TESTING OF SAMPLES FOR FITNESS-FOR-PURPOSE (ACCORDING TO THE FAO GUIDELINES)

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STANDARDS, GUIDELINES AND SPECIFICATIONS

- There are three recognized categories of microbiological criteria:
  - standards,
  - guidelines and
  - specifications.
- Standards are legislative and mandatory, and are embodied in law.
  - Failure to comply with standards may lead to prosecution.
  - The International Organization for Standardization (ISO) in Geneva publishes a range of written standards for many types of food.
- Guidelines are not legal standards, although regulatory bodies may use them.
  - In-house guidelines may vary from country to country, or even from company to company.
- Specifications are technical requirements that form the basis of a commercial transaction.

STANDARD TESTING METHOD FOR FOOD COMMODITIES

- There are no globally accepted standards for testing foods.
- However, validated methods have been published by the Association of Official Analytical Chemists (AOAC) and ISO.
- The US Food and Drug Administration uses the AOAC methods.
- These methods are not mandatory, and may be……
  - modified or varied from country to country based on the local laboratories' experience, standard operating procedures and local country guidelines.
- Notwithstanding which methods are used, it is important to be able to justify why a particular sampling plan or analytical method was employed, and this will vary depending on the commodity, amount, specification, etc.

WHY ARE TESTS NEEDED?

- There are two main reasons why a food may be tested, both at manufacture and after arrival at the distribution point.
- Tests may be required for quality or for safety.
  - is the food up to specification, and still nutritious?
  - **does consumption of the food pose a risk to health?**
- Food that is unsafe is, by definition, of poor quality, but poor quality food may still be safe to eat.

Sampling Stored Commodities

- Most food aid commodities are stored in bags.
- The number of bags to be sampled depends on…..
  - the type of commodity;
  - its amount; the amount that can be sampled (can the stack be broken down so that internal bags can be reached?);
  - the age of the stack (if newly built, bags on the faces can be assumed to be in the same condition as those inside, but if the stack is old the condition of external and internal bags may be very different).
  - the nature of the problem
    - In general terms, fewer samples are required if insects and fungi are the major problems,
    - but more samples should be taken if mycotoxin contamination is suspected (Table 9.1).

There are no hard-and-fast rules for sampling methods that cover all commodities under all conditions. The data in Table 9.1 should be used as guidelines only.

IS IT WORTH TAKING SAMPLES?

- Samples should be taken any time there is a need to obtain scientifically valid conclusions concerning the fitness of a consignment,
- Such decisions imply a good understanding of risk assessment and damage mitigation as applied to food aid.
- Some cases are difficult to assess. For example, grain infected with fungi may have produced mycotoxins, but testing for mycotoxins may not be needed if the presence of the fungi is itself sufficient to warrant disposal of the grain.
- However, it may be that a light fungal load can produce significant amounts of mycotoxins, so the opinion of a food microbiologist or mycologist should be obtained.

SAMPLING?

- Random samples are preferable – the number of samples will depend on the nature and size of the commodity and the problem.
- As a rough guide, every unit should be sampled if there are fewer than 10 in the batch,
- For 11–100 in the batch, 10 units should be sampled.
- If there are more than 100 units in the batch, then the square root should be sampled.
- Samples should be divided and half retained by the in-country office, so that cross-checks can be done at a later date.

Table 9.1 Minimum number of bags (primary units) to be sampled for different problems

Total number of bags	Number of bags to be sampled		
	Insects and moisture content	Fungi and bacteria	Mycotoxins
4–20		4	Every unit
Up to 10	Every unit		
11–100	10		
21–60		6	Every unit
61–100		9	Every unit
>100	Square root		
101–400	Square root	16	100
>400	Square root	20	100
1000	32 (square root)	100	100
10 000	100 (square root)	1001	1001
20 000	142 (square root)	200 (i.e. 2 x 100)*	200 (i.e. 2 x 100)*
30 000	174 (square root)	300 (i.e. 3 x 100)*	300 (i.e. 3 x 100)*
50 000	224 (square root)	500 (i.e. 5 x 100)*	500 (i.e. 5 x 100)*
100 000	317 (square root)	1000 (i.e. 10 x 100)*	1000 (i.e. 10 x 100)*

*When large stacks (>1000 tonnes) are to be sampled, divide the stacks into lots of about 500 tonnes (= 10 000 x 50 kg bags) and take 100 samples from every lot.

EMBARGOED BY A GOVERNMENT MINISTRY

- If a commodity has been embargoed by a government ministry,
- Then taking samples and sending them for analysis by an independent third party may be the best option for resolving the impasse and allowing disposal or use of the food aid.

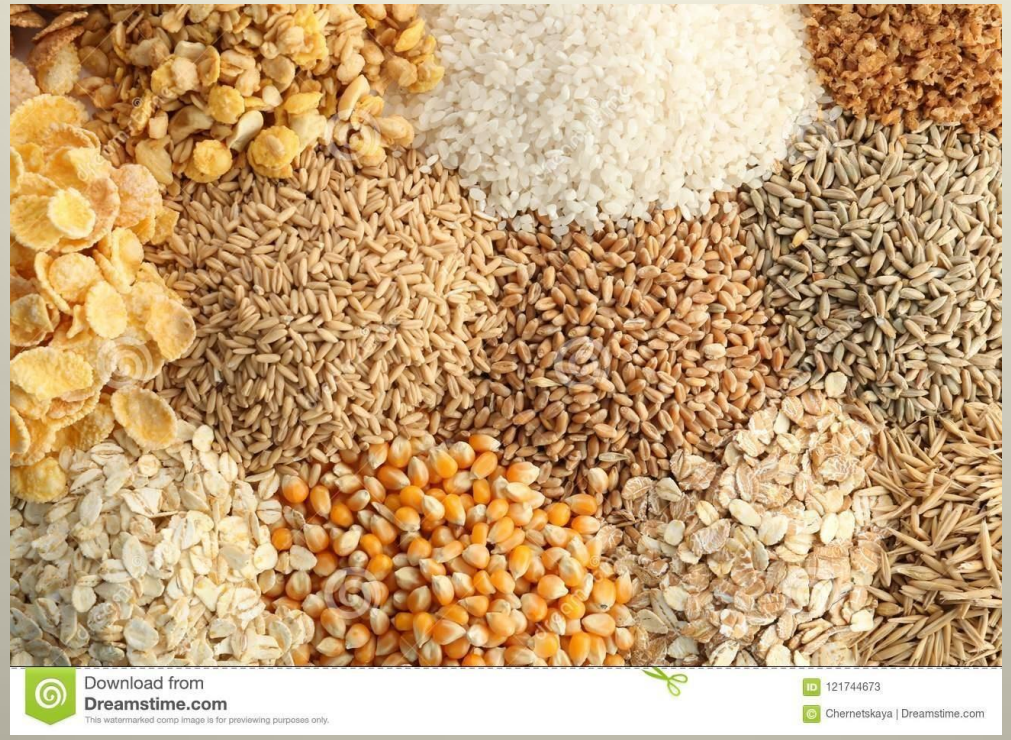
WHAT TESTS COULD BE DONE, AND WHY?

- Deterioration of food is largely dependent on three factors:
  - moisture,
  - relative humidity and
  - temperature,
- Temperature is the most significant effect on shelf-life.
- Foods can be tested for many parameters.

WHAT TESTS COULD BE DONE, AND WHY?

- 1. Test for decline in quality resulting from lengthy storage periods that change texture, colour, flavour or nutritive value, for example, protein content, vitamin and micronutrient content, palatability, organoleptic testing. Flour can lose its baking power after 6 months and not its suitability for human consumption.
- 2. Test for physical changes such as melting of fats in canned meats at high temperatures; or crystallization of sugars at low temperatures; or water absorption by sugar, salt or milk powder leading to crystallization and caking.
- 3. Test for chemical changes such as oxidation of fats, vitamin loss, non-enzymic browning, production of off-flavours, flour gluten content and acidity and corrosion of containers.
- 4. Test for the presence of insects or micro-organisms; or the effects of poor processing that does not kill all contaminants when the food is cooked, for example, meat or fish in cans. Micro-organisms may cause discoloration, caking or physical deterioration, fermentation, putridity or rancidity, or may produce carcinogens such as mycotoxins and other toxic chemicals, or transmit diseases such as salmonellosis.
- 5. Test for poor quality packaging or damage accrued in transit, from internal or external corrosion, to claim against manufacturers, shippers, handlers or storage agencies.
- 6. Test for specific contaminants where there is evidence that a problem has arisen.

WHICH TEST FOR CEREAL GRAINS AND FLOURS?



WHICH TEST FOR WHICH COMMODITY?

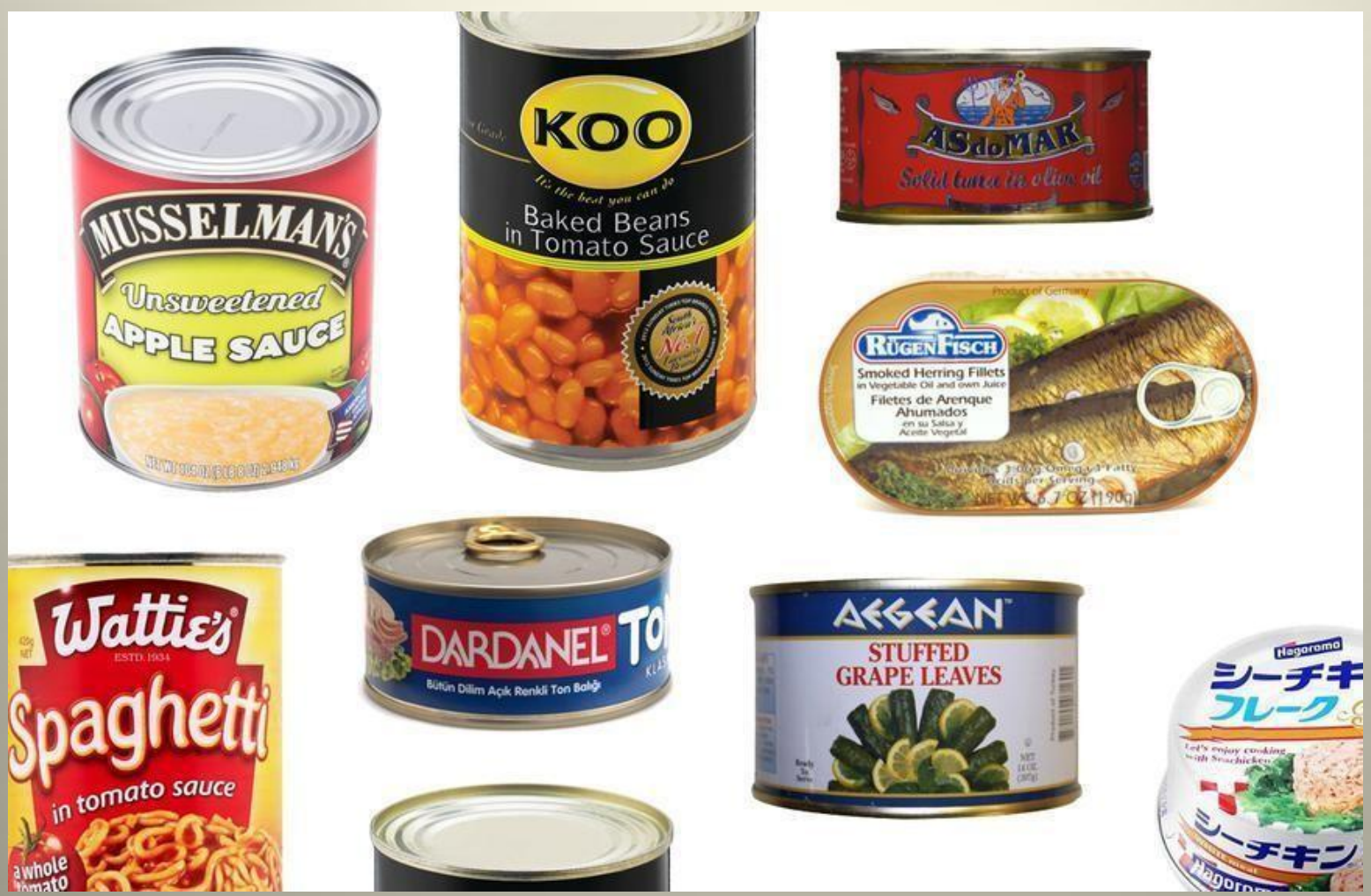
Cereal grains and flours:

- **Insect damage** – identify species and count numbers per kilogram. Compare against relevant standards.
- **Physical damage** – sieve and count damaged fractions. Compare against international standards.
- **Moisture content** – measure using internationally agreed (ISO) oven methods. Compare result with the specified standard for the commodity
- **Chemical changes** – fats in cereals stored for long periods are subject to oxidation which may lead to rancidity and off-odours, so tests for free fatty acid (FFA) content may be appropriate. The sample would be compared against a control sample. In rice, the FFA content declines at a known rate, so this test can be useful in providing a rough guide to the age of a consignment.

- **Wetting of dried products (cereals or dried powders)** – leads to microbiological contamination, which may also follow in the wake of insect infestation as the metabolism of insects raises the moisture content of the commodity. Laboratory analysis would involve plating grains on microbiological growth media to identify contaminant species and assessing the numbers per gram of sample.

- Simple technique: Flour may lose its baking qualities over time. Simple baking and organoleptic tests will usually suffice.

WHICH TEST FOR CANNED GOODS?



WHICH TEST FOR WHICH COMMODITY?

Canned goods

- Damaged cans should be destroyed because of the risk of contamination with *Clostridium botulinum*, which produces a heat stable botulinum toxin that is potentially fatal.
- Samples should be sent for examination in all instances where claims or retort actions are contemplated against the donor, shipper or manufacturer as a result of poor or defective quality

WHICH TEST FOR OILS AND FATS?

WHICH TEST FOR WHICH COMMODITY?

Oils and fats

- Changes in oil structure over time lead to rancidity and off-odours, which may lead to rejection.
- Chemical analysis of FFA, peroxide value and *p*-anisidine value are usual.
- At production, vegetable oil is likely to have an FFA content of less than 0.05%; FFA levels higher than this indicate that the oil has deteriorated.
- The peroxide value (PV) indicates the level of primary oxidation through measurement of the primary oxidation products.
- As the oil deteriorates further, these primary products (hydroperoxides) break down to give off-flavour and odour-producing compounds which are detected by the *p*-anisidine (AV) test.
- Effectively, the PV indicates the current oxidation state of the oil and the AV indicates its oxidation history.
- Rather, they should be combined (AV + 2PV) to give the Totox value, which is an overall indicator of rancidity.
- A Totox value of about 10 is generally accepted as the upper limit for oil considered fit for human consumption. Oils are sometimes supplemented with vitamin A, which can also be measured. However, if the Totox value is high there is little point, as the oil can be condemned on the Totox value alone.

WHICH TEST FOR WHICH COMMODITY?

Pulses

- Changes in protein structure over time lead to the hard-to-cook phenomenon, which means that long cooking times may be needed, leading to high demands for fuel.
- Even when these beans are well cooked they may be unpalatable or lead to stomach upsets when eaten. The hard-to-cook phenomenon can be assessed using organoleptic methods or by measuring hardness with a penetrometer.
- Insect and microbiological examination can also be done, as mentioned.

WHICH TEST FOR WHICH COMMODITY?

Table 10.1 Food aid commodities, shelf-lives, spoilage agents and recommended tests

Commodity	Packaging	Typical shelf-life (years) in temperate zones	Typical shelf-life (years) in tropical zones	Physical or chemical spoilage	Biological spoilage	Action by delivery point on receipt	Possible tests
Wheat	Polypropylene or jute sacks, or in bulk	2–3	<3 if moisture content ≤14%	Breakage during handling, wetting	Storage fungi, e.g. *Aspergillus, Penicillium, Mucor* and *Rhizopus*; insects, e.g. *Sitophilus, Rhyzopertha, Sitotroga*; rodents; birds	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; broken grains
Maize	Polypropylene or jute sacks, or in bulk	2–3	<2 if moisture content ≤14%	Breakage during handling, wetting	Storage fungi, e.g. *Aspergillus, Penicillium, Mucor, Fusarium* and *Rhizopus*; insects, e.g. *Sitophilus, Rhyzopertha, Prostephanus, Sitotroga*; rodents; birds	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; broken grains
Rice (polished)	Polypropylene or jute sacks, or in bulk	2–3	<1 unless very well polished and moisture content <14%	Breakage during handling, wetting; oxidation of oils	Storage fungi, e.g. *Aspergillus, Penicillium, Mucor* and *Rhizopus*; insects, e.g. *Sitophilus, Ephestia, Plodia, Tribolium, Corcyra* and *Cryptolestes*; rodents; birds	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; broken grains; Totox value and free fatty acid content; possibly vitamin content
Sorghum	Polypropylene or jute sacks, or in bulk	10–12		Breakage during handling, wetting	Storage fungi, e.g. *Aspergillus, Penicillium, Mucor* and *Rhizopus* spp.; insects, e.g. *Cryptolestes, Sitotroga, Rhyzopertha, Sitophilus*; rodents; birds	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; broken grains

WHICH TEST FOR WHICH COMMODITY?

Processed cereals (flours)	Lined sacks	1	0.5	Damage to sacks during handling, wetting	Insects, e.g. *Tribolium*, *Cryptolestes*, *Ephestia*, *Plodia*	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; broken grains; package integrity
Pulses	Polypropylene or jute sacks	2	1	Breakage during handling, wetting	Storage fungi, e.g. *Aspergillus*, *Penicillium*, *Mucor* and *Rhizopus* spp.; insects, e.g. bruchid beetles, *Plodia*, *Ephestia*, *Tribolium*; rodents; birds	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; broken grains; cooking time
Blended foods, e.g. corn soya blend	Lined sacks	1	<1	Damage to sacks during handling, wetting; non-enzymic browning; oxidation of oils	Insects, e.g. *Tribolium*, *Cryptolestes*, *Ephestia*, *Plodia*; rodents	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; Totox value and free fatty acid content; possibly vitamin content; package integrity
Biscuits	Cartons	0.5–0.75	0.5	Damage to containers during handling, wetting	Insects, e.g. *Tribolium*, *Cryptolestes* and *Stegobium*	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; package integrity
–	Sealed tins	5	3	–	–	–	–
Dried milk powder	Lined sacks	Instant, 1	1	Crystallization from water uptake in high humidity atmospheres, leading to caking	Toxins from *Staphylococcus* spp. (rare), fungi	Inspect for signs of insects, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; package integrity
–	–	Non-instant, 2–4	2	–	–	–	–

WHICH TEST FOR WHICH COMMODITY?

Table 10.1 *cont.*

Commodity	Packaging	Typical shelf-life (years) in temperate zones	Typical shelf-life (years) in tropical zones	Physical or chemical spoilage	Biological spoilage	Action by delivery point on receipt	Possible tests
Salt	Lined sacks	Indefinite	Indefinite	Crystallization from water uptake in high humidity atmospheres, leading to caking		Inspect for leakage and wetting	Iodine content
Sugar	Lined sacks	Indefinite	Indefinite	Crystallization from water uptake in high humidity atmospheres, leading to caking		Inspect for leakage and wetting	
Vegetable oils	Plastic bottles, cans, steel drums	>1	1	Poor lid seals or seams, leaks from split bottles; oxidation of oils		Inspect for blown, damaged or leaking containers	Totox value and free fatty acid content; possibly vitamin content; package integrity
Dried salt fish (local)	Cloth bales	0.2	0.2	Wetting	Bacteria, fungi, insects such as *Dermestes*; rodents	Inspect for signs of insects, bacteria, fungi, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities
Stockfish (tins)	Cloth bales	0.75	0.5	"	"		
Dried fruit	Plastic bags	0.75–5 (if hermetically sealed)	0.25	Crystallization from water uptake in high humidity atmospheres, but no caking	Yeasts, fungi, e.g. *Aspergillus*, *Penicillium*, *Mucor*, *Rhizopus*; mites; rodents; birds	Inspect for signs of insects, fungi, yeasts, rodents or wetting	Identities and numbers of colony-forming units; moisture content; insect counts and identities; package integrity

WHICH TEST FOR WHICH COMMODITY?

Meat	Cans	3*	1.5	Poor lid seals or seams	Spore-forming bacteria such as *Bacillus* or *Clostridium*; non-spore-forming bacteria, e.g. *Salmonella* and *Staphylococcus* spp.	Examine contents; if over-cooked distribute quickly	Identities and numbers of colony-forming units; package integrity
Corned beef and mutton	Cans	4*	2	*	*		
Fish in tomato sauce	Cans	2*	1	Poor lid seals or seams	Spore-forming bacteria such as *Bacillus* or *Clostridium*; non-spore-forming bacteria, e.g. *Salmonella* and *Staphylococcus*	Examine contents; if over-cooked distribute quickly	Identities and numbers of colony-forming units; package integrity
Fish in oil	Cans	3*	1.5	*	*	*	
Cheese	Cans	2.5**	1.5	Poor lid seals or seams	Spore-forming bacteria such as *Bacillus* or *Clostridium*; non-spore-forming bacteria, e.g. *Salmonella* and *Staphylococcus*	Examine contents; distribute before other canned goods	Identities and numbers of colony-forming units; package integrity

*Residual or guaranteed shelf-lives; effective shelf-lives could be two to four times longer.

WHAT TO DO WITH DOWNGRADED FOOD?

- This depends on the commodity and needs to be determined on a case-by-case basis.
- Options include ……
  - export to another country;
  - Destruction,
  - Blending at 5–10% with good quality food,
  - For animal feed.

QUESTION