Sampling for food composition

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Food sampling concerns the selection of the individual units of foods, food products or bulk foodstuffs from the food supply or source, whether it be market place, manufacturing outlet, field or from the homes of the members of the study population.
Various definitions

- The selection and collection of items of foods defined in number, size and nature to represent the food under consideration

- The physical operation of removal of items from lots or fields or large loads (e.g. ships)

- The consolidation and reduction of the collected items to form the portion for analysis

Objective of food sampling

Main objective:
- To provide representative mean values for individual components in foods

Dependent on requirements:
1. Nutrient composition purposes
   - Sampling plan designed to obtain representative estimates of the nutrient content for the nation
2. Labelling
3. Nationwide vs. Brand / Region
4. Research, e.g. Beef carcasses
Outcomes of good sampling

• Representative food composition data, obtained through:
  • Good protocols for sample selection (sampling)
  • Adequate methods for sample handling (transport & preparation)
  • Analytical quality control (analyses)

Guidelines

• Codex Committees
  – Methods of Analysis and Sampling (33rd)
  – Nutrition and Foods for Special Dietary Uses (33rd)
  – Food Additives & Contaminants (44th)
  – Pesticide Residues (44th)
  – Food Labeling (40th)

• South African legislation
  – Sampling guideline for the purpose of generating nutrition data by analysis and verification (R.146 of 1 March 2010)
Sampling plan

**Basic objectives**
1. To collect representative data
2. Ensure no changes (negative or positive) between sampling & analysis

**Specific objectives**
1. To collect foods representative of that available to, or consumed by, the population
2. To provide info on variations in the composition of the food
3. To ensure that that portions taken for analysis are representative
4. To prevent loss of constituents, contamination or degradation of the material during collection, handling, storage or analysis

Development of the Sampling Plan

1. Statement of the objective
2. Description of the problem and background
3. Demographic plan
4. Facts about the food
5. Relationship to the data table entries
6. Timetable and budget
7. Predicted impact
Sampling plan

1. Collect sample units
2. Transport & preparation
3. Analyses

Not that simple
1. Collecting sample units

Requires collection of units (packages, bunches, or items) representative of the total population of food units

• Samples units must be taken from the available types & forms of the food for which the composition data is being determined
• Production, consumption, or sales statistics may be used

Considerations

• How?
  • Methods of sampling
• What?
  • Number of samples
  • Sample size
• Where?
  Consider variability:
  • National/regional selection (demographic plan)
  • Recipe variations
  • Cultivar / Breeds
  • Seasonal changes
  • Maturity
  • etc…
**HOW? WHAT? WHERE?**

- Foods should be typical of the usual preparation and consumption practices
- Correct units of foods should be selected

**The example of Thohoyandou SPAR**

4.5 Tons Chicken Feet Per Day

60 000 Chickens

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**How? Methods of sampling**

- Random sampling
  - Best practice
- Representative sampling
- Stratified sampling
- Selective sampling
- Convenience sampling

alternative – may provide data of better quality

not acceptable for labelling
What?
Selection of foods & components

• Impossible to analyze all foods
  • *Select foods / food groups*
• Impossible to analyze all components in all foods
  • *Select food component / nutrients*
• Need to establish priorities

Establishing priorities of foods and food groups to include

• Food consumption statistics
• Food consumption patterns
• Nutritional contribution
• Nutrition-related health problems of country
• Changes in agriculture & food technology
• Trade and economics
• Specific local foods
Establishing priorities of food components / nutrients

- Nutrition-related health problems of country
- State of nutritional science
- Availability of existing data
- Existence of analytical methods
- Feasibility of analytical work

Number of samples

- Global standard for food comp databases
  - 10 food sample units, 3 analytical sample
- US nutrition labeling requires 12
- SA Labelling regulations
  - Relative homogenous e.g. Pasta
    - Minimum 3 samples
  - Non-homogeneous e.g. Muesli / Ready-to-eat meals
    - Minimum 12 samples
Number of samples is dependent on the knowledge of the food

- Where is the food consumed and by how many?
- What forms/types/brand names of the food are consumed?
- Where is the food produced? When?
- How is the food prepared?
- Is the food prepared from a recipe or formulation?
- Market Statistics available?

Sample size

**Amount of material required** depends on:

- objective of analyses
- analyses of individual or composite samples
- number of components to be measured
  
  – determine the number and weight of aliquots needed as required by analytical methods
- policy for saving reserve or archive aliquots
Sample size

- small samples $\rightarrow$ grand mean + variability
- mean of means of repeated sampling better than one small sample to estimate grand mean
- composite samples reduce estimate of variability over individual samples
  - 1 composite sample no estimate of variability
  - larger number of units better estimation of mean than a smaller sample

![Graph showing fat content of single peanuts, 100 g peanuts, and 1 kg peanuts with sample means and variability]

Example: Apple

Source Y, Limpopo
Source X, Western Cape
Source Z, KZN

Sampled Population

Sample

Individual analysis

Composite analysis

subsamples

Adopted from: Joanne Holden, USDA
Where?
Ensuring representative sampling

- Foods are biological materials, and as such, contain a natural variability in composition
- Even processed foods produced under highly controlled circumstances show variability
- Without variability one measurement would be enough to characterize food composition
- Need to incorporate variability in the sampling plan / protocol

Variability

- For critical components variability may impact the sufficiency, deficiency or excess of the intake of a given component / nutrient
- Sampling and analyses planning should specifically considering this variation
- The intended use of the data should determine the specificity and level of precision
Rationale for considering variability

- Different varieties of the same species have statistically different nutrient contents
- Identification of varieties in dietary surveys provides better data
- Nutrient data for varieties are essential in order to analyse dietary data
- Nutrient content needs to be among criteria in species promotion
- Variation in manufactured foods need to be documented

Basic statistical terms

- Difference between variability and uncertainty
- Variability — variation due to real differences in the food with cause either known or unknown
  - Example 1: protein content of milk in winter and spring
  - Example 2: variations in protein content of packages cereal product
- Uncertainty — variation due to lack of knowledge
  - Example 1: different estimates for the mean protein content (e.g. from 2 samples of the same population)
  - Example 2: different estimates for the protein content of a chemical sample (repeated analyses)
Variability

- breed, brand or cultivars
- season
- climate
- geographic location (e.g. soil type)
- fertilizer treatment
- method of husbandry
- harvesting
- distribution and marketing practices

- preservation state
- stage of maturity, age or ripeness
- enrichment/fortification standards
- preparation methods,
- food colour
- variation in recipes and formulations
- retail practices

Differences between countries
Nutritional quality of South African lamb

![Graph showing differences in nutritional quality between 1991 and 2004 for South African lamb. The y-axis represents % Fat and Cholesterol, while the x-axis represents the year, 1991 and 2004. The graph includes data from USDA and own data, with a bar showing 25% Fat in 1991 and 10% in 2004, and 108 mg Cholesterol in 1991 and 60 mg in 2004. The graph is color-coded with blue for 1991 and red for 2004.]
Cultivar Differences

**Tomatoes**

- \( \beta \)-Carotene 600 \( \mu g/100g \)
- \( \beta \)-Carotene 763 \( \mu g/100g \)

![Tomato images]

Cultivar Differences

**Apricots**

<table>
<thead>
<tr>
<th>Database</th>
<th>( \mu g \beta )-Carotene Equiv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDA (09021)</td>
<td>1566</td>
</tr>
<tr>
<td>British (860 5th ed.)</td>
<td>405</td>
</tr>
<tr>
<td>Australian (06C1-002)</td>
<td>208</td>
</tr>
<tr>
<td>New Zealand (L19)</td>
<td>\textbf{6939}</td>
</tr>
<tr>
<td>German (Pg 746-749)</td>
<td>1790</td>
</tr>
</tbody>
</table>

![Apricot images]
### Cultivar differences

#### Bananas

<table>
<thead>
<tr>
<th>Banana Variety</th>
<th>Edible Portion</th>
<th>Water g</th>
<th>Energy kJ (kcal)</th>
<th>Calcium mg</th>
<th>Phos mg</th>
<th>Iron mg</th>
<th>ß carotene mcg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavendish</td>
<td>64</td>
<td>74.4</td>
<td>435 (104)</td>
<td>139</td>
<td>20</td>
<td>0.8</td>
<td>75</td>
</tr>
<tr>
<td>Botoan</td>
<td>57</td>
<td>74.4</td>
<td>422 (101)</td>
<td>21</td>
<td>27</td>
<td>0.4</td>
<td>25</td>
</tr>
<tr>
<td>Ternatensis</td>
<td>62</td>
<td>66.3</td>
<td>552 (132)</td>
<td>15</td>
<td>19</td>
<td>0.9</td>
<td>370</td>
</tr>
<tr>
<td>Ternatensis</td>
<td>64</td>
<td>66.2</td>
<td>560 (134)</td>
<td>11</td>
<td>24</td>
<td>0.7</td>
<td>325</td>
</tr>
<tr>
<td>Tuldoc</td>
<td>76</td>
<td>74.8</td>
<td>414 (99)</td>
<td>26</td>
<td>28</td>
<td>1.6</td>
<td>1370</td>
</tr>
<tr>
<td>Uht en yap</td>
<td>69.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2780</td>
</tr>
</tbody>
</table>

Philippine Food composition tables, 1997 and Englberger et al. 2003 JFCA
Regional Differences
Plot of CV mean scores of different localities for milk

Retail practices
Global decreases in fat content of meats observed over time
Variation between brands
Pilchards in tomato sauce, per 100g serving

<table>
<thead>
<tr>
<th></th>
<th>Saldanha</th>
<th>Lucky Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (KJ)</td>
<td>704</td>
<td>479</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>23</td>
<td>18.9</td>
</tr>
<tr>
<td>CHO (g)</td>
<td>0.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Sugars (g)</td>
<td>-</td>
<td>1.2</td>
</tr>
<tr>
<td>Total fat (g)</td>
<td>6.08</td>
<td>2.8</td>
</tr>
<tr>
<td>Saturated fat (g)</td>
<td>0.87</td>
<td>0.6</td>
</tr>
<tr>
<td>Polyunsaturated fat (g)</td>
<td>3.29</td>
<td>1.2</td>
</tr>
<tr>
<td>Omega 3 (mg)</td>
<td>3.9</td>
<td>1016</td>
</tr>
<tr>
<td>EPA &amp; DHA (mg)</td>
<td>3.1</td>
<td>850</td>
</tr>
<tr>
<td>Dietary fiber (g)</td>
<td>0.59</td>
<td>1.1</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>262</td>
<td>377</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>404</td>
<td>370</td>
</tr>
<tr>
<td>Selenium (mcg)</td>
<td>-</td>
<td>1198</td>
</tr>
</tbody>
</table>

Source: A Booysen, DOH

Selecting sample units
Summary: How, what and where

Sampling Plan – evaluation criteria:

- Random selection of sampling locations
- Number of regions represented
- Number of cities/regions
- Number of samples taken
- Number of seasons/brands covered
Considerations

2. Transport & handling

• Coding & identification
• Sample handling
  – Stability of components (Temp, light, time, evaporation etc.)
  – Contamination & exposure
  – Damage
• Recipe preparation
• Simple / composite samples

Sample handling - Evaluation criteria

• Transport & storage conditions
• Homogenisation
• Equipment used
  – Validation of homogeneity
• Analysis of edible portion
• Data on moisture content
Sample protocol should be in place

• Include
  – Food storage
  – Transportation facilities
  – Sample unit documentation and labeling
  – Packaging
  – Short-term preservation requirements

• Documentation & handling of samples should be under careful control of principal coordinator
• Lab personnel should be informed prior to the commencement of the project on handling
• The samples should preferably be marked with 3 digit random codes for analysts to ensure unbiased analyses

Sample Handling Issues

• Stability of components
• Preparation and processing of samples
• Homogenization protocol
• Amounts of material
• Size of aliquot
Composite / individual sampling

- Collected sample units can be analyzed as:
  - individual units
  - combined together or composited
- Composite samples reduces cost
- Info on the variability of the component in that food will be lost

Considerations

- Coding & identification
- Duplicate / triplicate analysis
- Accreditation:
  - laboratory
  - methodology
- Saving reserve / archiving
- Documentation
Criteria for analysis

Number of Analytical Samples
• Number of independent analyses
• Multiple analyses of a single composite or the same sample count as one

Analytical Method
• Validity of method & Accreditation

Analytical Quality Control (QC)
**Analytical considerations**

- Do identified analytical laboratories meet requirements
  - Turn around time
  - Capacity
  - Appropriate methods
- Identification and estimation of variation that can be expected in national survey

**Danger of sampling error**

- Potatoes of different size
- Estimate average nutrient level per potato
- Without precaution: Higher probability to pick a larger potato
  - Nutrient level is higher in smaller potatoes
    - Changes in amylose to amylopectin ratio
  \[\rightarrow\] Biased estimate (too low)
Bias and variability

"It is better to be roughly accurate than precisely wrong"

Source: Wageningen University

Importance of Data Documentation

Needed to:
- qualify data
- evaluate data
- standardise / harmonise data
- interchange data
**Example: National sampling plan**

1. Draw up final sampling protocol
2. Collect samples from the selected markets/areas
3. Mark samples clearly and record collection procedure properly
4. Transport samples to laboratory
   - (Brown bags, protected from light, oxygen, temperature) (Fresh or frozen)
5. Field sample reduced to laboratory sample
6. Chemical analyses according to appropriate methodology
7. Reporting of data

**Possible sampling errors**

- Sampling Protocol not well documented
- Wrong place for sampling
- Not representative (monitoring)
- Lack of precision
- Inhomogeneity (no composite samples)
- Lack of balance in spending resources (sampling/analysis)
- Lack of coordination with others

E.g. Buffalo meat (India) used in African food composition table as beef values
  - Error carried throughout Africa
  - Borrowed by many other country tables
Conclusions for sampling

- Decide for most important features to be included in sampling scheme
- Sample for varieties
- Generate analytical data for varieties
- Compile these data systematically and centrally
- Collect diet survey data on varieties
- Consider nutrient content in crop variety promotions

Thank you

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