Probiotics: what is Africa doing?

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RUFORUM Seminar Presentation
at
Sokoine University of Agriculture
Wednesday 11th May 2016
1. Brief biography
2. The gut microflora
3. The concept of probiotics
   – Definition
   – Guidelines
4. The probiotics market
5. Diversity of probiotics
6. Health benefits of probiotics
7. Mechanisms of action
8. African based studies on probiotics
9. Challenges and opportunities for Africa
10. L. rhamnosus Yoba
    – Origins
    – Use in products
    – Yoba in Uganda
• Born 28 November 1977
• B.Sc Food Sci & Tech, MAK 2003
• M.Sc Food Tech, Katholiek University of Leuven and University of Ghent (Belgium), 2007
• PhD, Microbiology, Norwegian University of Life Sciences (Norway), 2012
• Taught at Makerere from 2002 to date
• Technologist in the Fish Industry, Uganda, 2003
Areas of interest

• Fermentation

• Food safety and quality

• Functional foods
  – Antioxidant enriched products
  – Probiotics
The gut microflora

NB: Only major groups shown here and mainly faecal flora. Up to 1,000 species reported!

Sterile GIT

Old age
- Less bifidobacteria
- More anaerobic and putrefactive flora
- Gut malfunction

Breastfed infants
- Dominated by bifidobacteria

While formula fed
- Have complex adult flora
- Flora stabilizes at abt 2 years and is essential for optimal gut functioning

NB: Only major groups shown here and mainly faecal flora.
The gut microflora

O’Hara and Shanaha. 2006. The gut flora as a forgotten organ. EMB, Vol 7 (7), 688 – 693; Mizutani,(1992)
The gut microflora

• Changing lifestyles make it difficult to maintain a ‘balance’
  – Stress
  – Changing dietary patterns
  – Eating habits
  – Consumption of antibiotics

• Possible shift of ‘balance’!
  – Reduction of potentially health-promoting bacteria (e.g lactobacilli and bifidobacteria)
  – Increase in more harmful flora (e.g clostridia, sulphate-reducers and proteolytic bacteroides)
# The gut microflora

## A cocktail of the good guys and the bad guys

<table>
<thead>
<tr>
<th>The good guys</th>
<th>The bad guys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce vitamins</td>
<td>Produce toxins</td>
</tr>
<tr>
<td>Ferment food</td>
<td>Produce carcinogens: Bowel cancer,</td>
</tr>
<tr>
<td>Modulate the immune system</td>
<td>Constipation</td>
</tr>
<tr>
<td>Enhance digestion and absorption</td>
<td>Diarrhea</td>
</tr>
<tr>
<td>Inhibit harmful species</td>
<td>Inflammatory bowel diseases</td>
</tr>
<tr>
<td>Remove carcinogens (reduce enzymes e.g B-glucuronidase, azoreductase, nitroreductase) and toxins</td>
<td>Putrefaction</td>
</tr>
<tr>
<td>Produce short chain fatty acids (SCFAs)</td>
<td>Increased susceptibility to transient enteropathogens e.g <em>Salmonella, Campylobacter, E. coli</em>...</td>
</tr>
</tbody>
</table>
Friendly Bacteria
L. acidophilus, L. salivarius, L. casei, L. thermophilus, B. bifidum, B. longum, etc.

Unfriendly Bacteria
Pathogenic bacteria & fungi, such as Candida albicans, etc.
Elie Metchnikoff

• Earliest mention of the probiotic concept by Metchnikoff in 1908
  – Complex microflora in the colon affected ‘auto-intoxication’
  – Longevity of Bulgarian peasants due to consumption of large quantities of yoghurt
  – The live microbes were believed to promote good health
  – Origins of the *Bacillus bulgaricus* (*L. delbrueckii* subsp. *bulgaricus*), which together with *Streptococcus salivarius* subsp. *thermophilus* form the yoghurt starter

"Inflammation as understood in man and higher animals is a phenomenon that almost always results from the intervention of some pathogenic microbe", E. Metchnikoff.
The concept of probiotics: Definition

• Several have been proposed over time:
  – **Substances secreted** by one microorganism that stimulate the growth of another (Lilly and Stillwell, 1965)
  – **Organisms and substances** that influence intestinal microbial balance (Parker, 1974)
  – A **live microbial feed supplement** which beneficially affects the host animal by improving its intestinal microbial balance (Fuller, 1989)
  – A **live microbial feed supplement** that is beneficial to health (Salminen et al., 1998).

• **Currently acceptable definition:**
  – Live microorganisms which when administered in adequate amounts confer a health benefit on the host (FAO/WHO, 2002)
Probiotic ingestion can be recommended as a preventative approach:
- To help maintain the balance of the intestinal microflora thus enhancing ‘well-being’.
- Prevent or alleviate some conditions.

Some studies have shown that effects can be due to:
- Dead bacteria i.e. paraprobiotics (Taverniti and Guglielmetti, 2011)
- Bacterial products (postbiotics; Tsilingiri and Rescigno, 2013)

However, the definition still emphasizes live microorganisms.
The concept of probiotics: guidelines

Guidelines for Probiotics*

• FAO/WHO in 2001: need for clear guidelines for systematic evaluation of probiotics and their related health claims

• Functional foods

**Strain identification**
Phenotypic and genotypic methods.
Genus, species and strain
Deposit strain in International Culture Collection

**Functional characterization**
*In vitro tests*
*Animal studies*

**Safety assessment**
*In vitro and/or animal*  
*Phase 1 human study*

**Double blind randomized placebo-controlled (DBPC) phase 2:** human trial or other appropriate design with sample size and primary outcome appropriate to determine if strain/product is efficacious

**Preferably second independent DBPC to confirm results**

**Phase 3. Effectiveness trial is appropriate to compare probiotics with standard treatment of a specific condition**

**Probiotic**

**Labeling.**
Contents: genus, species, strain  
Minimum number of viable bacteria at end of the shelf life  
Proper storage conditions  
Health claims  
Corporate contact details for consumer information


Probiotic effects are generally strain specific. Save for example *S. thermophillus* and *L. delbruecki ssp. Bulgaricus* which enhance lactose digestion.
Main *in vitro* tests for study of probiotic strains

- Resistance to gastric acidity
- Bile acid resistance
- Adherence to mucus and/or human epithelial cells and cell lines
- Antimicrobial activity against potentially pathogenic bacteria
- Ability to reduce pathogen adhesion to surfaces
- Bile salt hydrolase activity
- Resistance to spermicides (applicable to probiotics for vaginal use)

Safety considerations of probiotic strains

• Lactobacilli and Bifidobacteria associated with food are historically considered to be safe. GRAS status

• Probiotics may however, be theoretically responsible for four kinds of side effects:
  – Systemic infections: few reported in patients with underlying medical conditions
  – Deleterious metabolic activities
  – Excessive immune stimulation in susceptible individuals
  – Gene transfer

Safety considerations of probiotic strains

- Determination of **antibiotic resistance** patterns
- Assessment of certain metabolic activities (e.g., D-lactate production, bile salts deconjugation...)
- Assessment of **side effects** during human studies
- Testing for **toxin production** if strain belongs to a species that is a known mammalian toxin producer
- Determining **hemolytic activity** if strain belongs to a species with known hemolytic potential
- Lack of **infectivity** in immunocompromized animals

The concept of probiotics: evidence

The pyramid of evidence

- Meta-analysis RCTs
- Randomised control trials
- Open studies in humans
- Animal studies
- In vitro studies

Marteau, 2003
Health claims related probiotic strains

- General health claims allowed in most countries for probiotic containing foods. For example, ‘Improves gut health’

- Specific health claims, e.g. ‘reduces the incidence and severity of rotavirus diarrhea in infants’ can be used where sufficient scientific evidence exists, (FAO/WHO, 2002)

- Manufacturer responsible for getting independent third party review by experts to establish if the claim is truthful and not misleading
The probiotics market

Market

- Major product categories

Foods and beverages:
dairy, fermented meat, bakery, breakfast cereals, beverages, meat, fish & eggs and soy products

Dietary supplements:
tablets, capsules, and powders

Animal feed
The probiotics market

- Global probiotics market valued at USD 32.06 billion in 2013 (Grand View Research, 2016).
- Estimated to be valued at **USD 33.19 billion in 2015**
- Projected to reach **USD 46.55 billion by 2020**.
  - For comparison: The global value of the Coca-Cola brand rose from USD 41.41 billion in 2006 to **USD 83.84 in 2015**
- Industry growth likely due to:
  - Increasing global health awareness among consumers
  - Growth of global functional food industry
  - Technological advancements
  - Rising disposable incomes
The probiotics market

- Food and beverage applications to increase by 50% in N. America

The probiotics market

- As of 2014 more than 100 companies were involved in marketing probiotic products in the US!

- Some of the key players in the international market
  1. American Biologics, USA
  2. Arla Foods, USA
  3. BioGaia Biologics AB, Sweden
  4. Chr. Hansen A/S, Denmark
  5. ConAgra, USA
  6. DuPont Danisco, Denmark
  7. General Mills Inc., USA
  8. Groupe Dannon, France
  9. Institute Rosell, Canada
  10. Nestle SA, Switzerland
  11. Valio Ltd, Finland
  12. Yakult Honsha Co. Ltd., Japan
  13. BioGaia AB, Sweden
- ...
The probiotics market

• Limited information available on market share of probiotics in Africa
  – Africa’s market share likely very small in global terms

• South Africa has a relatively well established market:
  – Supplements (capsules)
  – Fortified food items (especially baby cereals)
  – Fermented dairy products

• Likely need or interest partly based on traditional fermented foods
  – Fermented foods considered to have health benefits
  – Some believed to aid in the control of some diseases (intestinal disorders)
## Diversity of probiotics

### Both bacteria and yeasts

<table>
<thead>
<tr>
<th><strong>Lactobacillus</strong></th>
<th><strong>Bifidobacterium</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>johnsonii LA1</td>
<td>breve</td>
</tr>
<tr>
<td>acidophilus LA5</td>
<td>lactis Bb12</td>
</tr>
<tr>
<td>acidophilus NCFB 1748</td>
<td>longum BB536</td>
</tr>
<tr>
<td>rhamnosus “GG”</td>
<td></td>
</tr>
<tr>
<td>casei “Shirota”</td>
<td></td>
</tr>
<tr>
<td>casei “Imunitass”®</td>
<td></td>
</tr>
<tr>
<td>casei Defensis</td>
<td></td>
</tr>
<tr>
<td>gasseri</td>
<td></td>
</tr>
<tr>
<td>reuteri</td>
<td></td>
</tr>
<tr>
<td>salivarius UCC118</td>
<td></td>
</tr>
<tr>
<td>plantarum 299v</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Enterococcus</strong> faecium SF68</td>
<td></td>
</tr>
<tr>
<td><strong>Escherichia coli</strong> Nissle 1917</td>
<td></td>
</tr>
<tr>
<td><strong>Bacillus cereus, Bacillus subtilis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Saccharomyces cerevisiae, boulardii</strong></td>
<td></td>
</tr>
</tbody>
</table>
Diversity of probiotics

Mainly isolated from

- Food
- Intestinal contents/stools of humans or animals
- The human urinogenital tract
- Oral cavity
- Human milk
Diversity of probiotics

Probiotic vehicles

• Several foods considered as vehicles for probiotic delivery:
  – Dairy products
  – Fermented or brined meat
  – Fermented vegetables, cereals
  – Fruit juice
  – Nutritional supplements (liquid, powder or tablets)

• The products are considered as functional foods
## Diversity of probiotics

### Some probiotic products on the African market

<table>
<thead>
<tr>
<th>Product name</th>
<th>ProbiFlora Adult Intensive Rescue</th>
<th>ProbiFlora™ Infant</th>
<th>ProbiFlora™ Adult Classic Bowel Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Danisco</td>
<td>Danisco</td>
<td>Danisco</td>
</tr>
<tr>
<td>Market</td>
<td>South Africa</td>
<td>South Africa</td>
<td>South Africa</td>
</tr>
<tr>
<td>Probiotic</td>
<td>9 strains</td>
<td>Not specified</td>
<td>4 strains</td>
</tr>
<tr>
<td>Claimed Benefits against</td>
<td>Lactose intolerance</td>
<td>Colic</td>
<td>Bloating</td>
</tr>
</tbody>
</table>

- **ProbiFlora Adult Intensive Rescue**
  - Company: Danisco
  - Market: South Africa
  - Probiotic: 9 strains
  - Claimed Benefits against: Lactose intolerance

- **ProbiFlora™ Infant**
  - Company: Danisco
  - Market: South Africa
  - Probiotic: Not specified
  - Claimed Benefits against: Colic

- **ProbiFlora™ Adult Classic Bowel Support**
  - Company: Danisco
  - Market: South Africa
  - Probiotic: 4 strains
  - Claimed Benefits against: Bloating
### Diversity of probiotics

#### Some probiotic products on the African market

<table>
<thead>
<tr>
<th>Product name</th>
<th>ProbiFlora™ Junior</th>
<th>ProbiFlora™ Adult Colon Ease</th>
<th>Forever Active Probiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Danisco</td>
<td>Danisco</td>
<td>Forever Living Products</td>
</tr>
<tr>
<td>Market</td>
<td>South Africa</td>
<td>South Africa</td>
<td>Kenya</td>
</tr>
<tr>
<td>Probiotic</td>
<td>3 strains</td>
<td>Not specified</td>
<td>6 strains (B. lactis, L. rhamnosus; acidophilus, B. longum; L. bulgaricus, L. plantarum)</td>
</tr>
<tr>
<td>Claimed Benefits against</td>
<td>Lactose intolerance, Low immunity, Food allergies</td>
<td>Enhances digestion, And regularity</td>
<td>Healthy digestive system, enhanced nutrient absorption and immune function</td>
</tr>
</tbody>
</table>

![Probiotic products images]
### Diversity of probiotics

#### Some probiotic products on the African market

<table>
<thead>
<tr>
<th>Product name</th>
<th>BioPro</th>
<th>Company</th>
<th>Market</th>
<th>Probiotic</th>
<th>Claimed Benefits against</th>
<th>Product name</th>
<th>Company</th>
<th>Market</th>
<th>Probiotic</th>
<th>Claimed Benefits against</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioPro</td>
<td>Wellington Pharmaceuticals, USA</td>
<td>South Africa</td>
<td>L. reuteri</td>
<td>Colic</td>
<td></td>
<td>Combiforte</td>
<td>Combiforte BV, Netherlands</td>
<td>South Africa</td>
<td>L. acidophilus, B. bifidus, B. longum</td>
<td>Antibiotic induced diarrhoea and other intestinal disorders</td>
</tr>
<tr>
<td>Culturelle</td>
<td>Culturelle, UK</td>
<td>South Africa</td>
<td>B. longum, L. acidophilus, L. rhamnosus GG S. thermophilus</td>
<td></td>
<td>Diarrhoea, bloating, Immune boosting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BioPro**

- **Serving Size:** Five (5) drops
- **Serving per Container:** 90 drops
- **Composition Per Serving:**
  - Lactobacillus Reuteri 100,000,000 colony-forming units
- **Directions:** Take five (5) drops daily as a dietary supplement.

**Combiforte**

- **Ingredients:** L. acidophilus, B. bifidus, B. longum
- **Claims:**
  - Anti-diarrhoea
  - Immune boosting
  - Helps with gut and bloating
  - Helps to restore your intestinal flora

**Culturelle**

- **Ingredients:** B. longum, L. acidophilus, L. rhamnosus GG S. thermophilus
- **Claims:**
  - Diarrhoea, bloating, Immune boosting
### Diversity of probiotics

#### Some probiotic products on the African market

<table>
<thead>
<tr>
<th>Product name</th>
<th>BioPro</th>
<th>Company</th>
<th>Market</th>
<th>Probiotic</th>
<th>Claimed Benefits against</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioPro</td>
<td>Bioflora CC</td>
<td>BioPro</td>
<td>South Africa</td>
<td>B. infantis</td>
<td>Diarrhoea, disturbances which are associated with antibiotic therapy, oral thrush, food allergies, lactose intolerance and nappy rash</td>
</tr>
<tr>
<td>Vagiforte Plus</td>
<td>Bioflora CC</td>
<td>Rameda, Egypt</td>
<td>South Africa</td>
<td>lactobacillus Bifidobacteria</td>
<td>Vaginal thrush</td>
</tr>
<tr>
<td>Lacteol Fort</td>
<td>Rameda, Egypt</td>
<td>Rameda, Egypt</td>
<td>South Africa</td>
<td>L. fermentum L. delbrueckii</td>
<td>Bacterial or viral diarrhoea</td>
</tr>
</tbody>
</table>

**Diversity of probiotics:**
- BioPro: B. infantis
- Vagiforte Plus: lactobacillus Bifidobacteria
- Lacteol Fort: L. fermentum L. delbrueckii
### Diversity of probiotics

#### Some probiotic products on the African market

<table>
<thead>
<tr>
<th>Product name</th>
<th>Trilac</th>
<th></th>
<th></th>
<th>Seeking Health</th>
<th></th>
<th></th>
<th>Kalsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Allergon AB, Sweden</td>
<td>Company</td>
<td>Seeking Health, USA</td>
<td>Company</td>
<td>Catalysis Lab., Spain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market</td>
<td>Kenya</td>
<td>Market</td>
<td>Kenya</td>
<td>Market</td>
<td>Kenya</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probiotic</td>
<td><em>L. acidophilus, L. bulgaris and B. animalis</em></td>
<td>Probiotic</td>
<td><em>S. boulardii</em></td>
<td>Probiotic</td>
<td><em>L. acidophilus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claimed Benefits against</td>
<td><strong>Diarrhea, constipation</strong></td>
<td>Claimed Benefits against</td>
<td><strong>Diarrhea, gut inflammation</strong></td>
<td>Claimed Benefits</td>
<td><strong>Fixing of calcium</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Some probiotic products on the African market include:*  
- **Trilac** by Allergon AB, Sweden, available in Kenya. Promotes *L. acidophilus, L. bulgaris and B. animalis* for **Diarrhea, constipation**.  
- **Seeking Health** by Seeking Health, USA, available in Kenya. Promotes *S. boulardii* for **Diarrhea, gut inflammation**.  
- **Kalsis** by Catalysis Lab., Spain, available in Kenya. Promotes *L. acidophilus* for **Fixing of calcium**.
# Health Benefits of Probiotics

## Several benefits associated with probiotics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Probiotic</th>
<th>Results</th>
</tr>
</thead>
</table>
| Hypercholesterolemia | *B. lactis Bb12*  
*B. Longum BL1*,  
*L. acidophilus L1*,  
*L. acidophilus La5*  
*L. reuteri NCIMB 30242* | Lower total cholesterol and LDL cholesterol in probiotic vs.  
Lowers total cholesterol, LDL cholesterol, and non-HDL cholesterol |
| Constipation       | *L. casei rhamnosus Lcr35*  
*L. casei Shirota* | Higher defecation frequency, less hard stool. Decreased severity of constipation and improved stool consistency |

Sources: Taibi and Comelli (2014).
### Health Benefits of probiotics

#### Several benefits associated with probiotics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Probiotic</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious diarrhea (prevention)</td>
<td><em>L. rhamnosus GG</em> <em>S. boulardii lyo</em> <em>B. lactis Bb12</em></td>
<td></td>
</tr>
<tr>
<td>Atopic eczema associated with cow’s milk allergy</td>
<td><em>B. lactis NCC2818 A</em> <em>L. rhamnosus GG</em></td>
<td></td>
</tr>
<tr>
<td>Immune response</td>
<td><em>B. lactis DN-173 010</em> <em>L. acidophilus LAFT1</em> <em>L. rhamnosus GG</em></td>
<td></td>
</tr>
<tr>
<td>Antibody response to vaccination</td>
<td><em>L. casei DN-114 001</em></td>
<td>Increased antibody response to influenza vaccination in the probiotic group</td>
</tr>
</tbody>
</table>

Sources: Taibi and Comelli (2014).
## Health Benefits of probiotics

### Several benefits associated with probiotics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Probiotic</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory infection</td>
<td><em>L. casei DN-114 001</em> &lt;br&gt;<em>L. rhamnosus GG</em> &lt;br&gt;<em>L. plantarum DSM 15312</em> (HEAL 9) and <em>L. paracasei DSM 13434</em> (8700:2)</td>
<td>Decreased duration of Infection  &lt;br&gt;Reduced risk of upper RTIs and duration of Symptom  &lt;br&gt;Reduced incidence and duration of common cold</td>
</tr>
<tr>
<td>Infantile colic</td>
<td><em>L. reuteri DSM 17938</em></td>
<td></td>
</tr>
<tr>
<td>Bacterial vaginosis</td>
<td><em>L. rhamnosus GR-1</em> &lt;br&gt;<em>L. fermentum RC-14</em></td>
<td>Reduced colonization of vagina by potential pathogens</td>
</tr>
<tr>
<td>Urinary tract infections</td>
<td><em>L. crispatus CTV-05</em></td>
<td>Reduction in recurrent UTIs in women</td>
</tr>
<tr>
<td>Oral health</td>
<td><em>Streptococcus salivarius K12</em></td>
<td>Reduction of malodour, prevention of pharyngeal infections</td>
</tr>
</tbody>
</table>

Sources: Taibi and Comelli (2014).
## Health Benefits of probiotics

### Several benefits associated with probiotics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Probiotic</th>
<th>Results</th>
</tr>
</thead>
</table>
| Antibiotic-associated diarrhea   | *Bacillus clausii* strains  
O/C, NR, SIN, and T  
*B. animalis Bb12* and  
*S. thermophilus*  
*Enterococcus faecium* LAB  
SF68  
*L. acidophilus CL1285*  
and *L. casei LBC80* R  
*L. casei DN-114 001*  
*L. rhamnosus E/N*  
*L. rhamnosus GG*  
*S. boulardii lyo* |                                                        |
| Infectious diarrhea (treatment)  | *Enterococcus faecium* LAB SF68  
*L. reuteri SD2112 A, L. rhamnosus GG*  
*S. boulardii lyo, E. coli Nissle 1917 (EcN)* | Reduced duration        |

Sources: Taibi and Comelli (2014).
# Health Benefits of probiotics

## Several benefits associated with probiotics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Probiotic</th>
<th>Results</th>
</tr>
</thead>
</table>
| *Clostridium difficile* associated diarrhea    | *L. acidophilus CL1285* and *L. casei LBC80 R*  
*L. casei DN-114 001*  
*L. rhamnosus GG*  
*S. boulardii lyo* |                                                                          |
| *Clostridium difficile* with no diarrhea       | *L. rhamnosus HN001*  
*L. acidophilus NCFM*                                                 |                                                                          |
| Bacterial vaginosis and vulvovaginal candidiasis | *L. casei rhamnosus Lcr35*  
*L. rhamnosus GR-1*  
*L. fermentum RC-14*                                                 | Enhanced restoration of the vaginal microbiota after antibiotic treatment of bacterial vaginosis |

Sources: Taibi and Comelli (2014).
# Health Benefits of probiotics

## Several benefits associated with probiotics

<table>
<thead>
<tr>
<th>Condition</th>
<th>Probiotic</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Helicobacter pylori</em></td>
<td><em>Bacillus clausii</em> strains O/C, NR, SIN, and T1b(t)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>L. casei DN-114 001</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>L. reuteri ATCC 55730</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>L. rhamnosus GG</em></td>
<td></td>
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<td></td>
<td><em>S. boulardii lyo</em></td>
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<td></td>
<td><em>L. johnsonii La1</em></td>
<td></td>
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<tr>
<td>Irritable bowel syndrome</td>
<td><em>Bacillus coagulans GBI 30</em></td>
<td></td>
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<tr>
<td></td>
<td><em>B. bifidum BB75, B. infantis 35624</em></td>
<td></td>
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<tr>
<td></td>
<td><em>B. lactis DN-173 010, B. longum 101, L. acidophilus 102, Lactococcus lactis 103, Streptococcus thermophilus 104</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>L. plantarum 299 V, L. reuteri SD2112, L. rhamnosus GG</em></td>
<td></td>
</tr>
</tbody>
</table>

Sources: Taibi and Comelli (2014).
Adequate probiotic intake?

- Still controversial/varrying opinions
- Can be expressed as cells per gram product or cells per serving
- Studies have used doses of $10^6$ – $10^9$ cells per day for 1 – 13 weeks
- A daily dose of $1–5 \times 10^9$ cfu for a minimum of 5 days is currently recommended*
  - About 10 ml of product with $10^8$ cells per ml
  - About 100 ml of product with $10^7$ cells per ml
  - About 1 L of product with $10^6$ cells per ml
  - About 10 L of product with $10^5$ cells per ml

* Kaur et al. (2002); Health Canada (2009)
Health Benefits of probiotics

Adequate probiotic intake?

Probiotic Starter culture

Log 5 - 7

100,000 to 10 million cells per gram at start fermentation

Log 8

100 million cells per gram at end fermentation

Log 10 per serving

20 billion cells per serving

Assuming a serving of 200 ml of yoghurt
Health Benefits of probiotics

The fate of ingested probiotics

The appearance of ingested probiotics bacteria in faeces

Colonies with marker of probiotic strain in faeces, %

Time, days

Administration needs to be continued
Mechanisms of action of probiotics

Suppression of endogenous pathogens

Colonization resistance: pH, mucus, bacteriocins, defensins, enhanced cell binding

Control of Irritable Bowel Syndrome (IBS)

Normalised intestinal microbial composition

Control of Inflammatory Bowel Disease

Balanced immune response

Alleviate food allergy symptoms in infants

Strengthened innate immunity

Suppression of exogenous pathogens e.g. travellers’ diarrhea

Colonization resistance: pH, mucus, bacteriocins, defensins, enhanced cell binding

Supply of SCF’s and vitamins (e.g. folate) to the colonic epithelium

Reduced risk of colon cancer

Lower levels of toxigenic/mutagenic reactions in the gut

Metabolic effects

Bile salt deconjugation and excretion

Lactose hydrolysis

PROBIOTICS

Immunomodulation: effects on lymphocytes e.g. cytokine production, stopping proinflammatory responses, preventing apoptosis, increased Ig release...

Balanced immune response

Lowered serum cholesterol

Improved lactose tolerance

Some studies on probiotics in Africa

- Mainly *in vitro* studies focussed on functional and technological properties

- A few human studies

### Some studies on probiotics in Africa

<table>
<thead>
<tr>
<th>Strains</th>
<th>Source</th>
<th>Inoculated/consumed product</th>
<th>Region were product is consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. faecium</em></td>
<td>Raw cow milk for <em>nono</em> production</td>
<td><em>In vitro</em> study</td>
<td>Nigeria</td>
</tr>
<tr>
<td><em>L. plantarum, L. fermentum</em></td>
<td>Fermented maize dough, cassava, Gari</td>
<td><em>In vitro</em> study</td>
<td>Ghana</td>
</tr>
<tr>
<td><em>L. plantarum, Pediococcus</em> spp</td>
<td><em>Fufu</em> and <em>Ogi</em></td>
<td><em>In vitro</em> study</td>
<td>Nigeria</td>
</tr>
<tr>
<td><em>Pediococcus</em> spp, <em>Lactobacillus</em> spp, <em>L. fermentum</em></td>
<td>Pearl millet slurry</td>
<td><em>In vitro</em> study</td>
<td>Burkina Faso, Ghana</td>
</tr>
<tr>
<td><em>L. Fermentum</em></td>
<td><em>Kimere</em>: pearl millet dough</td>
<td><em>In vitro</em> study</td>
<td>Kenya</td>
</tr>
<tr>
<td><em>L. Johnsonii</em> (BFE 6128, BFE 6154) <em>L. plantarum</em> (BFE 5092, BFE 5759, BFE 5878), <em>L. acidophilus</em>, <em>L. paracasei</em>, <em>L. rhamnosus</em>, <em>L. fermentum</em></td>
<td><em>Kule naato</em> (Maasai fermented milk) <em>Kwerionik</em> (fermented milk)</td>
<td><em>In vitro</em> study</td>
<td>Kenya, Uganda</td>
</tr>
<tr>
<td><em>L. acidophilus</em>, <em>L. pentosus</em></td>
<td>Fermented cow’s milk and cassava</td>
<td>Fermented cereal maize gruel</td>
<td>West Africa</td>
</tr>
<tr>
<td>LAB, mainly <em>W. confusa</em> and <em>L. fermentum</em></td>
<td><em>Koko</em> and <em>koko</em> sour water from millet porridge</td>
<td><em>Koko</em> sour water</td>
<td>Ghana</td>
</tr>
<tr>
<td><em>L. rhamnosus</em> GR-1</td>
<td>Milk yoghurt and milk yoghurt with Moringa powder</td>
<td></td>
<td>Tanzania</td>
</tr>
</tbody>
</table>

Major challenges in Africa

• High costs of randomized control trials
  – Lack of government investment in R & D
  – Lack of industrial and philanthropic funding

• High costs of developing and storing of cultures

• Getting the consumer to accept probiotics
  – The fear of eating microbes

• Legislation
  – Non existent in a number of countries
Opportunities for Africa

- Increasing interest in natural, non-drug related remedies
- Limited knowledgeable about probiotics
  - About 95% of medical practitioners in Nigeria not familiar with probiotics yet 64% in favour of their use (Anakum, 2006)
- Populations exposed to:
  - Poor hygiene conditions
  - Toxic compounds (aflatoxins)
  - Malnutrition (e.g. vitamin deficiency, iron deficiency)
  - Chronic enteric infections (e.g. diarrhea which accounts for 37% of childhood deaths in Sub-Saharan Africa)
  - Increasing NCDs
Opportunities for Africa

• Unavailability of locally sourced strains with documented health benefits

• A great diversity of traditional fermented foods
  – Potential sources of probiotics
  – Potentially acceptable probiotic vehicles

• Existence of several well-documented probiotic strains from the developed countries
  – No need for expensive trials
  – Could be evaluated for use in local foods
Lb. rhamnosus Yoba

• A generic strain of *Lactobacillus rhamnosus* GG

• LGG isolated in 1983 from the intestinal tract of a healthy human being

• Patent filed by Sherwood Gorbach and Barry Gordin on 17th April 1985
  − Strain initially identified as *Lb. acidophilus* GG (ATCC Accession No. 53103)

• Patent of LGG expired in 2006
Concept of ‘generic probiotics’ introduced by Kort and Sybesma (2012).
   - Patent-expired probiotics are free to be used by others

Remco Kort and Wilbert Sybesma (Yoba For Life Foundation) isolated LGG from a probiotic product

Clone of LGG named *L. rhamnosus* Yoba
   - Deposited in the BCCM/LMG labs in Belgium
   - Identity and genome sequence evaluated

Yoba for Life Foundation introduced *L. rhamnosus* Yoba in Uganda in 2013
   - First introduced in a small dairy plant in Mukono district
   - Mainly used in yoghurt production
**Lb. rhamnosus Yoba**

*Other African products in which Lb. rhamnosus Yoba has been tried*

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Country</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutandabota</td>
<td>Milk + baobab fruit pulp</td>
<td>Zimbabwe</td>
<td>Mpofu et al., (2014)</td>
</tr>
<tr>
<td>Uji</td>
<td>Fermented maize/sorghum beverage</td>
<td>Kenya</td>
<td>Kort et al., (2015)</td>
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<td></td>
<td></td>
<td></td>
<td>Meeme and Mukisa (unpublished)</td>
</tr>
<tr>
<td>Soy yoghurt</td>
<td>Fermented soy milk</td>
<td>Uganda</td>
<td>Lutalo, Nanyonga and Mukisa (unpublished)</td>
</tr>
<tr>
<td>Fermented vegetable salads</td>
<td>Mixed vegetables</td>
<td>Uganda</td>
<td>Kakeeto, Bion and Mukisa (unpublished)</td>
</tr>
<tr>
<td>Fruit juice cocktail</td>
<td>Mixed fruits</td>
<td>Uganda</td>
<td>Agaba and Mukisa (unpublished)</td>
</tr>
</tbody>
</table>
• First prototype of non-dairy based probiotic in Uganda produced at MAK in May 2016

• Obushera fermented using the *L. rhamnosus Yoba* starter
  
  – Acceptable
  – Probiotic viable for at least 8 weeks during cold storage (about log 8 cfu/ml)
Acknowledgement

- The Food Technology Business Incubation Center, Makerere
- Yoba for Life Foundation
- RUFORUM
- iAGRI
- SUA
Thank You
References

References

References

- O’Hara and Shanaha. 2006. The gut flora as a forgotten organ. EMB, Vol 7 (7), 688 - 693