Formulation of improved complementary foods of infants and young children (6-23 mo) for the pastoralist community of Ethiopia

By: Girma Mengistu, Tibebu Moges, Sara Wuehler, Aregash Samuel, Kaleab Baye

Conference place: Desalegn Hotel, Addis Ababa, Ethiopia
Outlines

- Introduction
- Objectives
- Methods
- Result and discussion
- Conclusion and recommendation
Background

- Inadequate complementary feeding results
  - Infrequent infections
  - Stunting
  - Reduced learning capacity and productivity
  - Increasing mortality
- Diets in developing countries are monotonous with low intake of ASFs.
Objectives

General Objective

➢ Formulation of improved complementary foods that suits the infant and young children (6-23 mo) in the pastoralist community.

Specific Objectives

➢ To characterize the portion size of meals
➢ To determine the frequency of consumption of IYC
➢ Formulation of complementary foods
➢ Sensory evaluation of the formulated products
Methodology

- 12-15 Million people
- 61% land mass

**Fig.1:** Map showing pastoralist communities in Ethiopia
Methodology

Sample size

- The sample size is calculated based on NFCS

\[ n = \left( \frac{z^2 \alpha}{2} \frac{p(1-p)}{ME^2} \right) \times deff \]

Where, 
- \( n \) = required sample size; 
- \( z \) = confidence level at 95% (1.96); 
- \( p \) = estimated prevalence (50%); 
- \( ME \) = margin error of 5% (0.05) 
- \( deff \) = design effect (2 used for most prevalence surveys)

- The total sample size were 896 in the pastoralist community.

Portion size of meals

- The average portion size of meals was estimated according to Lutter and Dewey (2003).
- The daily ration considered were: 40 g (6-11mo), 60 g (12-23 mo), and 50 g (6-23 mo) of IYC, respectively.
Methodology

**Frequency of consumption**

- Frequently consumed cereals and legumes were identified and
- Selected based on the frequency of consumption using SPSS.

**Formulation of complementary foods**

- Raw material collection;
  - Wheat (Kulumsa) and pea (Tegegnech) were collected from Kulumsa ARC, in Arsi.
  - Maize (Melkasa-2) and Sorghum (Teshale) were collected from Melkasa ARC.
Methodology

✓ White teff (DZ-Cr-37), Red teff (Key tena), Chickpea (Arerti) and Lentil (Alemaya) from Debrezeit ARC.

✓ Rice (Nericon-4) was collected from Werer ARC in Afar.

✓ Cereals and legumes were analyzed for biochemical composition at EPHI and AAU.

- Considering the nutritional composition, price per Kg, and the consumption pattern of the community;
  ✓ Wheat, maize, sorghum, white and red teff were selected from cereals.
  ✓ Chickpea and pea were selected from legumes
- The nutritional composition were inserted in to the linear programing software.
Methodology

Food composition

- Proximate analysis
  - Moisture, Crude protein, Crude fat, Crude fiber, Ash content, Carbohydrate, and Energy were analyzed (AOAC, 2000).

- Mineral analysis
  - The sample was digested in microwave digester
  - Fe, Zn, and Ca were analyzed using FAAS.

- Anti-nutritional factors
  - Phytate content were analyzed using colorimetric determination based on Vaintraub and Lapteva (1998).
Methodology

- Tannin content was analyzed based on Maxon and Rooney (1972) by colorimetric determination.

Sensory analysis

- Acceptability and preference was measured employing 9 point hedonic scales.

- Using twenty-six willing semi-trained mothers who have children less than five years of age.
Result and Discussion

*Portion size of meals*

- Portion size (g) of meals per day for breastfed and non-breastfed IYC aged 6-23 months in pastoralist communities of Ethiopia (2011)
Result and Discussion

- The average portion size (g) of meals was ~30 for 6-8 mo, ~31 for 9-11, and ~40 for 12-23 months (Portion size.docx)

- The average ration size is 35 g and were lower compared to previous estimates from Lutter and Dewey (2003).

- The low amount of food consumed per meal suggest that the complementary foods to be developed needs to be denser.
Cont,

*Frequency of cereals and legumes consumed by IYC (FrC.docx)*

- Cereals: white wheat (274) frequently consumed followed by white maize (273), white rice (172), white sorghum (139), red teff (42), and white teff (22).
- Among legumes: peas (74), broad bean (23), chick pea (19), and lentil (11) were most frequently consumed.
- Although, broad bean was frequently consumed by Afar and Somali due to the risk of favism not selected.

- The nutritional composition was analyzed to use LP for optimal blend.
Macro and Micro-nutrient composition

- The moisture content of raw and processed cereals and legumes (roasted and de-hulled) ranged from 8.2-12.2%.
  - This coherent to levels found in dry flour which contribute lengthening the shelf life.
- Both raw and de-hulled maize were better sources of energy compared to other cereals (P< 0.05).
- Among legumes chickpea, both in raw and processed forms, was the best source of energy.
Cont,,

- The protein content of cereals ranged from 8.1g/100g for de-hulled maize to 10.7g/100g for de-hulled rice.

- Legumes were better source of protein ranging from 20 g/100g for raw chick pea to 30 g/100g for de-hulled pea.

- The fat content was in the raw and processed cereals was in the range of 1.6 g/100g to 7.6 g/100g and the larger value was found in the raw maize.
In the legumes the fat content was between 0.7 g/100g and 7.4 g/100g for chickpea both in raw and processed forms.

The carbohydrate content of the cereals was in the range of 70.2 g/100g and 76.3 g/100g with the highest value for roasted teff.

Among legumes the carbohydrate content was between 57.3 g/100g for raw pea and 62.1g/100g for roasted lentil.

Except for whole white rice, crude fiber content in the cereals and legumes were less than 5 g/100g as recommended for the use in CFs.
The ash content of the cereals was less than 3.1 g/100g similar to the concentration of most legumes (~3 g/100g).

The iron content in the cereals was in the range of 2.4 mg/100g to 43.1 mg/100 g.

The highest iron concentration was found in the roasted red teff.

The iron content in legumes ranged from 5.7 mg/100 g to 17.5 mg/100 g and the highest was roasted lentils.
The zinc content in cereals ranged from 1.9 mg/100 g to 3.1 g/100 g and for legumes from 2.6 to 6.3 mg/100 g.

Roasted red teff and raw maize from cereals and raw and processed lentils was the best sources of zinc.

The calcium content in the cereals was highly variable and ranged from 2.2 for raw maize to 119 mg/100 g for roasted red teff.

The calcium content ranged from 14.9 mg/100 g to 109.1 mg/100 g, and the highest was found in roasted chickpea.

The phytate and tannin content were in the range often observed in cereal and legumes.
Considering the nutritional composition, price per kilogram and the consumption pattern of the community

- From cereals: Wheat, Maize, Sorghum, White and Red teff
- From legumes: Peas and Chickpeas

The nutrient composition of the processed cereals and legumes were inserted into NutriSurvey software.

- With a portion size of 35-40g dry matter and 74-121g dairy consumption.
- Three alternative formulations based on wheat, sorghum, and maize were developed.
### Formulation of CFs using linear programing

#### Table 4 The three complementary foods formulated using linear programing

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>LP constraints</th>
<th>Formulation1</th>
<th>Formulation2</th>
<th>Formulation3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHO requirements (50g)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>Actual (37 g)</td>
<td>Actual (39 g)</td>
<td>Actual (37 g)</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>176</td>
<td>220</td>
<td>219</td>
<td>222</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>3</td>
<td>5.5</td>
<td>9.1</td>
<td>8.0</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>100</td>
<td>200</td>
<td>154</td>
<td>145</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>4</td>
<td>5</td>
<td><strong>1.6</strong></td>
<td><strong>1.5</strong></td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>7</td>
<td>11</td>
<td>6.9</td>
<td>7.2</td>
</tr>
</tbody>
</table>
Macro- and Micro nutrient composition of formulated complementary foods

- The three formulations were analyzed to check whether their nutrient content is in line with the calculated values.

- Despite the small average meal portion size consumed all the three formulation will allow WHO intake requirements for energy, protein, and calcium.

- Assuming medium bioavailability iron intake of formulation one (91%), formulation two (97%), and formulation three (96%) met WHO intake requirement.
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### Table 5: Nutritional composition of complementary foods formulated for the pastoralist community per 100 g.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Formulation 1</th>
<th>Formulation 2</th>
<th>Formulation 3</th>
<th>WHO Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>92.50 ±0.02</td>
<td>91.2 ± 0.02</td>
<td>91.8 ± 0.02</td>
<td>70.5</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>4.8</td>
<td>2.4 ± 0.7</td>
<td>2.4 ± 0.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>541.1</td>
<td>406.0 ± 2.9</td>
<td>412.1 ± 0.6</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>415.78 ±3.7</td>
<td>541.1</td>
<td>412.1 ± 0.6</td>
<td>440</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>25.8</td>
<td>12.0 ± 0.1</td>
<td>14.4 ± 0.2</td>
<td>17.5</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>31.4</td>
<td>4.3 ± 0.1</td>
<td>4.6 ± 0.1</td>
<td>12.7</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>76.97 ± 0.8</td>
<td>77.0 ± 0.8</td>
<td>77.0 ± 0.2</td>
<td>68.1</td>
</tr>
<tr>
<td>Phytate (g)</td>
<td>0</td>
<td>205.9</td>
<td>296.8 ± 1.3</td>
<td>---</td>
</tr>
<tr>
<td>Tannin (g)</td>
<td>BD</td>
<td>0</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>Iron* (g)</td>
<td>17.95 ± 1.3</td>
<td>18.6 ± 3.4</td>
<td>17.8 ± 1.3</td>
<td>14</td>
</tr>
<tr>
<td>Zinc* (g)</td>
<td>3.89 ± 0.01</td>
<td>3.5 ± 0.1</td>
<td>3.4*</td>
<td>8.3</td>
</tr>
<tr>
<td>Calcium (g)</td>
<td>123.89 ± 3.7</td>
<td>107.5 ± 0.7</td>
<td>118.0 ± 1.5</td>
<td>336.5</td>
</tr>
</tbody>
</table>
In all formulations the zinc intake couldn’t be met the WHO nutrient requirement.

**Sensory evaluation of the formulated complementary foods**

- Sensory evaluation of the improved complementary foods was made for quality parameters;
  - Appearance, color, taste, flavor, odor, and texture.

- The overall product acceptability rating was 7.0 for both formula 1 and 2, and formula 3 had slightly higher (7.6).

- But the difference was not statistically significant (P> 0.05) except the texture.
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Table 6 Sensory evaluation of the formulated complementary foods on 9 point hedonic scale.

<table>
<thead>
<tr>
<th>Sensory parameters</th>
<th>Formulation1</th>
<th>Formulation2</th>
<th>Formulation3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>6.5± 1.73</td>
<td>6.2± 2.24</td>
<td>7.0± 2.03</td>
</tr>
<tr>
<td>Color</td>
<td>6.6± 1.84</td>
<td>6.5± 1.79</td>
<td>7.1± 1.41</td>
</tr>
<tr>
<td>Taste</td>
<td>6.4± 1.68</td>
<td>6.4± 1.29</td>
<td>6.8± 1.77</td>
</tr>
<tr>
<td>Flavor</td>
<td>6.6± 1.55</td>
<td>6.3± 1.82</td>
<td>6.8± 1.61</td>
</tr>
<tr>
<td>Odor</td>
<td>6.5± 1.66</td>
<td>6.2± 2.03</td>
<td>6.7± 1.48</td>
</tr>
<tr>
<td>Texture</td>
<td>6.0± 1.61</td>
<td>5.9± 2.30</td>
<td>7.2± 6.33</td>
</tr>
<tr>
<td>Product acceptability</td>
<td>7.0± 1.23</td>
<td>7.0± 1.68</td>
<td>7.6± 1.10</td>
</tr>
</tbody>
</table>

Values are mean ± SD; superscript with different letters in a row indicates statistically significant difference at P ≤ 0.05.
There is no much difference in price between formulations. Estimated price per Kg.

The estimated 10.1-11.8 birr per Kg with out accounting the labor cost suggest that the formulated products are relatively cheap (GAIN, 2013).

Investigation on willingness to pay are needed whether this is affordable to the pastoralist community.

**Limitation and strength of the study**

- Sensory evaluation was conducted using semi-trained panelist in Addis Ababa for logistical reasons.

- The large sample size; formulation of three improved CFs, sensory acceptable; alternative complementary foods based on detailed information on food consumption pattern of the targeted community makes the present study unique.
Conclusion

- Three alternative formulations based on wheat, maize, and sorghum were developed using LP.

- With low average portion size (30-40 g) energy, protein, calcium, and iron (91% to 97%) daily requirement were full filed.

- The zinc and vitamin-A recommended intakes could not be met with the formulated CFs.

- The sensory evaluation of the three formulations were equally acceptable and relatively cheap but further studies are needed on willingness to pay of the community.
Conclusion

- The present study indicates the possibility of improving complementary diets/foods using locally available cereals and legumes through the use of nutrient intake data and linear programming.
**Recommendation**

- Although the developed complementary foods provide adequate amount of energy, protein, iron, and calcium, strategies to improve their zinc and vitamin A content should be devised.

- This could be either through promotion of consumption of zinc and vitamin A rich foods such as ASFs or fortification with monitoring.

- More investigation on the viscosity, protein digestibility, and mineral bioavailability of the formulated CFs are needed.

- Although the estimated price seems reasonable, the affordability of the product should be tested by the pastoralist community through studies of willingness to pay.
Recommendation

- Nutrition intervention that promote the formulated CFs and other optimal IYCF are needed.

- Nutrition intervention on nutrition education in the community especially for the health extension workers also needed.
Acknowledgement

- My deepest appreciation goes to my advisor Dr. Kaleab Baye in AAU.

- My next gratitude goes to all EPHI Staffs especially Tibebu and Aregash.

- Last but not the list I want to say thank you Dr. Sara Wuehler from micronutrient initiative Ottawa, Canada.
THANK YOU!