PREBIOTICS, PROBIOTICS AND SYNBIOTICS AS FUNCTIONAL FOODS FOR DOGS

- Dr. K. B. Kore
- Assistant Professor/ Scientist
Outline

- Preface
- Functional food concept
- Prebiotics
- Probiotics
- Synbiotics
- Our study
- Future research
Preface

The term “Functional Foods” was first introduced in Japan in the mid-1980s

‘Japan explores the boundary between food and medicine’

a news in ‘Nature’ in 1993

‘physiological functional food’ (Swinbanks & O’Brien, 1993)

Food and nutrition science has moved from identifying and correcting nutritional deficiencies (improving life expectancy) to designing foods that promote optimal health and reduce risk of disease (improving life quality/wellness)
In past food was means to get rid of hunger

"Let your food be your first medicine"  
‘Hippocrates’

In Present foods are used to reduce the risk of disease besides nutritional need

This is recently being integrated into human and animal nutrition in the face of increased global demands for a more "natural" food
Functional food: Concept

- Aims at maximizing physiological as well as the psychological functions through nutrition.

- The term “functional food” in use today conveys health benefits that extend far beyond mere survival.

- A food can be regarded as functional, if it is satisfactorily demonstrated to affect beneficially one or more target functions in the body beyond the traditional nutrients in a way that is relevant to either improved stage of health and well being and/or reduction of risk of disease.
Foods in which one or more ingredients/components have been manipulated or modified:
- e.g. protein hydrolysates in infant formulas

2. have been added or removed:
- e.g. addition of selected probiotic bacteria to improve gut health

3. bioavailability has been increased:
- e.g. yeast-mineral chelates to increase bioavailability of minerals

4. any combination of the above possibilities
Increasing consumer awareness, health consciousness and expenditure are the socio-economic factors responsible for the expanding world-wide interest in functional foods.
Prebiotics?

- A prebiotic is a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon thus improving host health.

- Prebiotics concept revisited (Gibson et al. 2004)

  It is a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microflora that confers benefits upon host wellbeing and health.
Resistance to digestion in GI
Beneficially alter luminal or systemic aspects of host defense system
Selectively stimulate growth and/or metabolic activity of intestinal bacteria at the expense of pathogens
Fermentable by hindgut microflora
Be neither hydrolyzed nor absorbed by host enzymes or tissues
Resistant to gastric acidity
Resistance to digestion in GI

Ideal Prebiotics

Prebiotics
Some of the Prebiotics

- Inulin
- Oligofructose (scFOS)
- Fructooligosaccharide (FOS)
- Galacto-oligisaccharides (GOS)
- Lactulose
- Xylo-oligosachharides?
- Isomaltooligosaccharides?
- Soybean oligosaccharides?

Gibson & Roberfroid, 2008
Sources of prebiotics

- Garlic/onion
- Jerusalem artichoke
- Chicory
- Banana
Probiotics?

- According to Joint FAO/WHO Working Group
  “Live microorganism which when administered in adequate amounts confer health benefit to the host”

- A preparation or product containing viable, defined micro-organisms in sufficient numbers, which alter the microflora of intestine and by that exert beneficial health effects on the host
Ideal Probiotics

- Modulation of hindgut health
- Adherence to intestinal cells
- Persistence in intestinal tract
- Acid & bile stability
- Antagonistic against pathogenic bacteria
- Production of antimicrobial substances
- Clinically validated health effects
Microbial species used as probiotics

<table>
<thead>
<tr>
<th>Species</th>
<th>Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactobacilli</td>
<td><em>L. acidophilus</em>, <em>L. casei</em>, <em>L. rhamnosus</em>, <em>L. reuteri</em>, <em>L. plantarum</em>, <em>L. faecium</em>, <em>L. johnsoni LA1</em>, <em>L. brevis</em>, <em>L. delbrueckii subp. Bulgaricus</em>, <em>L. fermentum</em>, <em>L. helveticus</em>, <em>L. cellobiosus</em>, <em>L. curvatus</em></td>
</tr>
<tr>
<td>Bifidobacteria</td>
<td><em>B. longum</em>, <em>B. bifidum</em>, <em>B. breve</em>, <em>B. infantis</em>, <em>B. animalis</em>, <em>B. adolescentis</em>, <em>B. thermophilum</em></td>
</tr>
<tr>
<td>Gram-positive coci</td>
<td><em>Lactococcus lactis</em>, <em>Enterococcus faecium</em>, <em>Streptococcus thermophilus</em></td>
</tr>
<tr>
<td>Yeast</td>
<td><em>Saccharomyces cerevisiae</em>, <em>Saccharomyces boulardii</em></td>
</tr>
<tr>
<td>Fungi</td>
<td><em>Aspergillus orizae</em>, <em>Scytalidium acidophilum</em></td>
</tr>
</tbody>
</table>
Potential health benefits of Pre & Probiotics

- Modulation of hindgut health (mainly colon)
  - Maintenance of intestinal microbial balance
  - Lowering pH, production of organic acids, decrease in ammonia etc.
- Resistant to intestinal infection
- Improvement in bioavailability and absorption of minerals
- Hypoglycemic and Hypolipidemic actions
- Management of infectious diarrhoea
- Obesity
- Osteoporosis
- Colon cancer
- Inflammatory bowel disease
Recent advances in pet/companion animal nutrition targeting towards exploring the potential combinations of PRE & PRO as synbiotics.
Synbiotics

- A mixture of a Pre- and probiotics that helps to improve survival and implantation of live microbes in the GI tract by selectively stimulating the growth and/or activating the metabolism of one or a limited number of health-promoting bacteria.

- Some of the synbiotic are:
  - Bifidobacteria + FOS
  - Lactobacillus + FOS
  - Lactobacillus + Inulins
  - Bifidobacteria + Inulins
Overview of hindgut microflora

Health -ve
- Clostridia
- Enterococci
- Eubacterium
- Veillonella
- Streptococci
- Fusobacteria
- Salmonella

Health +ve
- Bifidobacteria
- Lactobacilli
- Bacteroides
What is desired?

Health Negative

Coliforms spp.

Clostridia spp.

Health Positive

Lactobacilli spp.

Bifidobacteria spp.

Others
Our Study

By:
Kore K.B., Pattanaik, A.K.
& Sharma, K.
Objective

To study the effect of prebiotics, probiotics and synbiotics as functional foods on nutrient utilization, hindgut health and faecal flora in Labrador dogs
Experimental design

- The study was carried out at the Clinical and Pet Nutrition Laboratory, Centre of Advanced Faculty Training in Animal Nutrition, Indian Veterinary Research Institute, India
- Sixteen Labrador dogs divided into four groups in completely randomized design (CRD)
- Experimental period: 11 weeks
- Dietary treatments:
  - CON – Experimental diet without PRE &/ PRO
  - PRE: 1.0% of chicory (*Chichorium intybus*) inulin on DM basis
  - PRO: 5% of diet DM, providing $1 \times 10^9$ of *L. acidophilus* NCDC 15
  - SYN: PRE+PRO
The experimental diet was fed twice a day to meet the nutrient requirements of the dogs.

A four-days digestion trial was conducted after 45 days of feeding trial.

Hindgut health attributes were studied after digestion trial.

Faecal microbial population was enumerated at the end of experimental period.
Observations

- Changes in live weight
- Food and nutrient intake
- Digestibility of nutrients
- Hindgut health characteristics:
  - Physical: faecal score, DM, frequency of defecation
  - Chemical: pH, ammonia, lactic acid, short chain fatty acids
  - Microbial: Lactobacillus, Coliform, Bifidobacteria, Clostridia
Results
## Chemical composition of the diet

<table>
<thead>
<tr>
<th>Nutrient/component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>95.99</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>22.66</td>
</tr>
<tr>
<td>Ether extract</td>
<td>4.94</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>3.97</td>
</tr>
<tr>
<td>Nitrogen free extract</td>
<td>61.50</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>65.47</td>
</tr>
<tr>
<td>Total ash</td>
<td>6.93</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.24</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>1.11</td>
</tr>
</tbody>
</table>
Dry Matter Intake of the Dogs

Results

Dry Matter Intake (g/d)
Body weight changes of dogs

Results

![Graph showing body weight changes over weeks with different treatments: CON, PRE, PRO, SYN.](image)
## Digestibility of nutrients in dogs

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Dietary groups</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>PRE</td>
<td>PRO</td>
</tr>
<tr>
<td>Dry matter</td>
<td>79.16&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>78.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>80.45&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein</td>
<td>77.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>76.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.65&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat</td>
<td>87.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>89.72&lt;sup&gt;a&lt;/sup&gt;</td>
<td>92.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fibre</td>
<td>28.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.62&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>35.60&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>CHO (NFE)</td>
<td>85.24</td>
<td>84.13</td>
<td>86.39</td>
</tr>
<tr>
<td>Calcium</td>
<td>48.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.31&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52.55&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphours</td>
<td>52.23</td>
<td>52.80</td>
<td>53.45</td>
</tr>
</tbody>
</table>

<sup>abc</sup>Means bearing different superscripts in a row differ significantly, *p<0.05, **P<0.01, ***P>0.001
### Hindgut health (Physical) indices of dogs

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Dietary groups</th>
<th>SEM</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>PRE</td>
<td>PRO</td>
</tr>
<tr>
<td>Faecal score†</td>
<td>2.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.75&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Freq. of defecat.</td>
<td>4.00</td>
<td>4.25</td>
<td>3.84</td>
</tr>
<tr>
<td>Faeces voided (g/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As is</td>
<td>509.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>559.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>516.3&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>DM (%)</td>
<td>19.72&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.58&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>18.63&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Faeces g/100g DMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet faeces</td>
<td>105.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>117.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>105.8&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b,c</sup>Means bearing different superscripts in a row differ significantly, p<0.05, **P<0.01, ***P>0.001
## Hindgut health (Chemical) indices of dogs

### Results

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Dietary groups</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>PRE</td>
<td>PRO</td>
</tr>
<tr>
<td>pH</td>
<td>5.20&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.99&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.72&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ammonia µmol /g dry fcs</td>
<td>31.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.54&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>26.46&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lactate µmol /g dry fcs</td>
<td>27.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>50.52&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coliform</td>
<td>7.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.81&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Clostridia</td>
<td>9.46&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.13&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>8.82&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lactobacillus</td>
<td>8.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.09&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bifidobacteria</td>
<td>9.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.90&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
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<sup>abc</sup>Means bearing different superscripts in a row differ significantly, p<0.05, **P<0.01, ***P>0.001
Comparative faecal pH

Results
Comparative faecal ammonia and lactate concentration

Results
Comparative faecal SCFAs concentration

.............Results
Comparative faecal Lactobacilli and Bifidobacteria (health positive bacteria) count

..............Results
Results

Comparative faecal Coliform and Clostridia (health negative bacteria) count

![Bar chart showing comparative faecal Coliform and Clostridia counts across different groups (CON, PRE, PRO, SYN).](chart.png)
Conclusion

- **Prebiotics** (Chicory inulin): positively modified fibre digestion, calcium absorption, hindgut health indices and intestinal microflora

- **Probiotics** (*Lactobacillus acidophilus*): Improved some of the nutrients utilization (fat, fibre, Ca), hindgut health attributes and intestinal microbial balance

- **Synbiotics**: shown added or synergistic effect than using them (pre or probiotics) alone from all aspects of functional properties ascribed to prebiotics and/or probiotics

- Animals age, health, diet type, environmental conditions, dose etc. may influence the effect of pre and/or probiotics
Future research
From scientific view

- Search for alternate sources of prebiotics, probiotics (and synbiotics) would add to the gamut of already existing and upcoming resources for enhancing target function.
- Future research should target to ascertain the influence of proven synbiotics combinations across the different feeding regimens, breeds and lifestyle.
- Nutrigenomics approach to explore functional role of the food at genetic level i.e. diet-gene interrelationship.
From industrial view

- Natural sources of prebiotics
- Selecting new and more specific strains of probiotics for health & well-being of the host (age group, health of the population, disease specific)
- To develop technology for non-dairy probiotics (cereal based materials)
- Appropriate delivery vehicle for synbiotics
- Product development: Sensory properties, viability during processing and stability in the product as well as during storage