«Improve malnutrition by increasing protein quality in Zambia»

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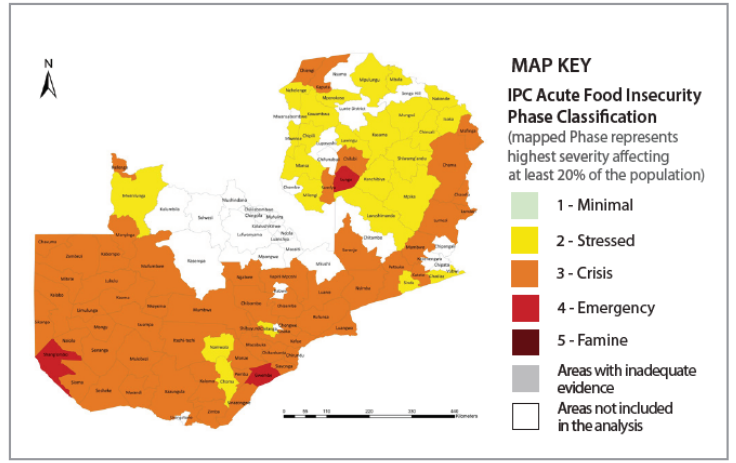
Agricultural situation in Zambia

- 2018/19 rainy season => central & western Zambia very low levels of rainfall in contrast to northern & eastern parts: affected by flash floods
  =>food production capacity of the country was decimated

Projected Acute Food Insecurity Oct 2019 - March 2020



- About 1.7 million Zambians are severely food insecure
  (Estimates from the EU 2019)

- Productivity of the major staple food maize in Zambia is below global average (Kabaghe et al.,, 2015)

- Conventional land preparation & cropping => degrade the soil
  "high cost of farming inputs, limited agricultural infrastructure and service provision, poor post-harvest storage and little access to credit" = major constrains to increase agricultural productivity (FAO, 2020a).

- Advancing climate change and severe climate events are estimated to increase => the growing seasons might be shorter, leading to higher food insecurity, declining maize yield and increased maize yield variability (FAO, 2020b).

Nutritional Situation in Zambia

- In Zambia, 47% of the population is undernourished, making it one of the three most undernourished countries in the world.

- 40% of children under 5 years are stunted in Zambia (UNICEF 2019)

- Child wasting affects around 6% of children under 5 years, as many families suffer from seasonal hunger (mainly in the lean agricultural periods of the year preceding the maize harvest)

  (Mwanamwenge, M. & Harris, J., 2017).

- Future of the world's children report, WHO-UNICEF-lancet commissions:

  Zambia is at position 148 (from 180) of the child flourishing and future profile

  => an important factor in the calculations is the nutritional situation (Clark et al., 2020)

- World Food Programme Zambia Zero Hunger Report 2018:

  => safeguarding children, reducing food insecurity and providing

  => a proper nutrition is a top national priority

Nutrition of Children and Women of Reproductive Age

- Children are especially affected by the low dietary diversity: only 22% of the age group 6-23 months received food from four or more food groups out of seven (Central Statistical Office, Ministry of Health and ICF International, 2014).
- Children in Zambia have in general a low consumption of animal-source foods (Mwanamwenge, M. & Harris, J., 2017).
- Diet of the local rural children is inadequate to meet Ca, folate, Vit. B12 and Fe recommended intake (Caswell, Talegawkar, Siamusantu, West, & Palmer, 2018).
- An adequate meal frequency is achieved by only 42% of children across Zambia, resulting in only 11% of children receiving an adequate minimum feeding (Central Statistical Office, Ministry of Health and ICF International, 2014).
- Breastfeeding rates under 6 months are quite high reaching 73% (Central Statistical Office, Ministry of Health and ICF International, 2014).
- But lactating and non-lactating women of reproductive age in rural Zambia were found to have an inadequate micronutrient intake, especially for Niacin, Vit. B6, Vit. B12, Iron and Zinc (Kaliwile et al., 2019).

Diet composition in Zambia

- Traditional diets in Zambia are based on maize meal porridge

  (Nyirenda & Musukwa, 2007).

- Nutrient-rich foods like legumes, animal-source foods, fruit and vegetables are eaten mostly in so-called “relishes”, which change throughout the year according to season.

- Consumption of indigenous vegetables has declined in favor of a narrow selection of introduced varieties (Hivos, 2016).

- Intake of sugar, salt and cooking oil is excessive (Tateyama et al., 2019).

- over 90% of the dietary energy is provided by cereals, starchy roots, fats, oils and sugars and diet is low in nutrients (Harris et al., 2019; Nyirenda et al., 2007). nevertheless, energy intake per capita is reported to be consistently **below 2000 kcal** since the 1990ies.

⇒ In summary, dietary diversity in Zambia is low, although reliable data on modern Zambian diet is scarce (Harris et al., 2019).

Protein intake and child growth in general

- Maternal diet: implementation of maternal balanced energy protein supplements as needed **could prevent about 80000 deaths** in children younger than 5 years of age (Black et al., 2013)

- Protein requirements released by the WHO estimate that the need for protein in the third trimester is significantly higher than previously estimated with **an additional 31 g of high quality protein** required in the third trimester (WHO Report No 935, 2007)

- Protein and energy restriction has **severe consequences and approx. 30 millions of newborns in developing countries** show intrauterine growth retardation (Ashworth1998) => shorter, lighter, and weaker at adolescence (Martorell et al., 1998).

- In contrast, the consumption of a high percentage of energy from protein in early pregnancy increased the birth body and placental weight (Moore et al., 2004).

- In childhood an adequate protein intake is important for growth and decreases the levels of insulin-like growth factor 1 in healthy children (Smith 1995).

Protein quality recommendation and approaches

- The WHO recommendation focusses not only on the protein amount, but also on the protein quality

  DIAAS % = ((mg of digestible dietary indispensable amino acid in 1 g of the dietary protein)/(mg of the same dietary indispensable amino acid in 1 g of reference protein) (FAO 2013).

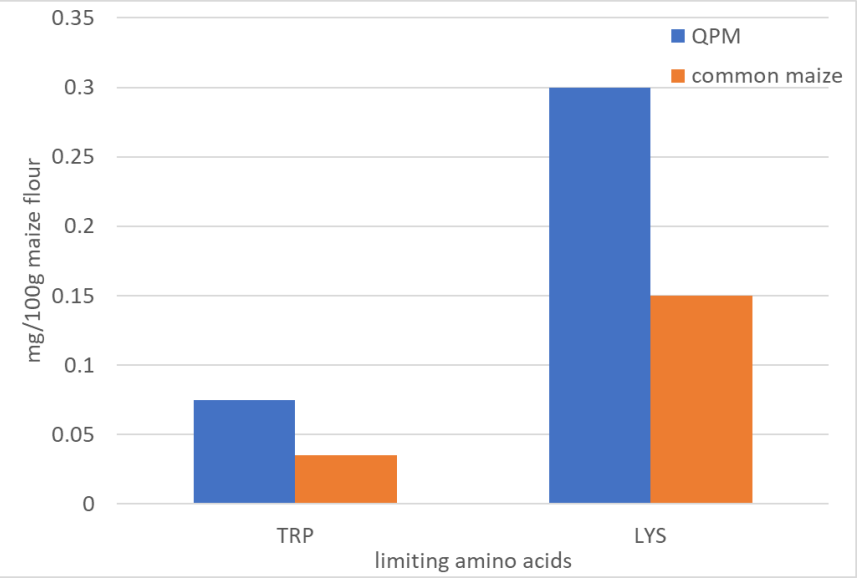
	milk protein	soy protein	oat protein	rice protein	maize protein
DIAAS	1.18	0.90	0.54	0.59	0.48
% of EAA of TAA	49%	41%	34%	39%	35%

- The role of animal protein in the diet is due to the high protein quality very important. The effect of dairy products on growth is important to prevent stunting in developing countries with a high prevalence of undernutrition (Grenow et al., 2020).

- Plant based protein sources exhibit a lower protein quality due to the amino acid composition and the occurrence of antinutritive substances (e.g. glucosinolates, trypsin inhibitors and haemeagglutennins, tannins, phytic acid and polyphenols..)

Limiting amino acids in maize

- In children in Ethiopia low quality protein intake was associated with linear growth failure and nutrition programs to improve protein quality are needed. Especially lysine and tryptophane are particularly lacking in Ethiopia, because children consume mostly cereals and maize (Tessema et al.,2018).
- Another study suggest that similar lack in lysine in Nigeria due to high cereal consumption can be ideally balanced with the **addition of animal-source foods** to ensure a better protein quality (Judith de Vries et al., 2020).

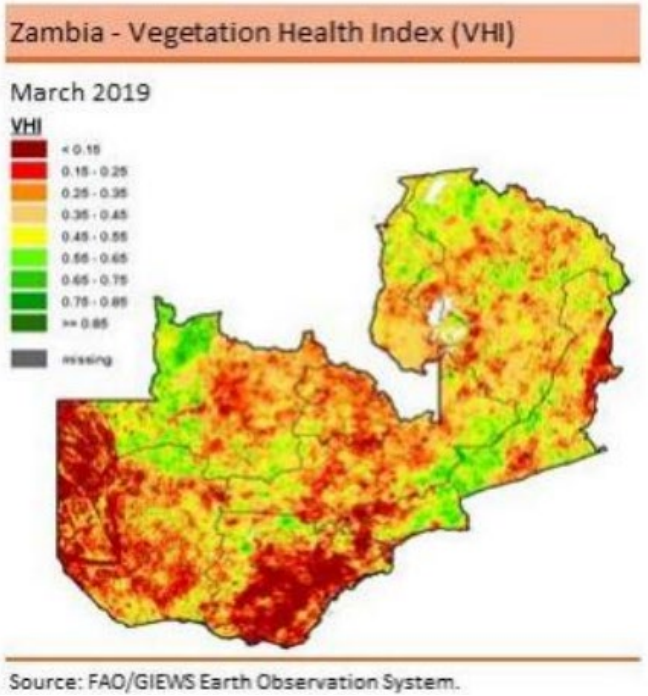


=> Maize lacks adequate amounts of the essential amino acids lysine and tryptophan, DIAAS 0.48 only!

=> QPM has twice the amount of lysine and tryptophan, as well as better protein bioavailability (Prasanna et al., 2020)

Increasing protein via agronomical approaches

- Detailed analysis about the cultivated protein sources and their distribution in the country
- Evaluation of the climate stability of the protein sources
- Analysis of the protein quality of the cultivated protein sources and detection of limitations
- Revealing the potential of different varieties and balancing protein crops to reach higher proportions of essential amino acid
- Evaluation of the possibilities for home gardening



Increasing protein quality via processing

- Protein bioavailability can be greatly increased by processing (e.g. heating, extrusion, fermentation) (Day 2013; Gueguen et al. 2016).

- Antinutritive substances are often heat labile => protease inhibitors and lectins e.g. soaking and cooking => 78-100% reduced activity of trypsin inhibitors in beans (Shi et al., 2017)

- Saponins and phytic acid are heat stable but can be reduced by shelling, soaking, germination or fermentation => in vitro digestibility increases from 40% up to 98%.

- House-hold processing advices, increasing storability, recipies for longer conservation

Injera: a spongy fermented pancake, a traditional staple from teff flour

Increasing protein quality by combining

- Combining protein sources to increase the protein quality
  e.g. study in India that concluded that complementary to the high cereal consumption less in lysine, an increase of pulse production is wanted that improves the amino acid composition of the diet (Shivakumar et al., 2019).

Digitally optimization model for protein mixtures – NutriOpt (BFH)

Databank (include groups and subgroups for better sorting, etc..)

Selected Database

- special needs
-given raw materials
-priorization on digestibility or sustainability

Algorithmus

- Based on the needs of the target group

Target vector

(Developed by Dr. Katrin Kopf and Prof. Dr. Roger Robyr, BFH)

Optimization developed for protein approximation of ideal amino acid combination

Increasing protein quality in the diets

- Composition analysis of traditional meals
- Advices for combination of protein sources according to useful combinations
- Advices for house-hold processing
- Increasing the diversity of protein sources => increase of dietary diversity
- Advices to improve general nutrition situation on long term (frequency, amounts,..)
- Nutrition education for mothers and children
  e.g. formation of nutrition advisors
  as contact persons

Systematic assessment of protein supply & quality:

Agronomy: analyze which and how much protein sources are available: general agronomic situation & access to other protein sources

- Processing: evaluate which processing methods can be applied at the household-level

- Nutrition: to analyze determinants of stunting at household-level (e.g. dietary diversity, breastfeeding, complementary feeding, child nutrition and care) and their influencing factors (e.g. socio-economic and cultural determinants of stunting at a regional, community and a household level)

  => focusing on protein intake in the diet (amount and quality)

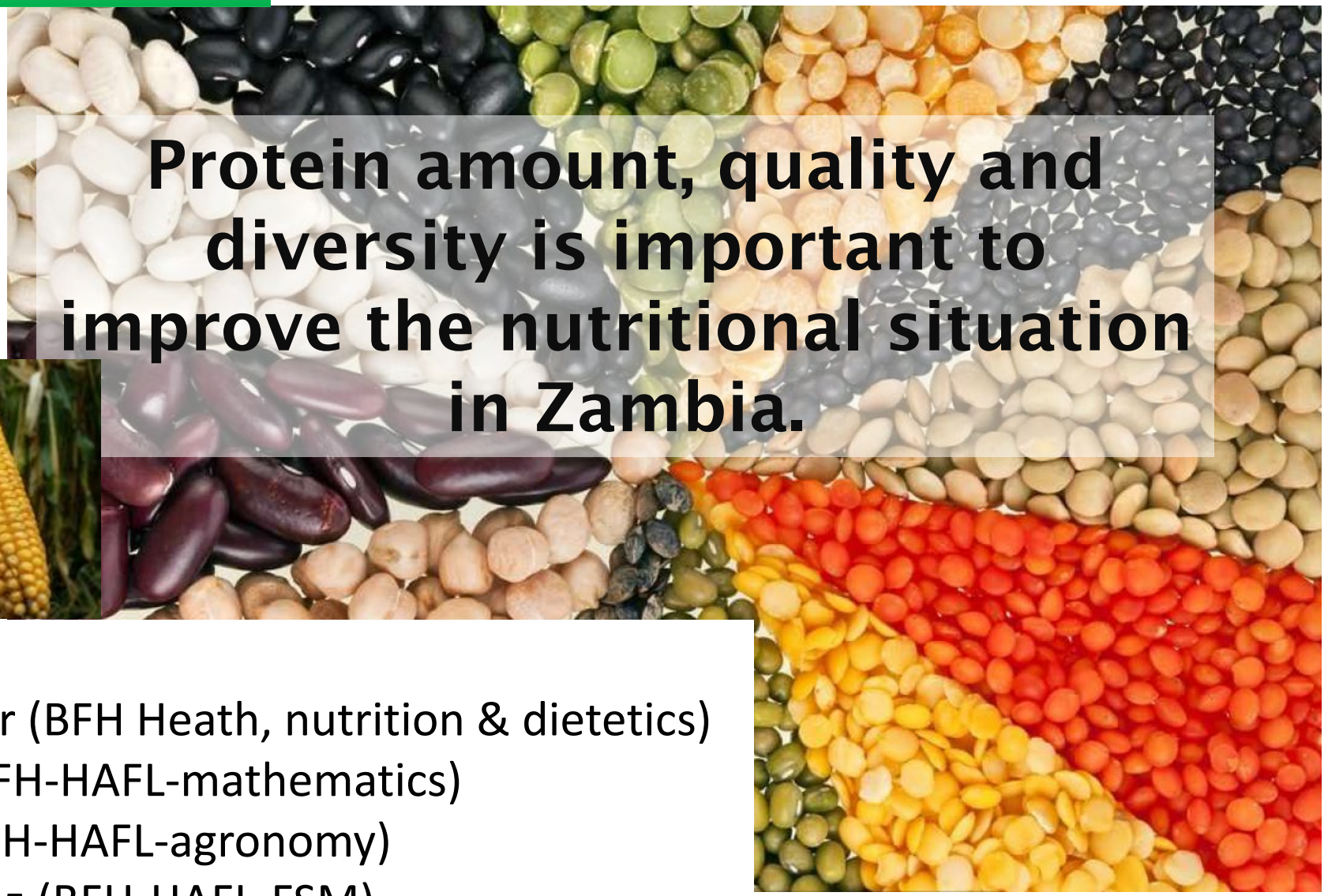
Systematic approach to improve protein supply & quality

- Agronomy : to develop agricultural intervention suggestions; Conservation agriculture (CA) & more divers protein crops, drought adapted varieties & varieties adapted to the wet climate, varieties with higher protein content, protein plants that balance limiting amino acids
  => additional home gardening to balance the limiting amino acids

- Processing: recommendations for food processing at the household level to decrease the amount of antinutritive substances and to ensure a higher protein bioavailability and to ensure storability (e.g. fermentation to reduce anti-nutritive substances + meals and recipes will be adapted for better protein quality with different protein combinations)

- Nutrition: develop, implement and evaluate appropriate and effective nutrition interventions for women of reproductive age and infants together with local actors

Thanks for listening!



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