take only a few sweet potatoes from each pile, but to sample as many piles as possible.

Example 2: Sampling cassava flour from sacks stacked in a store

Aim To measure the particle size and to estimate the amount of extraneous contamination in cassava flour which is in sacks stacked in a store. Here again, unless the flour all comes from one batch of processing, it is unlikely that the contents of one sack will be representative of the flour throughout the store, so more than one sack needs to be sampled and a sampling strategy decided.

Sample selection

In this case it may be reasonable to assume that particle size will not be affected by position within the stack, and that by sampling at widely spaced positions around the stack, a representative sample may be obtained. However, as in the previous example, it is important to devise selection rules so that personal choice, and hence possible bias, are avoided. If it is known, for example, that sacks in different parts of the stack were processed in different places, it may be better to stratify and to take a sample of sacks from each processing place.

Sub-sample selection

Having selected the sacks, a sample must be drawn from the contents of each sack, since it will probably be too time-consuming to sieve all the contents. It is possible that particle sizes and extraneous contamination may vary in different parts of a sack, so ways must be devised to obtain a representative sample from within any sack. This can be done by taking small grab samples from within a sack, either by hand or by using a sampling device such as a cup, but ensuring that they are randomly spread through the sack. All the samples from one sack are then combined.

When samples from the desired number of sacks have been collected, material will need to be passed through sieves to measure particle sizes and to extract extraneous material. There are two possible procedures for doing this. The first is to take each sample and make measurements on that. An alternative method is to combine all the samples and mix them together very thoroughly. Samples of a size suitable for sieving can then be taken from the combined sample and passed through the sieves. Provided that the original samples are properly mixed, only a small sub-sample of the mixture needs to be measured, because it will represent almost perfectly the overall composite sample. Thus, time can be saved without the overall sampling error being increased.

The second method is often preferable because it is possible, for the same cost, to sample more sacks. Therefore, the sample is more representative than if the sample from each sack is measured. Measuring the sample from each sack is only likely to be

necessary if, as well as needing to know the overall particle size of the flour and the amount of contamination in the store, information on the range of variability from sack to sack is required. This may be necessary if quality is being checked and sacks are to be sold individually. It may be sensible to keep samples from different strata separate to provide extra information. In that case, care must be taken when combining the results if the strata were of different sizes.

Example 3: Sampling cooking bananas from a market

Aim To assess the ripeness of bananas on sale in a particular market by comparing banana peel colour with a colour chart. Here, decisions must be made on which sellers to visit and which of their bananas to check.

Sample selection

Clearly it will not be possible to obtain a representative sample only from one stall, but, unlike sampling in a particular store, the exact population size or sampling frame is not known, since only some of the sellers will have bananas. One approach is to establish the sampling frame first by looking right round the market, noting where the banana sellers are and allocating a number to each seller. By using a table of random numbers, a truly random sample can be selected, ensuring that every seller has an equal chance of being included. Alternatively, it may be sufficient to visit the first banana seller seen and then to move into another part of the market before selecting another seller, and so on. In this way, the sample is drawn from the population as widely as possible, but all sellers are not equally likely to be included.

Again, if this method is chosen, rules for selection must be established to avoid personal bias, such as walking in a certain direction, passing three stalls, continuing in the same direction and selecting the first banana seller seen after that. It may be useful to divide the population of banana sellers into groups or strata and sample each separately. For example, some sellers may have very large numbers for sale, whereas others might have only a few, and the types of banana sold might differ between the two. If this is the case, care will have to be taken when presenting the final results. For example, those selling large numbers might have a higher proportion of green bananas; then the proportion of green bananas in the market would be higher than the proportion of sellers selling green bananas. It is therefore necessary to define clearly the objective of the measurement.

For each seller selected it is necessary to decide which bananas to match to the colour chart. A representative sample must be chosen. For a proper random sample, tables of random numbers should be used first to select a random sample of bunches, and then to select a banana within the bunch. However, this is likely to be too time-consuming, so again some simple rules must be set up which enable the selection of both a bunch and a banana without advance knowledge of what it will look like. For example, the seller might be asked to choose a bunch to show, and the bunch nearest to it might then be selected for the sample. If it is apparent that sellers with larger stocks have bananas of a different colour, the problem of estimating the overall colour of bananas in the market can be solved by recording the colour of a fixed proportion of the bananas on each randomly selected stall.

GENERAL POINTS TO NOTE WHEN DEVELOPING A SAMPLING STRATEGY

1. The exact population to be sampled must be known.
2. What is to be ascertained about that population must be exactly defined.
3. A representative and unbiased sample must be chosen.
4. Any selection method which allows personal choice of sampled units is likely to be biased, particularly if units are consciously selected as being representative.
5. Only by the use of formal randomization techniques can the true random selection of samples be ensured.
6. Samples which are not truly random may still be representative if they are drawn from as wide a range as possible within the population, and are selected using rules which ensure that personal choice is not involved.
7. The larger a sample is the more closely will it represent the overall population, provided it is selected correctly.
8. The size of the samples will depend on the variability of the population and the precision of the required results. For most of the products and variables considered in this manual, population variability is not recorded so it will be necessary to learn by experience. Initially, large samples should be taken to ensure that the data collected are useful.
9. In two-stage sampling (e.g. sweet potatoes from within piles of sweet potatoes) for a fixed size sample, a few second-stage samples (sweet potatoes in the example) within many first-stage samples (piles) are likely to be more representative of the population than the many second-stage samples taken from a few first-stage samples.
10. If the population is known to consist of several groups or strata, it may be more efficient to sample each separately, in proportion to the size of the stratum, rather than to take a random sample from the whole population.

11. It may be possible to reduce labour whilst maintaining sample representativeness if the individual samples are mixed together and the required variable is measured on a small sub-sample. This is likely to be particularly important if the tests are carried out in a laboratory using a process which requires a very small sample of the original material.

12. A suitable sampling strategy is more likely to be devised if, rather than following recipes, the required end result is borne in mind.

Section 1.3 Laboratory safety

INTRODUCTION

Most laboratories have safety instructions or guidelines. Every laboratory is different, but in this section of the manual, the safety guidance notes provided to NRI staff have been reproduced with some minor changes.

The guidance given, although related to a laboratory, is also relevant to the field methods. It is recommended that all staff are made fully aware of safety procedures.

IMPORTANT DOs AND DON'Ts

DO keep yourself and your place of work tidy.

DO stack things in such a way that they will not fall down.

DO label things clearly.

DO obey 'no smoking' and other warning signs.

DO cultivate a safety awareness.

DON'T undertake laboratory work when no one else is about.

DON'T allow trainees to work unsupervized.

DON'T store food and drink in laboratory refrigerators where there is the slightest possibility of contamination, or in cold rooms.

DON'T eat, drink or smoke in laboratories.

DON'T chew or lick pencils, pens, rulers, sticky labels etc., particularly in laboratories.

DON'T pipette by mouth.

DON'T allow telephone or electricity cables to trail, especially where they can be tripped over.

DON'T open more than one drawer of a filing cabinet at a time.

DON'T put the heavier things in the upper drawers of filing cabinets.

DON'T play practical jokes in laboratories or workshops.

DON'T take chances. If you are not sure, ASK.

DON'T sit at a fume cupboard if potentially hazardous work is in progress, as this could restrict mobility in an emergency.

Avoid rapid movements, especially of your arms, inside the fume cupboard.

Never leave potentially hazardous work unattended.

Always tidy up the fume cupboard at the end of the work; leave it ready for others, clean and free of equipment and rubbish.

The last person to leave a laboratory at night should check that all taps and switches have been turned off.

IMPORTANT: To assist rapid exit from buildings in an emergency:

corridors, gangways etc. must be kept free from all obstructions;

ensure all areas of your work place, such as steps and staircases are well lit.

SAFETY EQUIPMENT IN LABORATORIES

Potentially, laboratories are more hazardous than workshops and offices, so extra care and vigilance is necessary. Always wear clothing suitable for the job in hand; use protective clothing where appropriate. Wearing white laboratory coats at all times is a good habit to acquire.

Laboratories should never be used as stores. Remember good housekeeping.

Goggles and eye protection

Appropriate safety glasses or goggles should be worn if there is a risk of anything entering the eyes, especially when:

- using grinders;
- working with an irritant dust;
- using corrosive liquids that might splash;
- handling glass that is, or might be, under pressure or vacuum.

Suitable eye protection should be worn at all times in the laboratory. Spectacles are *not* suitable for use when handling acids, alkalis or other dangerous corrosive materials, whether liquid or solid, and other substances which are similarly injurious to the eyes. Goggles or face shields resistant to chemical splashes *must* be worn when handling such materials. Make sure that the protection is of the right type for the job and that it fits properly.

Transparent blast screens should be used when carrying out vacuum distillations or when there is risk of explosion.

Desiccator shields made of strong wire mesh should always be used when glass desiccators are evacuated.

Suitable eye protection must also be worn during exposure to any radiation if there is a reasonably foreseeable risk of injury, particularly from ultra-violet radiation of wavelengths shorter than 320 nm.

Gloves and hand protection

Wear suitable gloves when handling anything

- corrosive
- toxic
- irritating
- very hot
- very cold
- sharp edged.

Rubber, PVC or other suitable gloves should be worn when handling corrosive, poisonous or irritating substances or when handling objects with sharp edges. No glove offers complete protection against all solvents.

Wear heat-resisting gloves for handling hot or very cold objects. Solid carbon dioxide and liquid nitrogen, for example, should never be handled without gloves.

There is nothing like soap and water for preventing industrial dermatitis and similar skin troubles, or for preventing the spread of numerous infections. Hands should always be washed before leaving the laboratory, before meals and before going home. If infected animals or pathogenic bacteria have been handled, hands should be rinsed in a suitable antiseptic solution before washing.

Masks and lung protection

Wear a dust mask or respirator, with the correct filter, when working in the presence of:

- toxic gases and vapours;
- dusty or mouldy materials.

Respirators fitted with the appropriate absorption canister should be used when toxic gases or vapours are being handled. When the canisters are intact in the original packing, they have several years' shelf-life. When they have been removed from their packing, their shelf-life will depend on the quality of the atmosphere in which they are stored. Regard must also be paid to the extent to which they have been used already for absorbent gases or vapours, and to the possibility of a gas or vapour displacing those absorbed previously.

Different canisters or cartridges are required for protection against different classes of toxic gases or vapours; attention to the manufacturer's information printed on them is essential.

Certain respirators are suitable only for gases or vapours in relatively low concentrations not immediately dangerous to life in atmospheres which are not oxygen deficient. Otherwise, breathing equipment which is self-contained under positive pressure, or is fed from an airline, must be used.

Dust masks or other appropriate protection, such as a helmet and visor with a filtered air supply, should be used when dusty or mouldy materials are being handled. The effect of some of these materials is cumulative and may be disabling many years later.

It is most important to select the correct type of filter or canister for the dust or gas concerned.

Coats, overalls and aprons

Wear a laboratory coat at all times when carrying out practical work.

Wear a laboratory coat or overall and remove ties, necklaces, bracelets, watches and rings when working with moving machinery.

Take off protective clothing before leaving the laboratory.

Put dirty clothing out to be laundered regularly.

Appropriate lung protection must be used whenever a dust is produced (see under 'Lung protection'). Adequate protective clothing should be worn when handling potentially toxic samples which can create toxic dust. In addition to lung, head and body protection, overshoes must be worn if there is any possibility of such potentially toxic dust being transferred on shoes out of the work area.

Where potentially toxic samples are ground, all protective clothing and overshoes must be removed before leaving the work area.

It is advisable to display a 'Toxic Hazard' notice at the work area when the grinding of potentially toxic materials is in progress.

Fume cupboards

Avoid using a fume cupboard as a store. Do not carry out experimental work in a fume cupboard that is being used as a store.

Decide if the fume cupboard available is suitable for the proposed operation. Consult a senior officer if in doubt.

Before beginning work, confirm that the fume cupboard is operating satisfactorily, and that its use will not impair the efficiency of any other equipment (fume cupboard, glove box, spray chamber) using the same extraction duct.

Ensure that all necessary items are in the fume cupboard before starting the work. This avoids the need to leave the work, with the attendant disturbance of air flows.

If significant quantities of highly flammable liquids are involved, use flame-proof equipment. Even if such materials are not involved, naked flames should be avoided, unless essential, as they can disturb the air flow.

Do not set up equipment close to the front edge of the fume cupboard, as this increases eddies and the risk of fumes escaping. Avoid unnecessary clutter.

Always carry out chemical reactions and distillations in fume cupboards as a matter of routine where there is any possibility of hazard.

Operations such as grinding solids, sieving powders or using chemical aerosol sprays should be carried out in the fume cupboard or other suitably vented chamber and never in the open laboratory.

Use the minimum practicable sash opening, with a safety screen if appropriate.

GENERAL LABORATORY SAFETY ADVICE

This section deals with the general handling of gases, liquids and solids in the laboratory.

Equipment

Make sure users are competent to use equipment. Obtain instruction from the senior officer responsible. Read the operator's instructions manual and keep it handy for reference.

When using knives and cutting tools, cut away from the body whenever possible. Always wear a chain mail glove on the free hand when using a knife. If practicable, lay material to be cut on a flat surface and use a straight edge as a guide. If the material cannot be gripped satisfactorily with a free hand, it should be clamped. Special care should be taken when cutting frozen or chilled materials.

Glassware

Do not use cracked or chipped glassware; discard cheap and easily replaced items in a glass waste bin and request repair of expensive items.

Score tubing before cutting by using a triangular file or a disposable glass file.

Hold tubing in a cloth when breaking to a shorter length; flame tubing ends.

Take special care when inserting tubing into corks and rubber bungs: use a cork borer of the right size; place the bung or cork on a bench and use a downward pressure; bore from both ends; lubricate the borer (detergent or glycerol are suitable); lubricate the tubing if possible; hold both tubing and bung or cork in a cloth; hold tubing as near as possible to the bung or cork; insert slowly, with a slight twist, a little at a time.

Take similar care when inserting glass tubing into rubber tubing.

Remove a difficult bung by sliding a cork borer over the glass tubing and down through the bung.

Remove difficult rubber tubing by cutting it from the glass tubing.

Store glassware safely, behind closed doors or in labelled drawers.

Never stack glassware.

Keep the doors of cleaned stock cupboards shut to maintain cleanliness.

Mark containers clearly and conspicuously to show:

- contents;
- date prepared;
- user's name.

Use labels that are resistant to the contents and storage conditions.

Use volumetric glassware for making up solutions, not for storing them.

Use plastic stoppers for volumetric glassware or containers holding alkaline solutions.

Store volatile solutions in amber glass bottles with bakelite screw caps containing aluminium-faced cork wadding.

Store small items such as vials by standing them in a container, with packing to fill spare space so that they will not fall over.

Rinse used glassware with a suitable solvent before cleaning to ensure that it is free from harmful residues.

Pipetting

Never pipette by mouth, always use a safety bulb or automatic pipette.

Make sure that the tip is kept well below the surface of the liquid when filling.

Clean the bulb if liquid should enter it accidentally; never leave it contaminated for others to use.

Never let concentrated acid contaminate the body of an automatic pipette.

Gas cylinders

When gas cylinders are used for special purposes, the following points should be observed:

- always lift cylinders from trucks. Never drop or slide them;
- treat every cylinder as 'full' and handle carefully;
- remember that handling large cylinders is a two-person job;
- always use a wheeled carrier for transportation and secure the cylinder into it;
- store *all* cylinders so that they cannot fall. If upright, they must be chained or strapped; if lying down, they must be chocked. Acetylene and propane cylinders must always be stored and used in the *upright* position;
- keep them away from sun, artificial heat, flammable materials, corrosive chemicals and fumes;
- avoid damage to valves and fittings. Do not use them for lifting or carrying. It has been known for a valve to break off and the cylinder to become airborne;
- never permit oil or grease to come into contact with any cylinder valve or fitting;
- be sure to check the identity of the gas before use;
- wear suitable body and face protection before 'snifting' gas from cylinders. Never snift with a hand in the gas stream. Never snift hydrogen as it may ignite spontaneously. Instead, carefully inspect the outlet and, if there are any signs of dirt, blow it out with a jet of compressed air;
- open the cylinder valve slowly and close it sufficiently to shut off the gas; never use force;
- close cylinder valves when gas is not required, even if still connected to the equipment or pipeline. Replace outlet caps or plugs and cylinder caps or guards as soon as the cylinder is disconnected from the equipment or pipelines;
- suitable pressure regulating devices must be used on all cylinders before connection to equipment or pipelines. No attempt should be made to repair or modify cylinder valves, safety relief devices or regulators;
- check that valves, regulators and fittings are appropriate for the gas being used.

Flammable liquids

Many liquids commonly used in laboratories are flammable or highly flammable; most of these are organic solvents.

Definition of flash point: the temperature at which the vapour above the surface of a liquid ignites or flashes when an external ignition source is introduced.

Table 1.1 Solvent flash points

Flammable (above 32 °C)	
Ethoxythanol	44 °C
1-butanol	36 °C
Butanone	35 °C
Highly flammable (below 32 °C)	
Xylene	29 °C
Amyl acetate	25 °C
Propanol	22 °C
Dichloroethane	15 °C
Acetonitrile	13 °C
Methanol	12 °C
Ethyl acetate	7 °C
Toluene	6 °C
Hexane	−14 °C
Tetrahydrofuran	−17 °C
Acetone	−20 °C
Ethanol	−23 °C
Pentane	−40 °C
Petroleum ether	−40 °C
Diethyl ether	−45 °C

Used improperly they are dangerous, and some are also explosive and toxic.

Avoid inhalation and skin contact.

Wear safety spectacles when using highly flammable liquids.

Know what to do if the solvent ignites.

Know where the fire extinguishers are and which kind to use.

Keep flammables in marked flammable-materials metal storage cupboards. Never bring naked lights or burning cigarettes near such cupboards.

Never leave such cupboards unlocked and unattended. Use labelled siphons to dispense solvents from drums to containers.

Empty the siphons after use.

Report leaking drums.

Move Winchesters and other large bottles in appropriate carriers.

Clean up any spills as described below.

- *Spills over about 400 ml*
  Cordon off the area; inform a senior officer; get assistance before cleaning up; wear goggles, gloves and a vapour protective mask; it is advised that a solvent spill kit be used and the manufacturer's instructions followed.
- *Spills of about 50–400 ml*
  Use a solvent spill kit and follow the manufacturer's instructions.
- *Spills of less than about 50 ml*
  Use paper towels; take them in a covered container to a fume cupboard; allow the liquid to evaporate; dispose of towels.

Never throw solvent-soaked paper in a waste bin or leave it lying about in the store. Place it in a fume cupboard until it dries out.

Label each container with its correct name and hazard warning pictogram.

Keep all Winchesters in special, lockable, steel cupboards. Never keep solvents on open shelves or in direct sunlight.

Wear safety goggles.

Use a working fume cupboard for all but the smallest quantities.

Put a notice on the fume cupboard to show:

- solvents and chemicals being used;
- date;
- name.

Close the shutter and do not leave unattended unless safe. Inform others in the laboratory of what is being done.

Never leave distillations unattended for long periods in case the supply of cooling water fails.

Never leave bottles of solvents in fume cupboards.

Never throw waste solvents down the sink.

Never allow waste solvents to accumulate in the laboratory.

Collect waste solvents in properly labelled and hazard-marked containers. Ensure their suitable disposal.

Ask a senior officer for advice on which drum to use.

Treat waste bottles in the same way as stock bottles.

Wash hands with soap and water after using solvents.

Corrosive chemicals

Corrosive chemicals include concentrated acids and alkalis.

Wear a laboratory coat, safety spectacles and protective gloves.

Know what to do if there is an accident, and make sure the means to do it are available.

Know where the eyewash bottles are kept in the laboratory.

Label each bottle with its correct name and hazard-warning pictogram.

Keep Winchesters in a properly labelled and hazard-marked cupboard.

Store as little as possible.

Never carry Winchesters or other bottles by their necks; transport them safely in appropriate carriers.

Never use Winchesters as stock bottles; transfer a small quantity of liquid as needed to a small, properly labelled and hazard-marked clear glass bottle.

Clean up any spills as described below.

- *Acid spills over about 500 ml*
  Get help fast if any spill of corrosive chemical occurs; wash under a shower or in running tap water; cordon off the area; inform a senior officer; obtain assistance before clearing up; wear goggles, gloves and a vapour protective mask; spread sodium bicarbonate; mop up and run to waste with plenty of water.
- *Acid spills of about 20–500 ml*
  Use an acid spill kit and follow the manufacturer's instructions.
- *Acid spills of less than about 20 ml*
  Wear gloves and use tissues; wash tissues in running water and dispose. Keep tissues in trays to avoid drips.
- *Solid alkali spills*
  Wear goggles, gloves and mask; shovel spill into an enamel or polythene container; add a little at a time to a large volume of water whilst stirring; run to waste with running water; mop up site with water.
- *Alkali spills of about 20–400 ml concentrated solution*
  Use a caustic spill kit and follow the manufacturer's instructions; use breathing apparatus, if required, for ammonia solution.
- *Alkali spills of less than 20 ml*
  As for acids, above.

Never put water into concentrated acid.

Never pipette by mouth.

Use a working fume cupboard and close the shutter as far as possible.

Never leave bottles on open shelves or in fume cupboards when not in use.

Never throw concentrated acids and alkalis down the sink; pour them carefully into plenty of water (take care—heat is generated) and wash them away with the tap running.

Wipe the outside of bottles free of drips to avoid burns if anyone picks them up.

Wash the worktop while still wearing gloves; then wash hands.

Toxic chemicals

A toxic reaction can be either:

- *acute*—the almost immediate effect of a single dose; or
- *chronic*—the cumulative effect of a succession of small doses, or of extended exposures.

Avoid using toxic chemicals if they can be replaced by other non-toxic chemicals.

Wear a laboratory coat and protective gloves.

Know the toxic properties of the chemicals being used.

Know what to do if there is an accident, and ensure that the means of carrying it out are available.

Know where the eyewash bottles are kept.

Know where the cyanide antidote is kept.

Record new acquisitions in an appropriate book, including quantity, date and name.

Never leave the cupboard containing toxic chemicals unlocked and unattended.

Remove the required chemical and return the stock bottle to the cupboard.

Record the quantity used, date and signature.

Never leave toxic chemicals unattended; lock them away.

Clean up any spills. For solvents, corrosives and mercury, use the appropriate spill kit and follow the manufacturer's instructions; consult a senior officer if in doubt.

Use a fume cupboard if the chemical gives off a toxic vapour.

Never pipette by mouth.

Do not contaminate laboratory notebooks.

Take care when disposing of waste; check the method before starting work; consult a senior officer.

Wash the worktop, wash gloves while still wearing them, then wash hands.

Carcinogenic chemicals

Many common laboratory chemicals are known or suspected carcinogens.

Handle carcinogens taking special precautions agreed with senior officers.

Wear a laboratory coat and gloves.

Keep carcinogens in the same way as toxic chemicals, above.

Clean up any spills, cordon off the area; inform a senior officer; get help and seek advice on the method of cleaning up.

Use carcinogenic chemicals only in a laboratory with a working fume cupboard, good room ventilation and washing facilities.

Define the working area clearly.

Cover worktops and benches with disposal bench coating.

Use a fume cupboard for all work with suspected carcinogenic organic solvents (e.g. chloroform).

Take special care when using powders; if possible, use non-volatile powders as suspensions or paste.

Never pipette by mouth.

Dispose of waste carcinogens by an appropriate means. The best method is chemical destruction by competent contractors.

Wash the workplace, any rubber and plastic items, and then hands.

Irritant chemicals

Effects of irritant chemicals range from mild skin irritation to chemical burns. Irritation may develop into a slow-healing dermatitis, resulting in blistering.

Skin may become sensitized to a particular chemical.

Some solvents cause a defatting of the skin, tending to enhance the possibility of dermatitis or sensitization.

Some chemicals cause tumours; others penetrate the skin or eye and cause systemic effects.

Avoid skin contact by wearing appropriate gloves.

Report sensitization and avoid further contact with the irritant.

Use a fume cupboard for all work with irritant vapours.

Explosive chemicals

Keep picric acid under water and never allow it to dry out.

Micro-organisms

The following requirements are in addition to those for general laboratory safety.

Some micro-organisms (pathogens) have the propensity to induce illness by ingestion, inhalation or through open wounds. All work carried out using micro-organisms must be done in such a way as to reduce those risks to safe levels.

All incoming samples should be treated as if they contain pathogens until results are available which prove otherwise. Similarly, all plates produced from such samples should be treated as potentially harmful.

Consult a senior officer *before* commencing any new work which might be hazardous.

Cultures of known pathogens may need to be handled in a fully functional safety cabinet; consult a senior officer for advice. Pathogenic organisms must not be handled in a laminar flow cabinet.

Cultures of micro-organisms maintained for laboratory use must be held in a locked cupboard or refrigerator as appropriate.

All samples and cultures arising from them must be disposed of in a safe manner which will normally involve steam sterilization.

All contaminated glassware must be treated to destroy micro-organisms *before* being washed. Steam sterilization is the normal procedure.

Pipettes must be discarded into a jar containing enough phenolic disinfectant to ensure that the entire pipette is submerged. Disinfectants must be made up to the correct strength as recommended by the supplier.

Plastic dishes and bottles must be steam sterilized *before* disposal.

Strict personal hygiene should be observed when working with micro-organisms. Hands should be washed with liquid soap and water, before and after microbiological examinations, and dried with paper towels.

Clean and intact laboratory coats must be worn for all work and they should preferably be of the Howie style. Laboratory coats used in the microbiology laboratory must not be worn outside the microbiology laboratory.

There must be no contact between hand and face while in the laboratory and nothing should be placed in the mouth. This precludes eating, smoking or drinking, and mouth pipetting.

Cuts and other skin lesions should be covered by a waterproof dressing to prevent infection.

The flaming of implements with alcohol must be carried out with great care.

Work areas and associated equipment should be cleaned before and after use with a disinfectant suitable for the surfaces involved.

Water-baths should be cleaned regularly and either filled with a disinfectant recommended by the manufacturer, or heated to 80 °C for 30 min each week.

Spillages from cultures or samples should be mopped up using paper towels wetted with a phenolic disinfectant and the entire area cleaned and disinfected before continuing.

In the case of illness which might be attributable to working with micro-organisms, medical advice should be sought without delay.

Trainees

Trainees carrying out experimental or practical work must be supervized at all times.

If the senior officer considers an operation to be of sufficient importance, written instructions must be provided to ensure a safe working system.

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