Energy and Micronutrient Densities of Complementary Foods Developed from a Composite of Teff, Soybean and Orange-fleshed Sweet Potato

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Orange-fleshed Sweetpotato (OFSP) Value Chains for Sustainable Food Systems in Sub-Saharan Africa: A model for Root and Tuber Crops and Banana

Presentation Outline

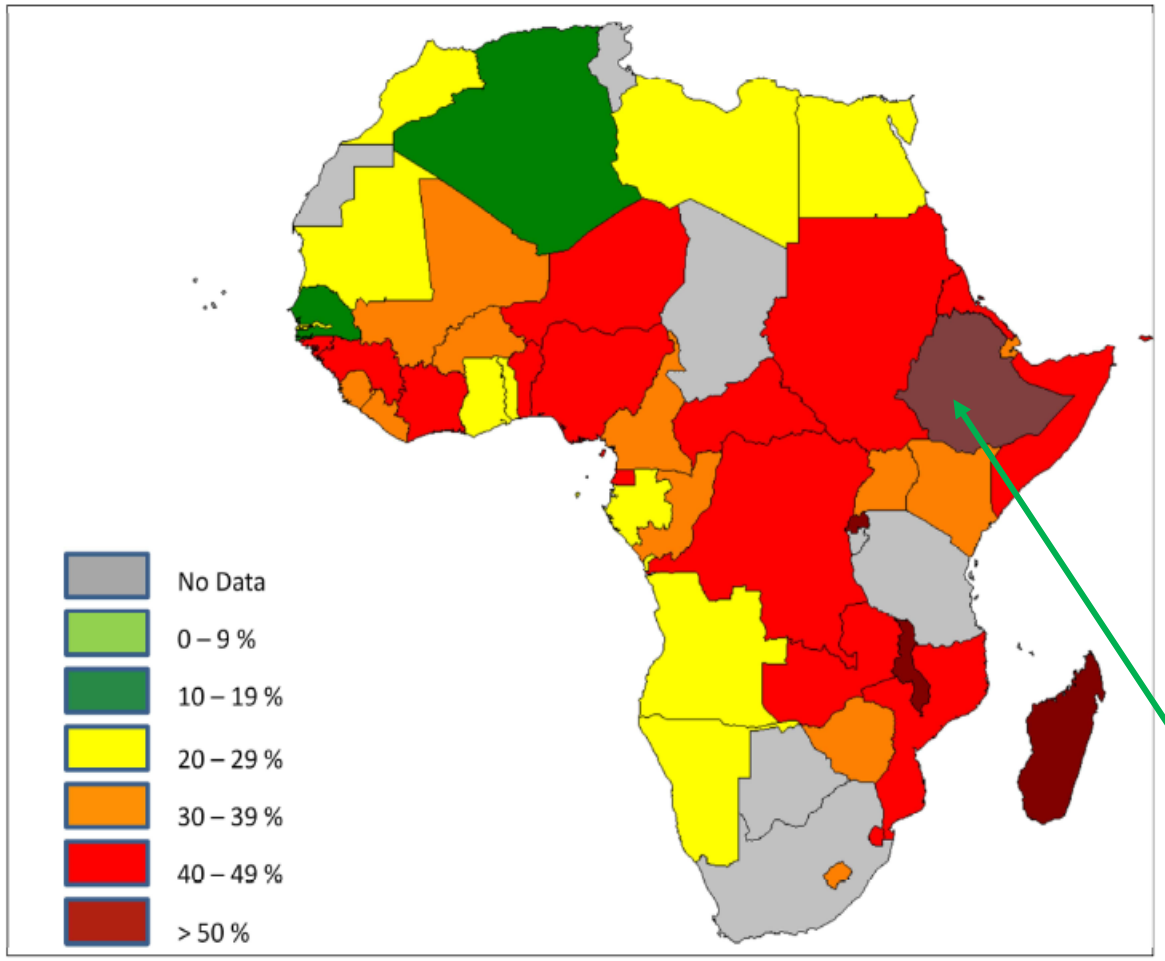
- Introduction
- Problem statement
- Raw materials
- Processing
- Formulation of complementary foods
- Preparation of complementary foods
- Determination of nutrient density
- Results
- Conclusion

Introduction

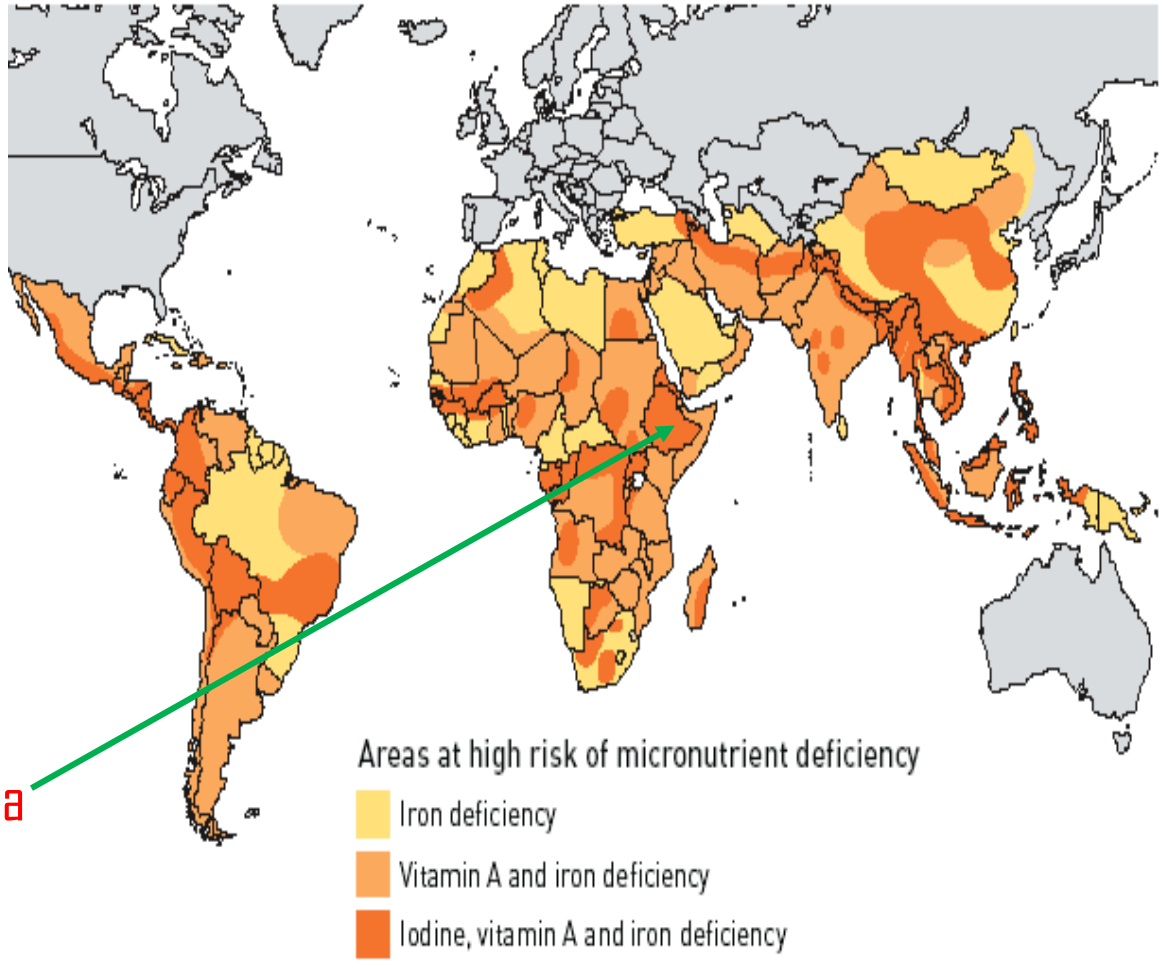
- The most neglected form of human deprivation is malnutrition:
  - ★ Protein-energy malnutrition (PEM)
  - ★ Micronutrient malnutrition (MNM)
- Infants and children the most vulnerable and highly affected groups of any society (rural areas + urban slums)
- Begins when infants are introduced to solid foods
  - ☞ Complementary foods (CFs)
- Worse during the second 6 months of the infant's life
  - ☞ The challenge for meeting nutrient needs is very high
- Developing countries-Sub-Saharan Africa and South-East Asia
  - ➢ Highest prevalence of stunting in **Eastern & Central Africa**
    - ☞ 50% and 42%, respectively (2008)
  - ➢ One third of all undernourished children globally reside in Sub-Saharan Africa (2015 MDG report)

⇨ Around the world (2014): **Stunting**: About 159 million; **Wasting**: About 50 million

Introduction



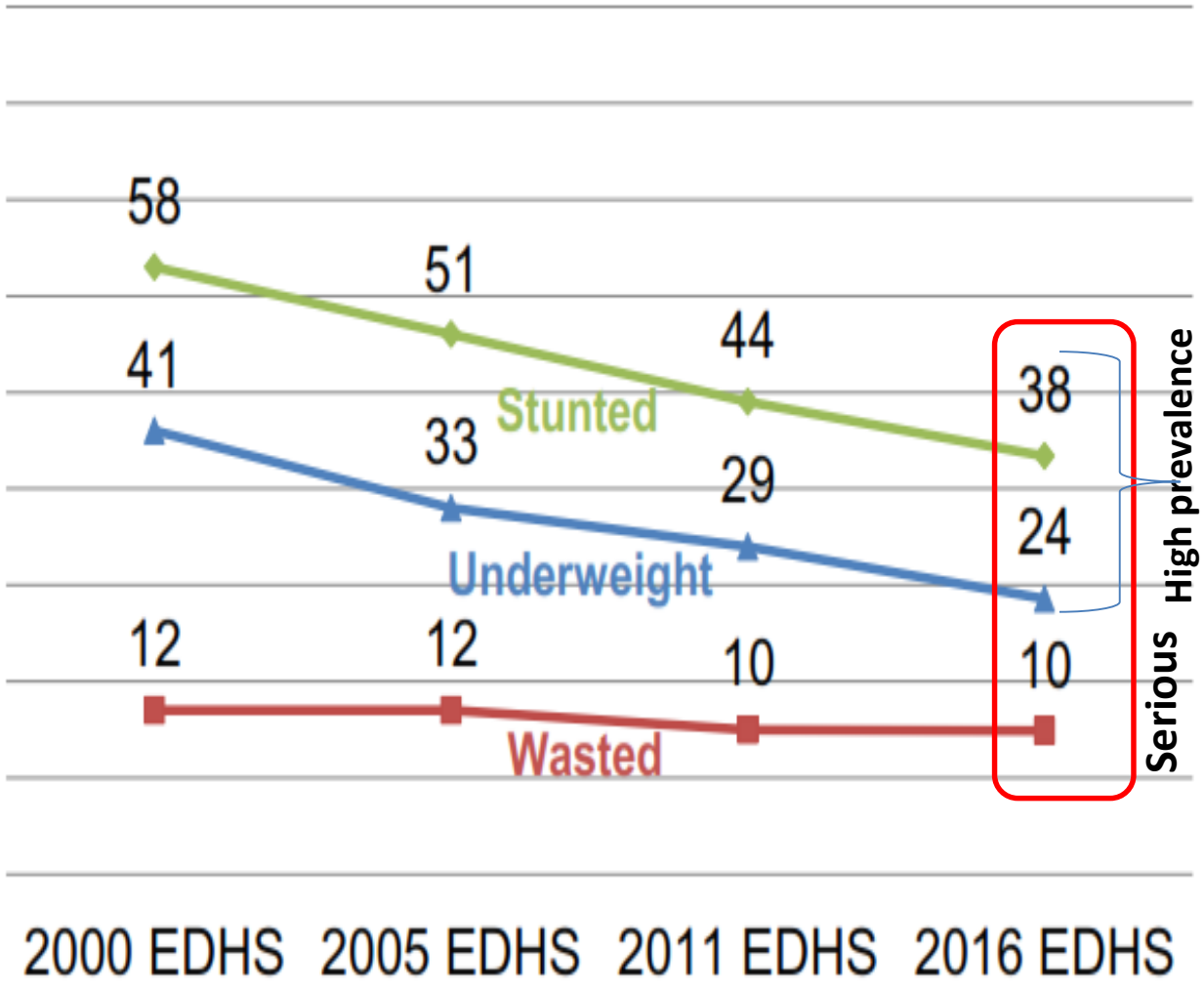
Ethiopia



Prevalence of moderate to severe stunting in children under five years of age in Africa (Fanzo, 2012)

Global prevalence of the major micronutrient deficiencies (Challenged Kids International, 2013)

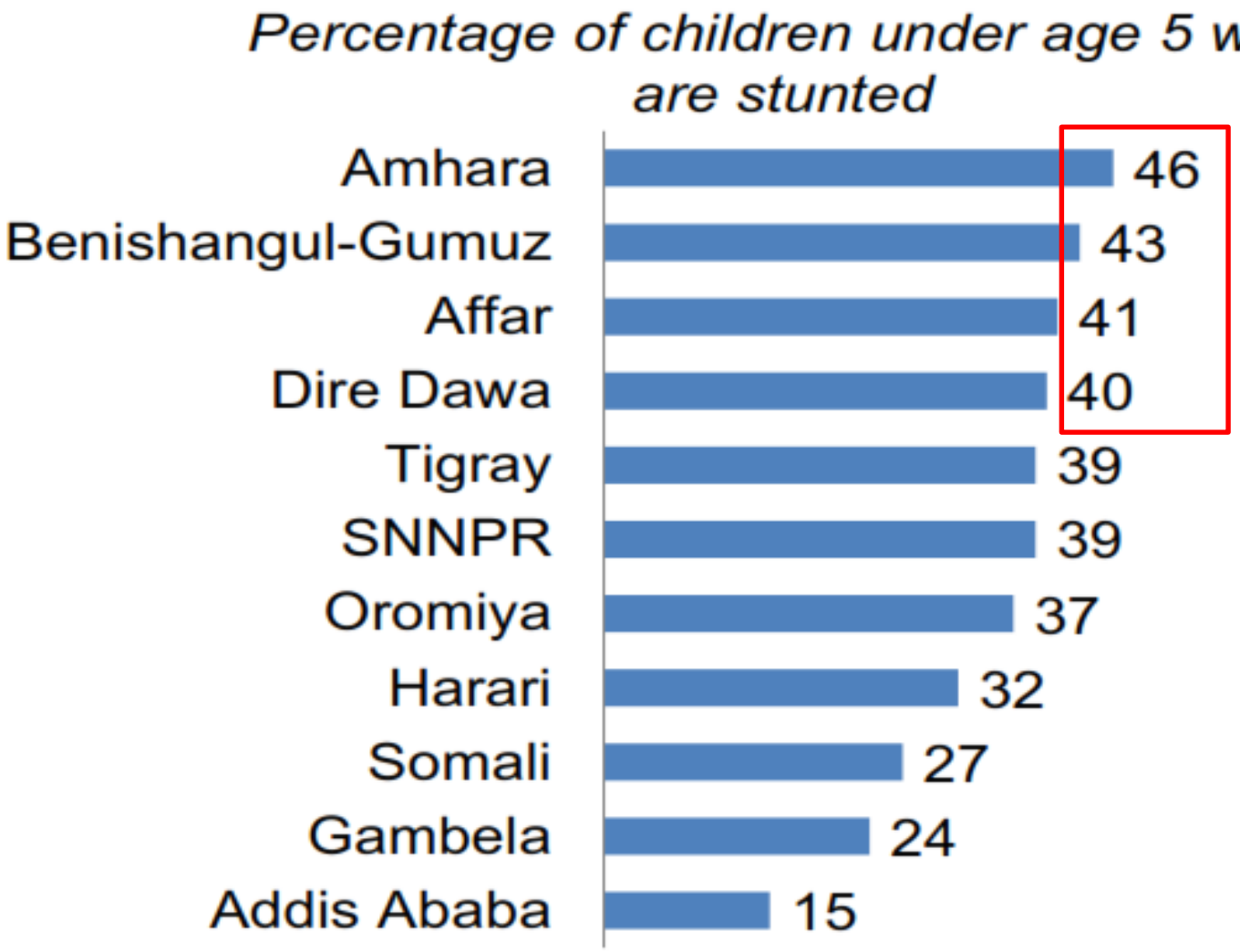
The Scenario in Ethiopia



Trends of stunting, underweight and wasting among Ethiopian children _EDHS surveys (2000, 2005, 2011, 2016)

- Malnutrition among infants and children is very high (EDHS, 2016):
- More than 50% of all childhood deaths in Ethiopia
  - The 6th highest country in the world
- The 2nd highest rate of MNMs in Africa
  - IDA about 44% of children under 5 years
  - VAD_Public health problem
- Inappropriate infant and child feeding practices:
  - Only 4% of children (6-23 months) fed appropriately (EDHS 2011)
    - Regular family diet_Monotonous, or
    - Cereal-only or cereal-legume porridge
- **Poor quality of infant foods**
- **Current recommendations:** Processing locally available crops, compositing

Ethiopia



Stunting in children by region

The Problem

Enough food available

(cereals, legumes, roots)

Lack of access to fortified CFs

Limited access to animal origin foods

Poverty/Low purchasing power

Inappropriate feeding

Regular family diet

- Little/no modification

Porridge (high bulk)

Breast feeding only

Limited gastric capacity

Low energy density

Low nutrient density

Poor bioavailability

Poor digestibility,....

Poor sanitation

Inadequate health care

Poor physical growth

Delayed cognitive development

- Need for complementary foods with appropriate formulation and processing:
  - Readily available/low cost
  - Energy and nutrient dense
  - Of desirable consistency
  - Acceptable by the community
- Food-based approach is more effective and sustainable to meet these needs

Poor school performance

Lower earnings

Higher probability of NCDs

Public health costs

Loss of human capital

- Morbidity, Mortality, Disability

Negative impact on economic development

E.g: Ethiopia (2009):

- USD 4.7 billion lost (16.5% of GDP for that year)

Energy and Nutrient Density

- ⇨Of paramount importance in complementary feeding
- ⇨Energy density - amount of calories per unit of volume or weight of the food
- ⇨Nutrient density - amount of nutrient per 100 kcal of food
- ⇨Complementary foods should be energy - and nutrient-dense
  - – Rapid growth and development of infants
  - – Limited gastric capacity

Raw Materials

☞Compositing of the raw materials aiming at complementarity of nutritional components

- Food-to-food fortification

Teff grains

Soybean grains

OFSP tubers

Source: WHO, 2009

Figure 1. Raw materials

Raw Materials….Cont'd

☞Teff (*Eragrostis tef*)

- ✓Staple crop (approximately 20% of cereal production in Ethiopia (mainly *injera* preparation)
  - ✓Provides over two-thirds of the human nutrition
- ✓Rich in iron (especially the red variety), calcium, other minerals, fibre
- ✓Excellent essential amino acids balance
  E.g. Lysine levels higher than wheat or barley

☞Soybean (*Glycine max*)

- ✓Commonly produced in many parts of Ethiopia
- ✓Rich in protein (quality + quantity), up to 40%
- ✓Well-balanced amino acid pattern, PDCAA close to 1.0
- ✓High fat content (~20%)
- ✓Appreciable proportion of unsaturated fatty acids such as linoleic and linolenic acid
- ✓Phytochemicals: Health benefits

☞Orange-fleshed sweet potato [OFSP] (*Ipomoea batatas*)

- ✓Ethiopia is one of the largest sweet potato producing countries in East Africa
  - ✓ OFSP already introduced
- ✓Developed for tackling VAD and energy deficiency simultaneously
  - ✓ Rich in β-carotene and starch
- ✓**Close to 90%** of the carotenoids is **β-carotene**
- ✓Imparts antioxidant activity, flavour (fructose)

Processing of Raw Materials

i. Processing of teff

- Processed into three types of flours:
  - ungerminated teff flour
  - germinated teff flour_24 h
  - germinated teff flour_48 h

Ungerminated teff flour

- Used for developing household- and industrial-level complementary foods

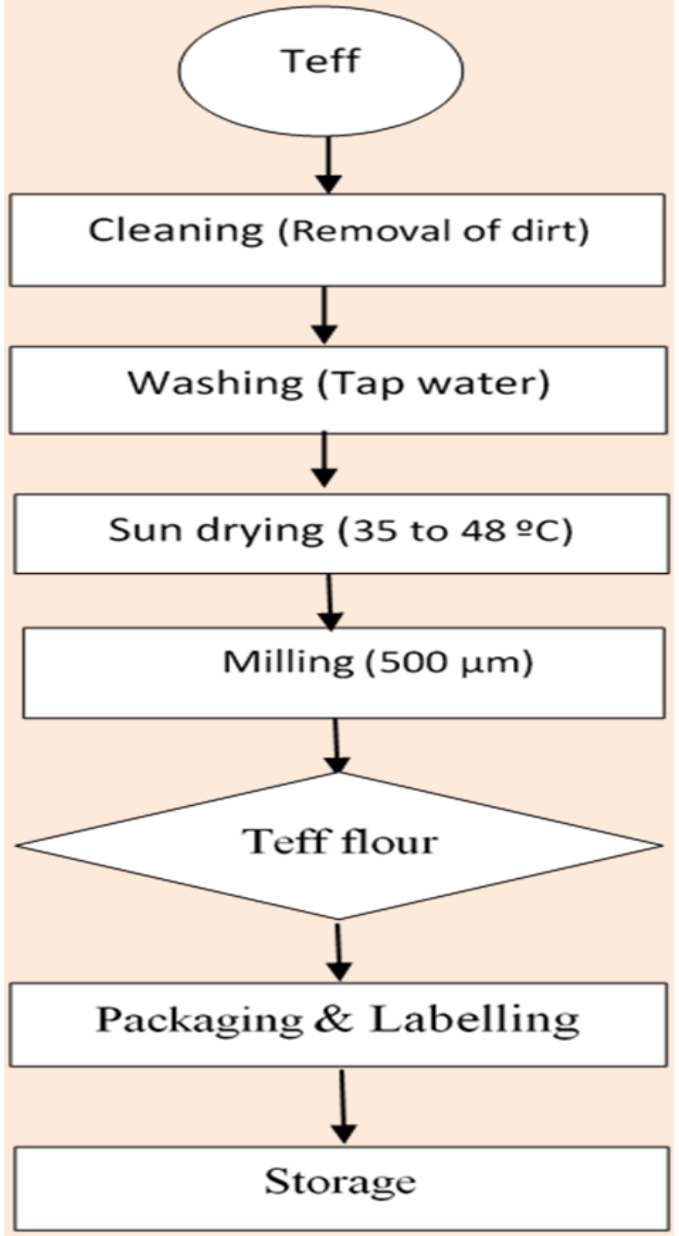


Figure 2. Preparation of ungerminated teff flour

Germinated teff flour

- Teff grains germinated for two durations at room temperature:
  - 24 h, 48 h
- Germinated teff flour
- Used in formulation of household-level complementary foods

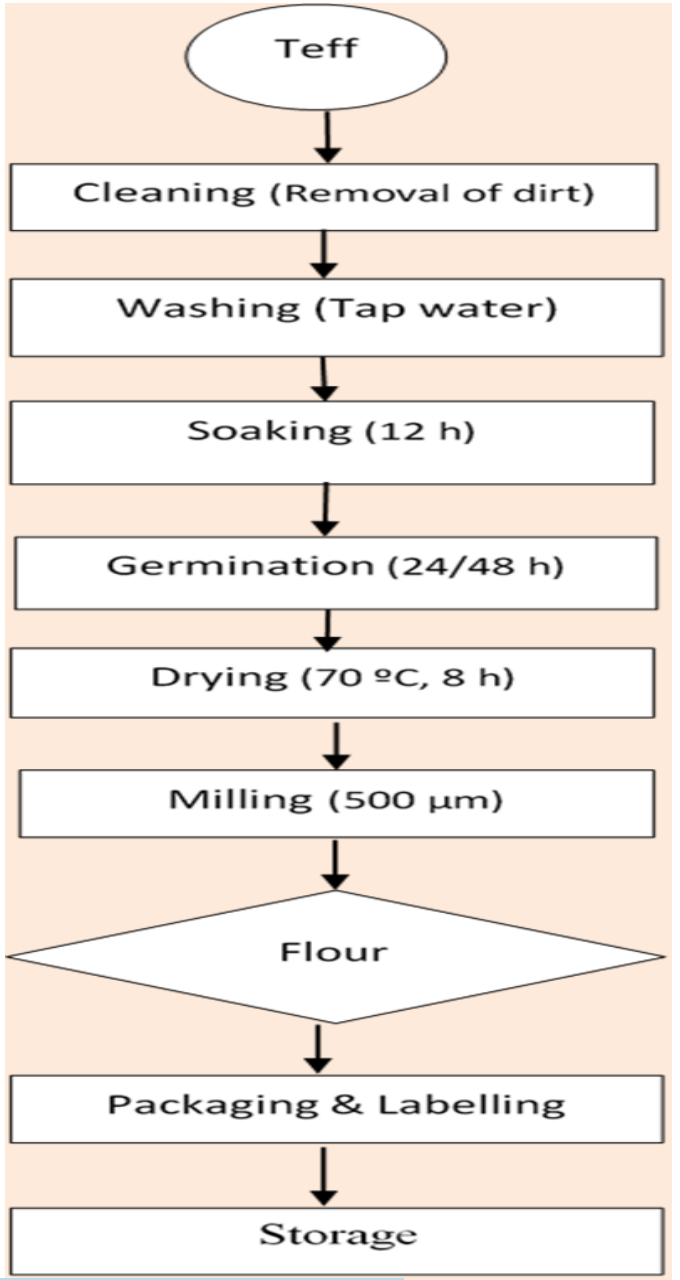


Figure 3. Processing of germinated teff flour

ii. Processing of soybean

- Soybean was processed to give three different types of flours:
  - Soybean flour_unblanched/unroasted
  - Blanched soybean flour
  - Roasted soybean flour

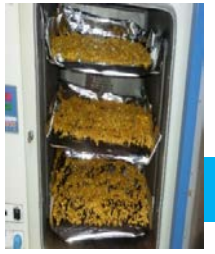
Soybean

Roasting

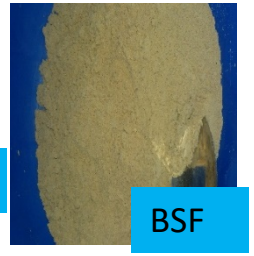
Milling

Blanching

RSF



Milling



BSF

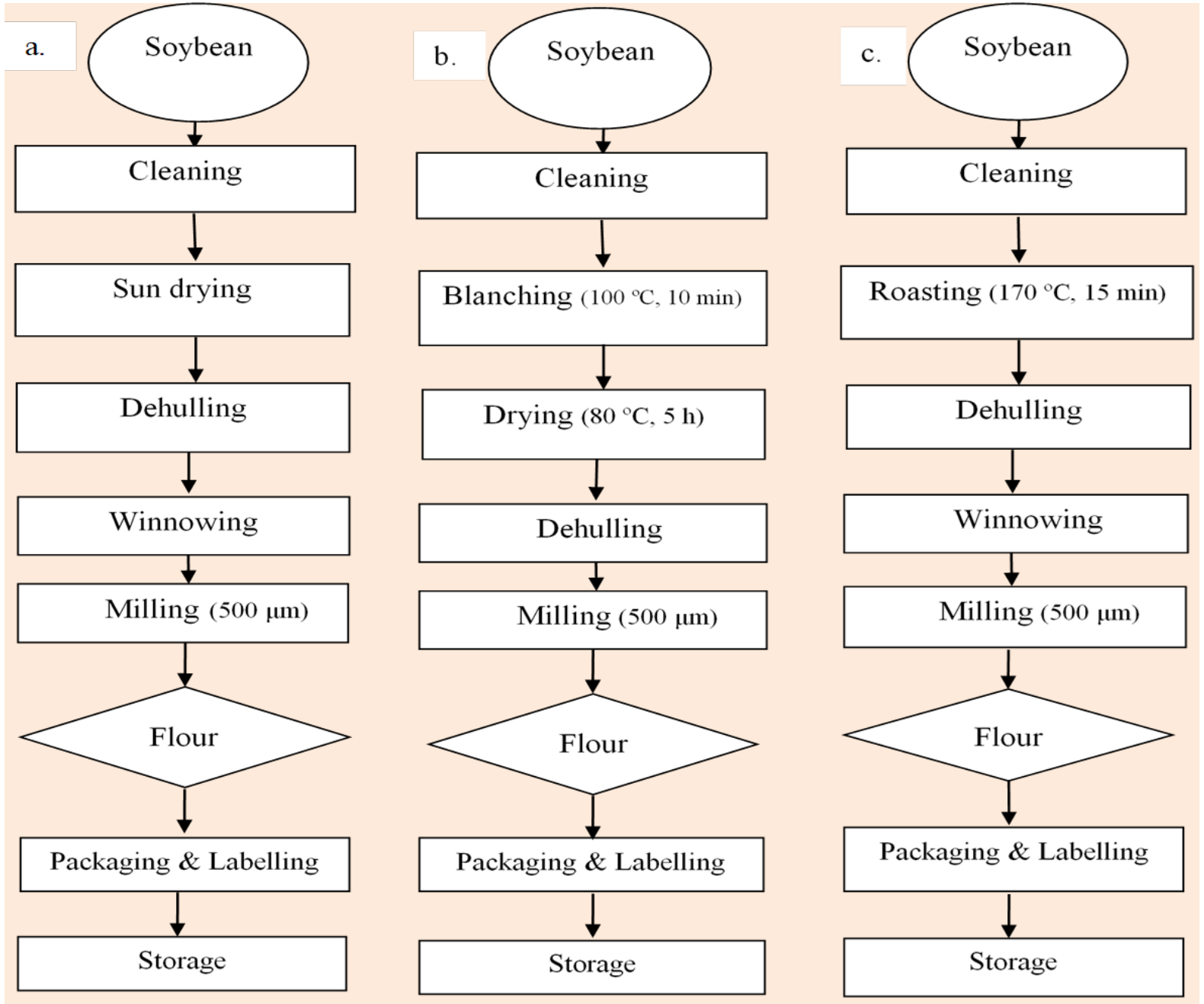


Figure 4. Preparation of soybean flours: a. Unblanched/unroasted b. Blanched c. Roasted

iii. Processing of orange-fleshed sweet potato

- ✓ According to the method described by Haile et al., (2015)
- ✓ Fresh OFSP tubers were processed into flour
  - Used to prepare both household and industrial-level complementary foods

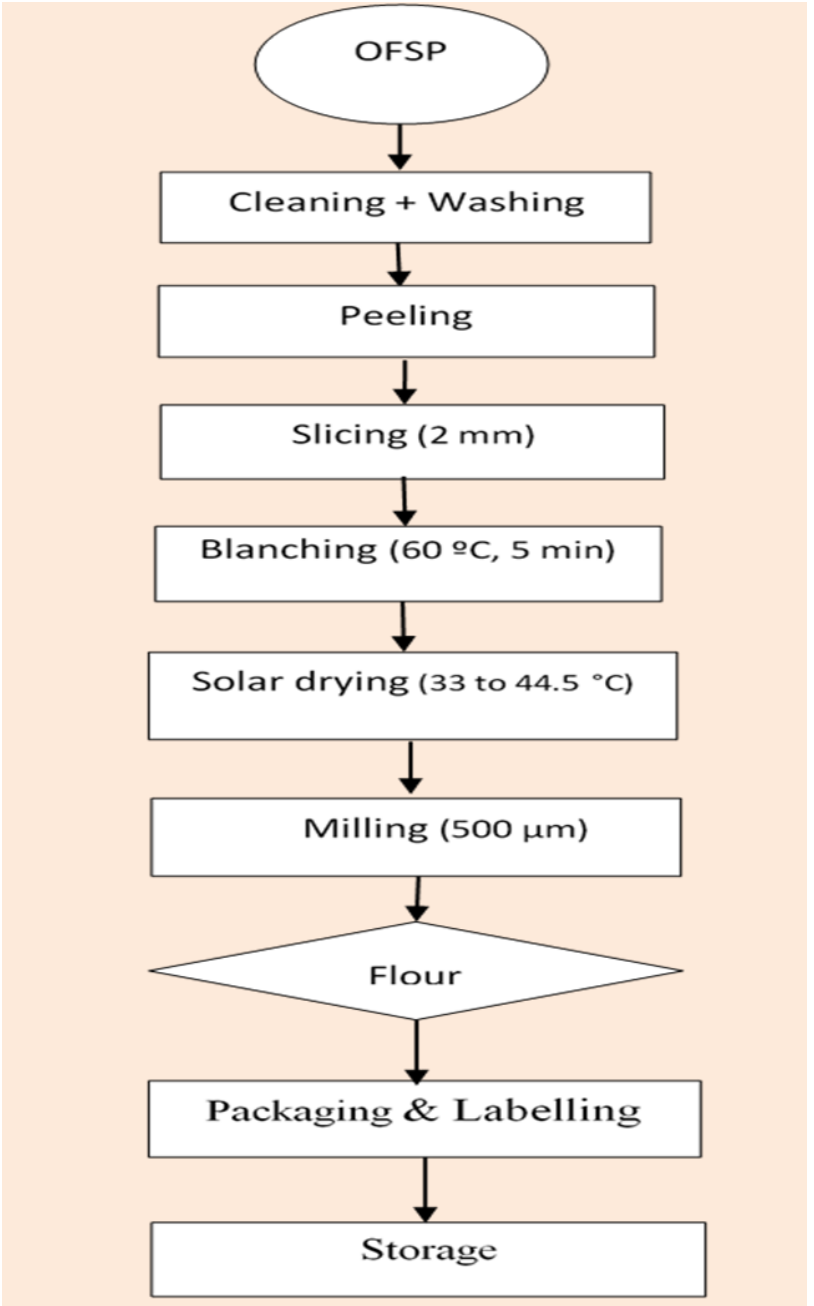


Figure 5. Preparation of orange-fleshed sweet potato flour

Formulation of Complementary Foods

- Used a proportion of 70:20:10 (w/w) for teff (the base ingredient), soybean and OFSP flour, respectively
  - Based on the recommendations to use 75% cereal and 25% legume blend for formulation for complementary foods
- Addition of OFSP flour (10%) by replacing 5% from each of teff and soybean
  - To supplement the formulations with β-carotene (Vitamin A)
- Approximation for adequacy of major nutrients using NutriSurvey software (2007)
- In case of household-level CFs, 10% germinated teff flour used
  - 60% ungerminated teff flour
- Two types of complementary foods:
  - ✓ Household level (blending) and Industrial level (extrusion cooking)

Table 1. Formulations of complementary flours with the respective ingredients and their percentage proportions (w/w)

Formulation	Processing method	Ingredients (Flour)	Proportion (%)
ComF1	Extrusion cooking	Ungerminated teff	70
		Soybean (Unblanched/unroasted)	20
		OFSP	10
ComF2	Household methods	Ungerminated teff	60
		Germinated teff (24 h)	10
		Blanched soybean	20
		OFSP	10
ComF3	Household methods	Ungerminated teff	60
		Germinated teff (24 h)	10
		Roasted soybean	20
		OFSP	10
ComF4	Household methods	Ungerminated teff	60
		Germinated teff (48 h)	10
		Blanched soybean	20
		OFSP	10
ComF5	Household methods	Ungerminated teff	60
		Germinated teff (48 h)	10
		Roasted soybean	20
		OFSP	10

Development of Complementary Flours

i. Household-level complementary flours

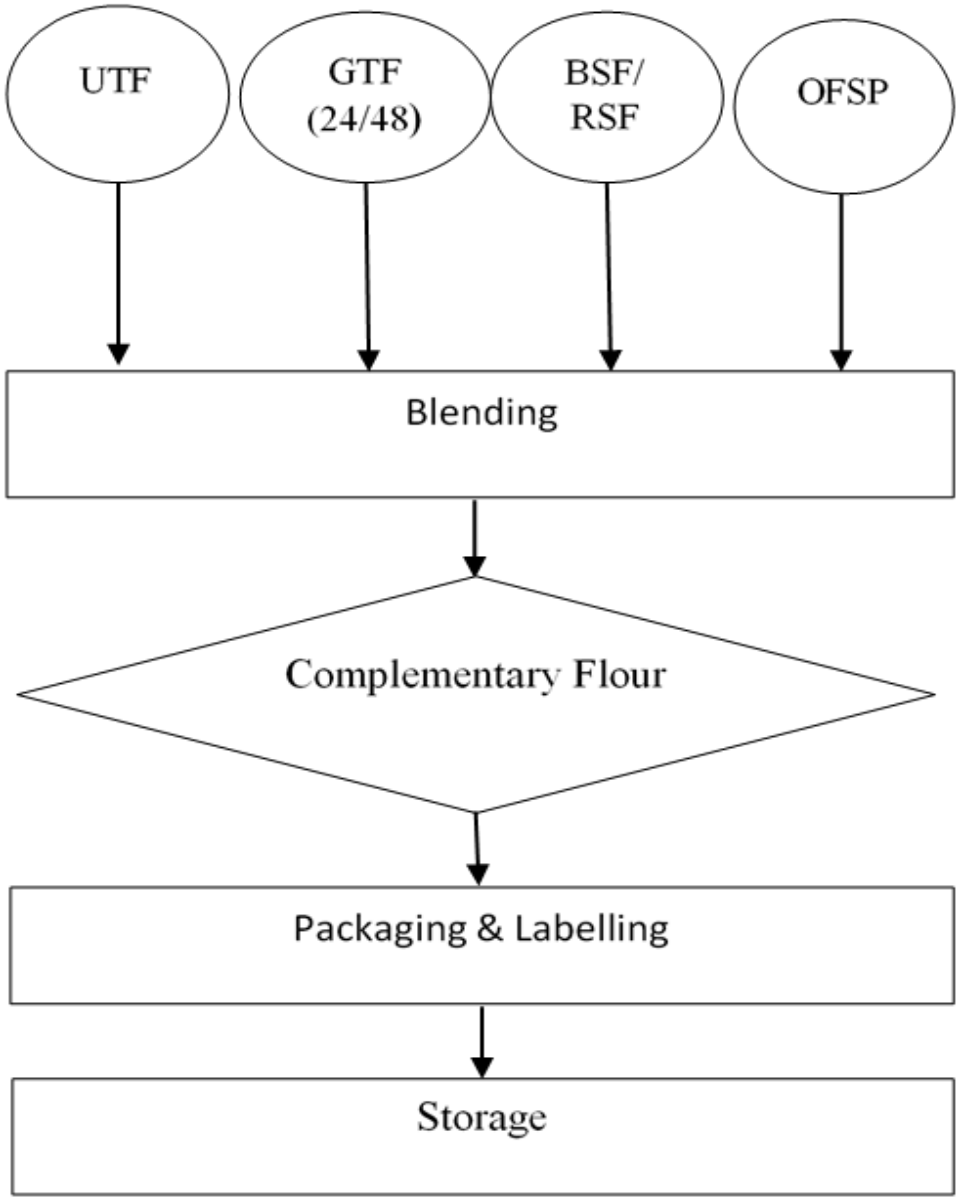


Figure 6. Blending of ingredient flours to develop household-level CFs

Mixing of ingredients manually

Further mixing of ingredients with a mixer

Complementary Flour (Final blend)

Key: UTF – Ungerminated teff flour; GTF – Germinated teff flour; BSF – Blanched soybean flour; RSF – Roasted soybean flour; OFSP – OFSP flour

ii. Industrial-level complementary flour

- Preparation of a composite flour:
  - Ungerminated teff flour
  - Soybean flour (unblanched/unroasted)
  - OFSP flour
- Extruded into a complementary flour

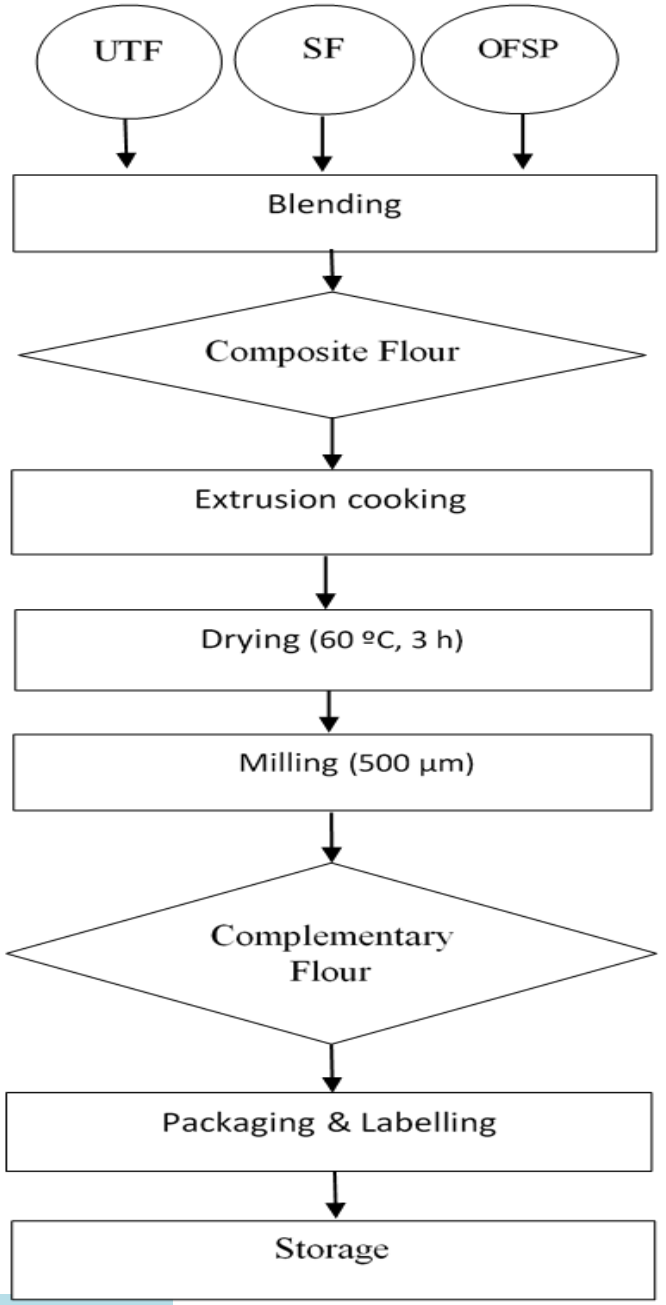


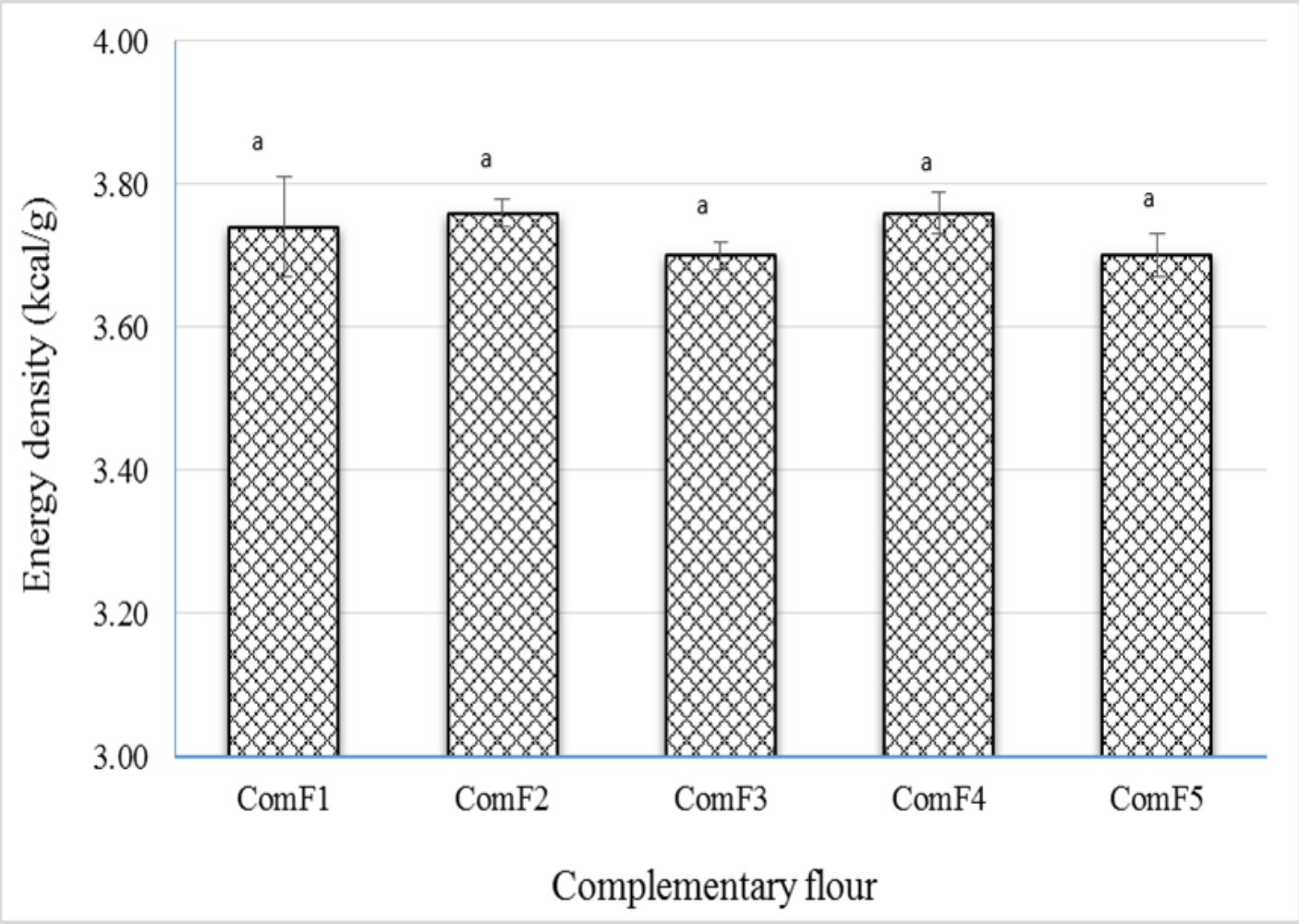
Figure 7. Development of extruded complementary flours

Determination of Nutrient Density

- √ Determined from the respective nutrient contents obtained through laboratory analyses
  - Energy
  - Micronutrients
    - β-carotene/vitamin A, Calcium, Iron, Zinc
- √ Energy and nutrient contents were converted into **energy density** (kcal/g) and **nutrient density** (mg/100 kcal)
- √ Energy density was determined by dividing the energy contents of the complementary foods by 100
- √ Nutrient density obtained by dividing the nutrient content by its energy content and then multiplying by 100

RESULTS

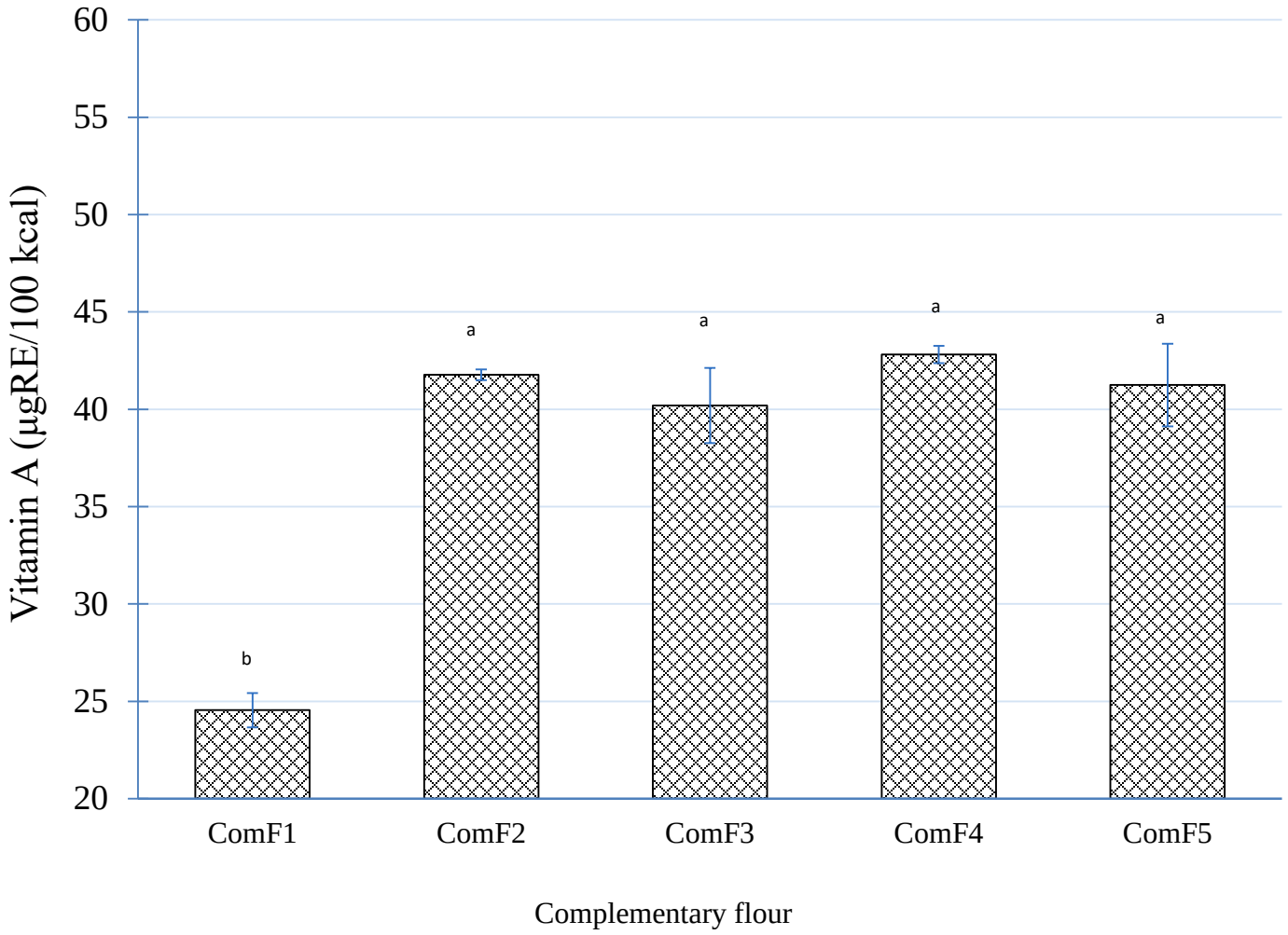
Energy Density



- Energy density in the range of 3.70 to 3.76 kcal/g
  - ☞The complementary foods are energy dense
  - ☞Effect of processing methods
- Energy density of cereal-based CFs should be ≥4.0 kcal/g (Codex)

Figure 8. Energy density of the complementary foods

Micronutrient Density



- Vitamin A density **24.55 to 42.81 µg RE/100 kcal**
- The lowest for ComF1
  - ⇨ Loss of β-carotene because of degradation during extrusion cooking
  - – high contents of household-levels CFs---mild processes
- The minimum stipulated vitamin A density of cereal-based CFs for 6 to 8 month-old infants is **31 µg RE/100 kcal**

Figure 9. Vitamin A density of complementary foods

Micronutrient... Cont'd

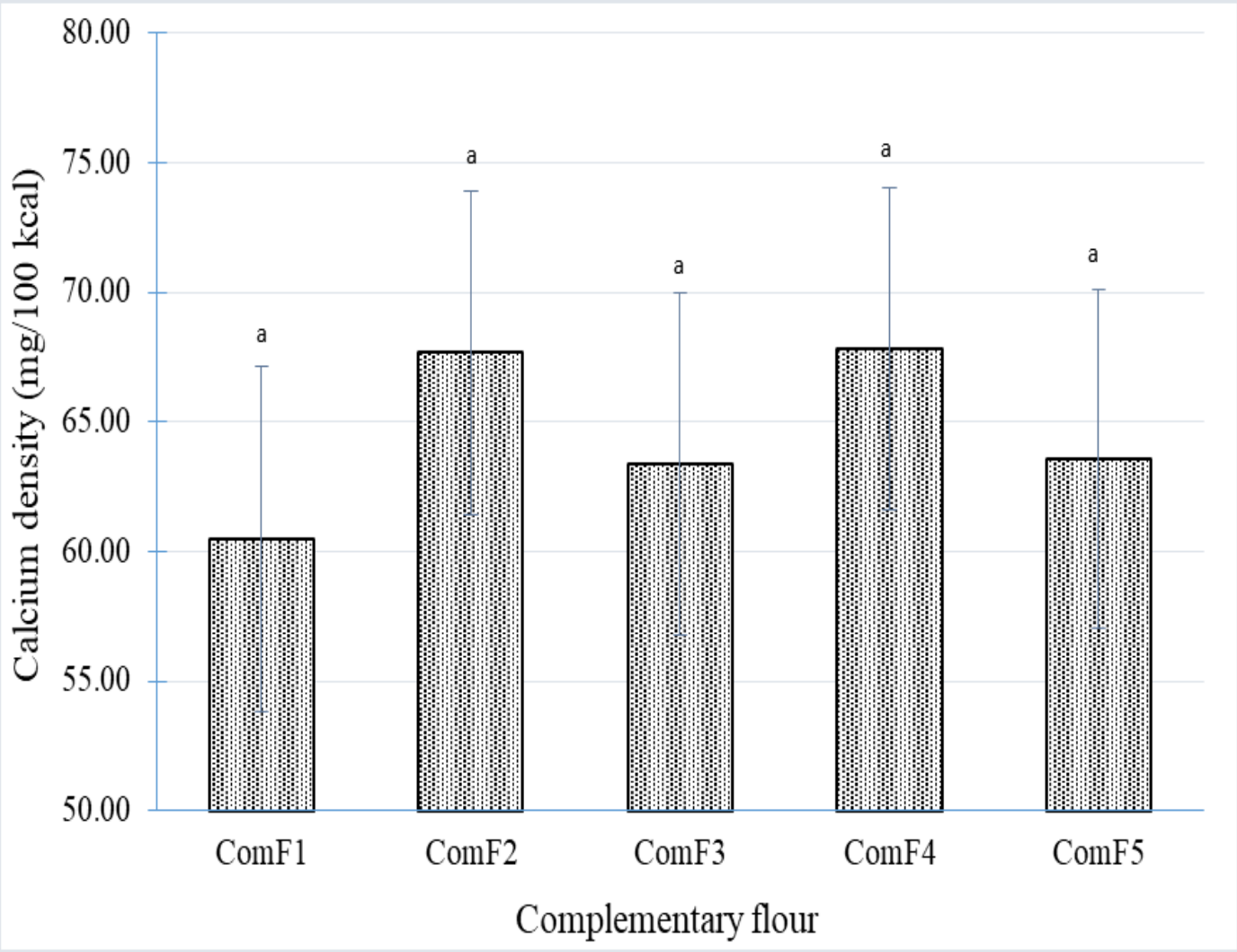


Figure 10. Calcium density of the complementary foods

- Calcium density in the range of **60.68 to 67.84 mg/100 kcal**
- All CFs satisfactorily met the requirement by infants of 6 to 8 months old
  - 50 mg/100 kcal

Micronutrient...Cont'd

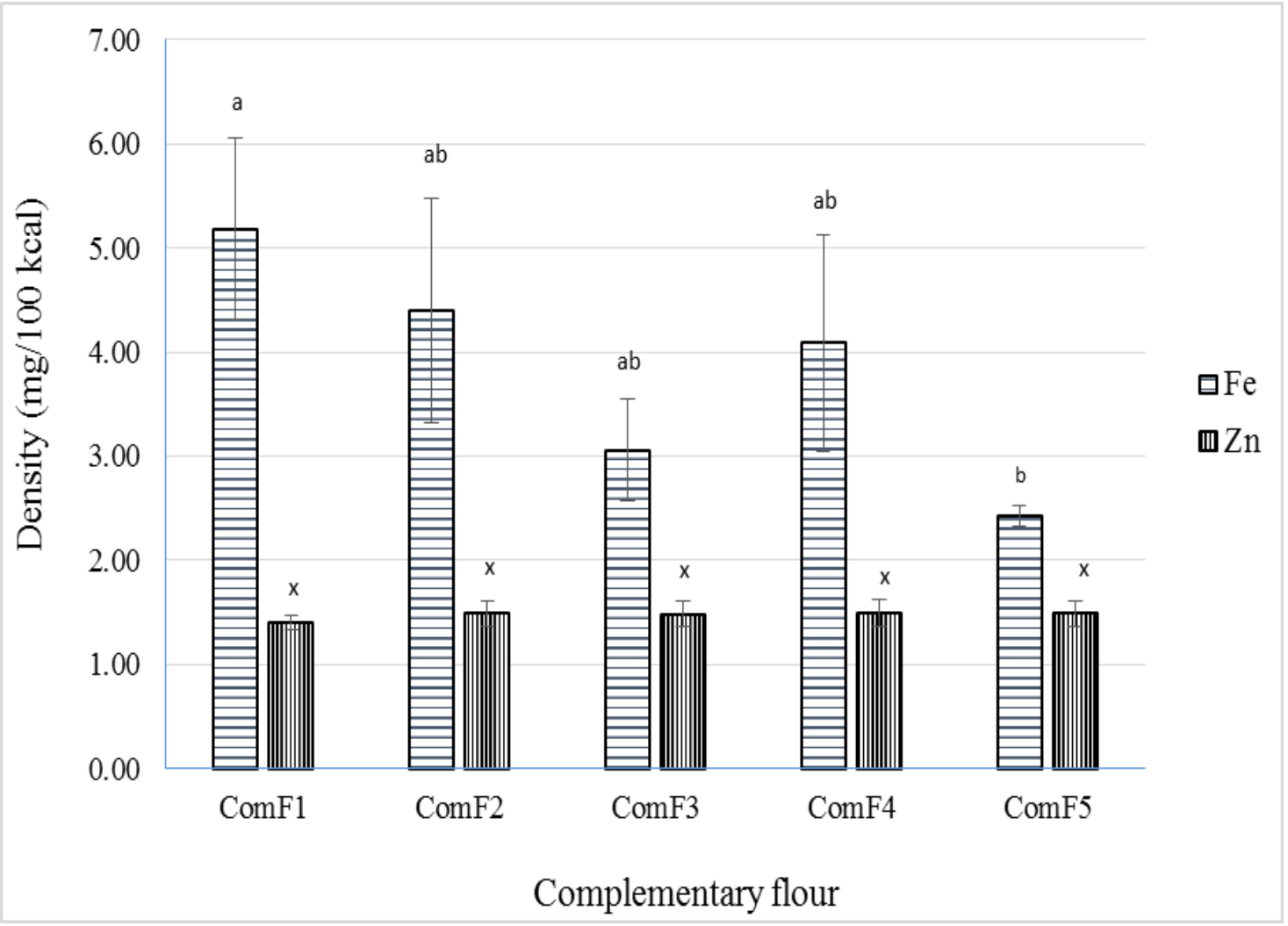


Figure 11. Iron and zinc density of the complementary foods

- **Iron density:** 2.42 to 5.19 mg/100 kcal
  - Recommended = 4.5 mg/100 kcal
- ComF1 had the highest value
  - Extrusion cooking
- Absorption of iron from plant-origin foods is very low, up to 8%
  - advisable if cereal-based CFs are fed with a small quantity of:
    - animal-origin foods (meat and fish) or
    - other iron absorption enhancers (fructose and ascorbic acid)
- **Zinc density:** 1.41 to 1.49 mg/100 kcal
  - Slightly below the recommended value of 1.6 mg/100 kcal

Conclusion

- Energy and nutrient dense teff-based complementary foods fortified with soybean and OFSP were developed
  - Household level
  - Industrial level
- The complementary foods appreciably met recommended levels of micro-nutrient densities:
  - vitamin A, and minerals (Calcium, Iron, Zinc) Compositing + Processing
- Loss of β-carotene may be prevented by blending the OFSP after extruding a mixture of teff and soybean
- The approach benefits low-income groups in the Sub-Saharan Africa
  - The processing approaches are easily applicable at home- and/or community-level.

Acknowledgement

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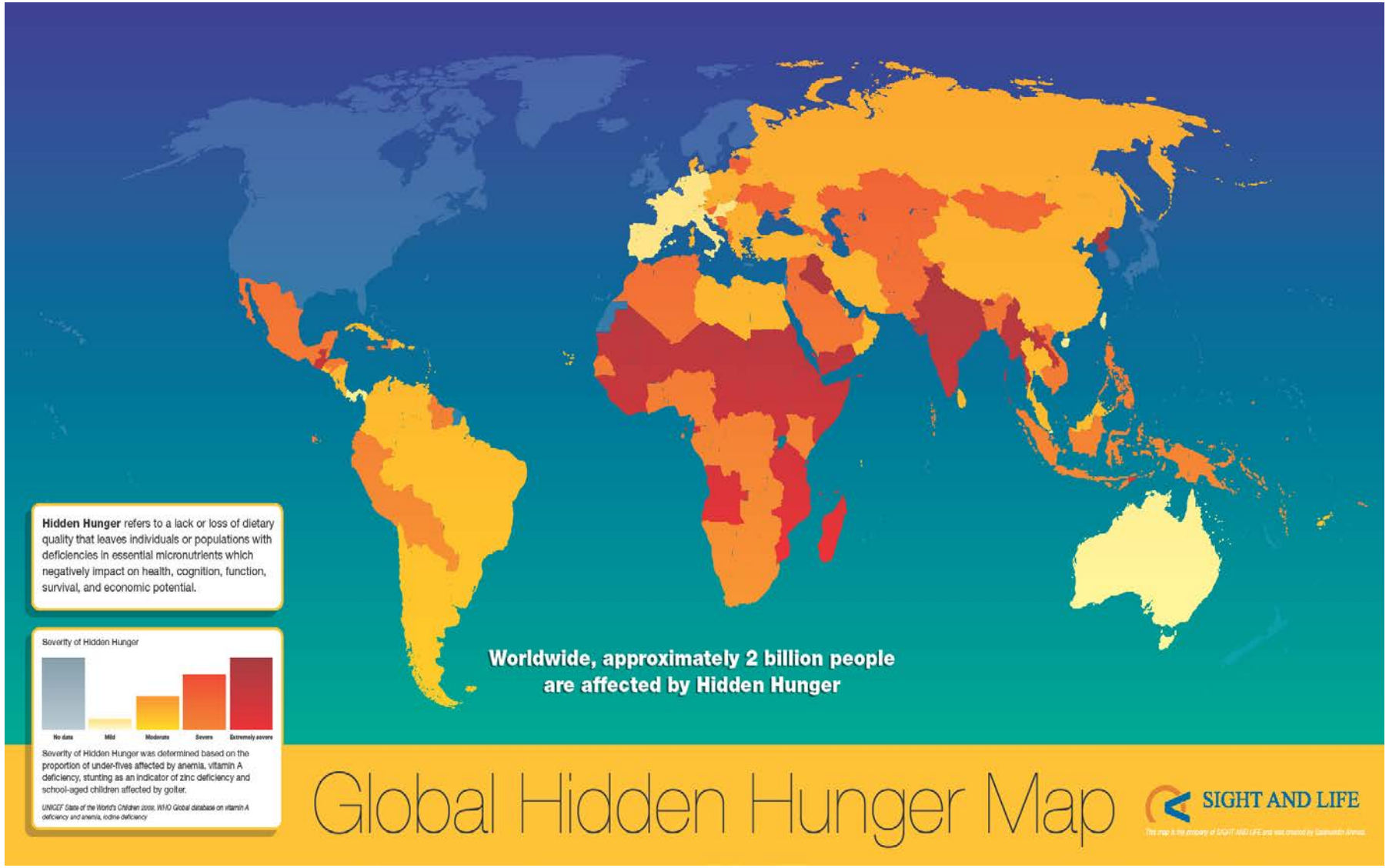
- RUFORUM/DAAD
- Humboldt University, Germany

THANK YOU!

A well-fed infant is healthy, happy and productive!
(WHO, 2000)

Cut-off Values for Public Health Significance

Underweight	< 10% Low prevalence
	10-19% Medium prevalence
	20-29% High prevalence
	≥ 30% Very high prevalence
Stunting	< 20% Low prevalence
	20-29% Medium prevalence
	30-39% High prevalence
	≥ 40% Very high prevalence
Wasting	< 5% Acceptable
	5-9% Poor
	10-14% Serious
	≥ 15% Critical



[Global hidden hunger map]

Why Teff, Soybean, OFSP?

Teff

- Staple crop for Ethiopia----**highly valued**
- Excellent nutrient profile: essential amino acids, fiber, iron, calcium, potassium **+ more**
- Red teff has the highest iron content
- Becoming a functional food nowadays!

Soybean

- High protein content, well-balanced amino acid pattern, high fat content
- Complements the protein of cereals - quantity + quality
  - Rich in lysine and tryptophan
- Promoted for improving food security problems

Sweet potato (OFSP)

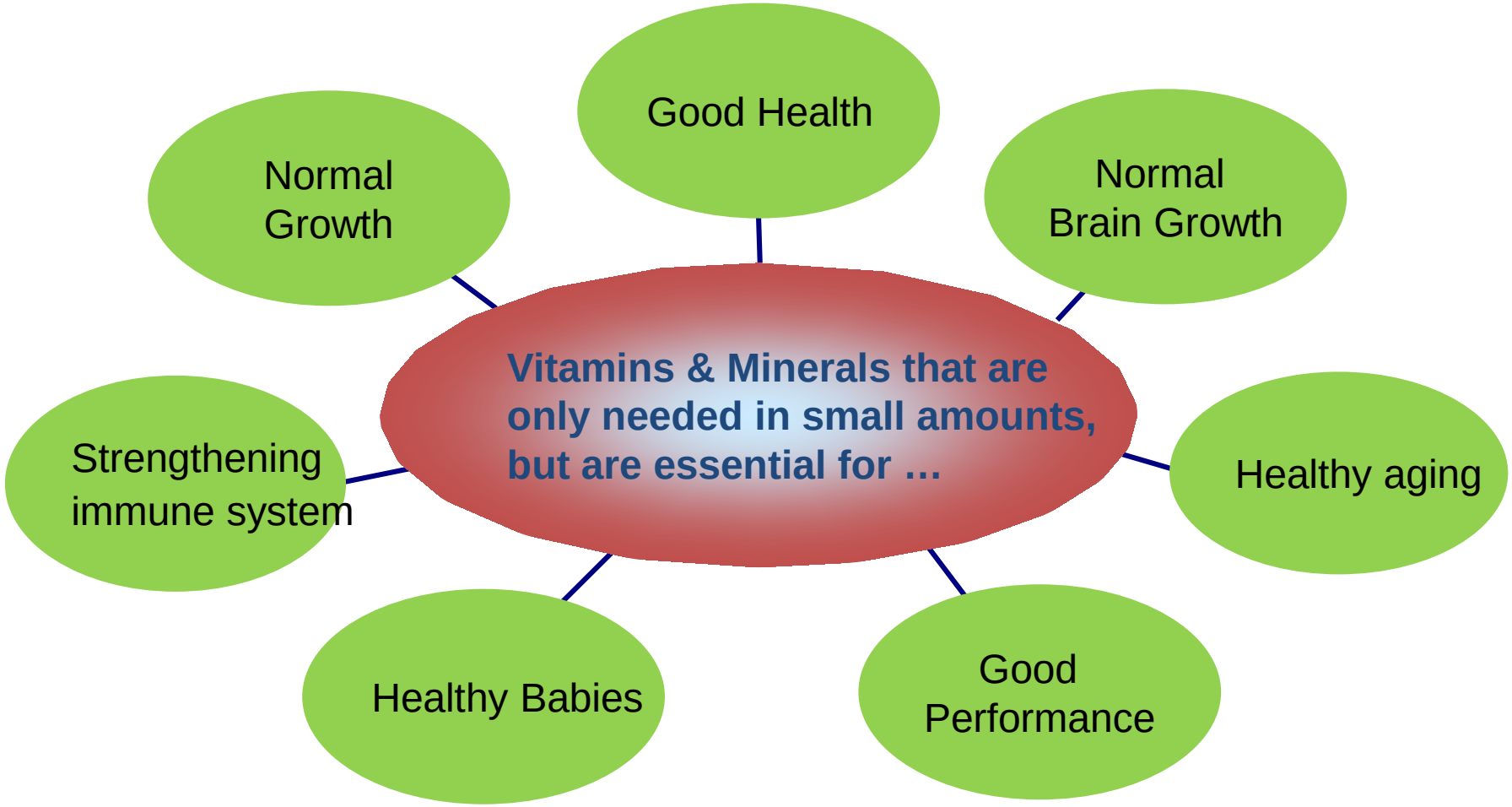
- Produced in large quantity but the white variety
- OFSP is highly promoted to prevent VAD
  - **Excellent source of beta carotene**

Why Teff, Soybean, OFSP

- Teff
  - A significant crop in only one country in the world- Ethiopia
  - Probably the tiniest grain on the planet
  - Excellent source of essential amino acids, especially lysine
  - an excellent source of fiber and iron, and has many times the amount of calcium, potassium and other essential minerals found in an equal amount of other grains
  - gluten-free, and is gaining popularity in the whole food and Health food industry
  - Red teff has the highest iron content
    - Iron content = 11.5 – 150mg/100g

Micronutrients (vitamins and minerals)

are essential for many functions and health



They cannot be produced by the body and have to come from the diet