Chapter 3

INTRODUCTION TO T AND B CELLS

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Bacteria

NADPH OXIDASE

NADPH

H₂O₂

2O₂

2e⁻

NADP⁺

H₂O

GSHpx

SOD

Respiratory burst

Neutrophil

Chew, 1996
INTRODUCTION

- Nutrition interact with animal immune system (Pring and Ahmed, 1993)
- Micronutrients (Minerals and Vitamins)
  - Minerals Zn, Cu, Cr, Se, Mn, Fe, Co
  - Vitamins like E, beta carotene and vitamin A, Vitamin C
- Stress condition
- The requirement of micronutrient for optimal immune response is greater than the amount required for growth and reproduction (Harmon, 1994; Scaletti, 1992)
Micronutrients

Minerals
Zinc
Copper
Chromium
Selenium

Vitamins (Antioxidants)
Vitamin E
Carotenoids (beta carotene) and Vitamin A
Immunity refers to reactions by an animal body to foreign substances such as microbes and various macro molecules (Abbas et al., 1991)

Immune system

A collection of cells and molecules that protect the body against infection, malignancy and damaged cells (Abbas et al., 1991)
IMMUNITY

INNATE
• Physical and chemical barriers
• Phagocytes (Neutrophils & Macrophages) - Inflammatory process.

ACQUIRED
Specific towards particular antigen and enhanced with repeated exposure
ACQUIRED IMMUNE RESPONSE

- Mediated by B lymphocytes.

(Galyean et al., 1999)
B lymphocytes

- Mature in bone marrow
- Antigen binding receptor in their membrane

(Chew, 1996)
T lymphocytes

- Mature in thymus gland
- Function to:
  - Killing infected cells.
  - Stimulate microbial and cytotoxic activity of immune effector cells
- T cell membrane receptor.
- Membrane protein Major Histo Compatibility (MHC) molecule.
- Three types of subpopulation
  - T helper cells (Th cells)
  - T cytotoxic cells (Tc)
  - T suppressor cells (Ts)
- T helper cells
  - Secrete growth factor –cytokines.
  - Having membrane glycoprotein CD4

(Chew, 1996)
Cells of the immune system

- B cells
- T cells
- NK cells
- Monocytes/macrophages
- Neutrophils
- Eosinophils
- Basophils

(Chew, 1996)
Measures of immune response

Humoral immune response
Measured by estimating the antibody (Ig) produced
- Zinc turbidity method (McEwan and Fisher, 1970)
Measures of immune response

Cell mediated immune response

• Lymphocyte transformation test, i.e. Blastogenesis

  *In vitro* assay measures mitosis of cultured lymphocytes in response to mitogenic chemicals (e.g., Concanavalin A) by counting radio activity [counts per minute (cpm)] incorporated into newly synthesized DNA from radio labelled precursors. This is expressed as Stimulation Index (SI) (Larson, 1979)

  \[
  \text{Mean cpm in culture with mitogen} - \text{Mean cpm in culture without mitogen}
  \]

• *In vivo*, antigen instead of Con A
**Mitogen**

- Agents capable of inducing cell division in a high percentage of T cells or B cells.
- Poly clonal activators.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ConcanavalinA (Con A)</th>
<th>Phytohemoagglutinin (PHA)</th>
<th>Pokeweed Mitogen (PWM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Jack bean</td>
<td>Kidney bean</td>
<td>Poke weed</td>
</tr>
<tr>
<td>Target cells</td>
<td>B cells</td>
<td>T cells</td>
<td>T cells and B cells</td>
</tr>
</tbody>
</table>

Burton, 1995
MINERALS
Zinc

Zinc is component of numerous enzymes

- Super oxide dismutase (SOD)
- RNA Polymerase
- DNA polymerase
- Ribonulease
- Thymidine kinase
Zinc influences host defence mechanisms via:

- Phagocytic activity
- Cell mediated immunity
- Humoral immunity

**Phagocytic activity**

Zinc enhances phagocytic activity of macrophages and neutrophils (Babior, 1978)

Phagocytic activity through respiratory burst (McCord & Fridovich, 1969; Chew, 1996)

Increase release of vasoactive amines by basophils
Cell mediated immunity:
Enhances T cell mediated immunity
Zinc is a cofactor for thymic hormone thymulin

Thymulin deficiency
↓
Impaired T lymphocyte proliferation
↓
Impaired T lymphocyte function

Humoral immunity:
Increases antibody production

(Bach, 1983)
Copper immune mechanism

Phagocytic activity
- Neutrophils
- Monocyte

Humoral Response:
- Increases antibody production
- Ab production decreased in Cu deficient diet (Gengelbech and spears, 1998)
COPPER

Copper is component of
• Superoxide dismutase (SOD)
• Ceruloplasmin.
  • Modulate inflammatory response by phagocytosis
Cell mediated immunity

• Mainly through T-lymphocytes (T_h, T_c) by cytokine production

• Inhibit viral replication

• Interlukin production
  B cell maturation
  NK cell activity
  Chemo tactic attraction

Tumour necrosis factor α

• Act on tumor cell-kill it.
CHROMIUM

Component of Glucose Tolerance Factor (GTF).

* Potenciate the insulin activity  (Cheng and Mowat,1999)
* Facilitate interaction between insulin and insulin receptor in target tissue.
* Reduces cortisol level in stress.
Increased cortisol in blood

Antagonist the insulin action

Prevents glucose uptake by insulin receptor

Prevent entry of glucose to vital tissue

Immune system under stress.

(Orth, 1992)
VITAMINS
Vitamins

• Act as natural antioxidant
• Includes Beta carotene and vitamin A, Vitamin E, Vitamin C
• Protect tissue against damage caused by free radicals.
• Free radicals are,
  • Generated in normal cellular metabolism
  • React with enzymes, DNA and damage the tissue
  • Common free radicals are super oxide, hydrogen peroxide, hydroxyl radical, fatty acid radical
## Antioxidant system of mammalian cells

<table>
<thead>
<tr>
<th>Component</th>
<th>location</th>
<th>Nutrient involved</th>
<th>function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superoxide dismutase</td>
<td>cytosol</td>
<td>Cu, Zn, Mn</td>
<td>An enzyme that converts super oxide to hydrogen peroxide</td>
</tr>
<tr>
<td>Glutathione peroxidase</td>
<td>cytosol</td>
<td>Se</td>
<td>An enzyme that converts hydrogen peroxide to water</td>
</tr>
<tr>
<td>Catalase</td>
<td>cytosol</td>
<td>Fe</td>
<td>An enzyme that converts Hydrogen peroxide to water</td>
</tr>
<tr>
<td>Alpha tocopherol</td>
<td>membrane</td>
<td>Vitamin E</td>
<td>Break fatty acid peroxidation chain reaction</td>
</tr>
<tr>
<td>Carotene</td>
<td>membrane</td>
<td>Carotene</td>
<td>Prevents initiation of fatty acid peroxidation chain reactions</td>
</tr>
</tbody>
</table>

Smith *et al.*, 1984
Role of antioxidant on immunity
Vitamin E and Selenium

**Vitamin E**

- Vit E reduces harmful lipid free radicals.

- Enhances phagocytic activity of neutrophils, macrophages and NK cells. (Miller, 1993)

- It is major antioxidant in the blood.

**Selenium**

- Biochemical role through glutathione peroxide

- Enhance neutrophil function
Vitamin E and Selenium

• Both vitamin E and Se influences the function of immune cells especially in mammary gland immunity

• Cows are immuno suppressed when plasma concentration of vitamin E and Se is low (Grasso et al., 1990)
Milk and plasma levels of vitamin E in healthy and mastitis cows

Aroshi et al, 1986
• Supplementation of Vit E (1500 IU) and Se (0.3ppm) increases plasma concentration of vitamin E and reduce incidence of mastitis (Smith, 1986)
Feeding heifers with supplemented vitamin E (1500 IU/d) and giving a selenium inj (0.3 ppm) 21 days post calving reduced several measures of mastitis. (Smith et al, 1984)
Beta carotene

- Act as an antioxidant

**Beta carotene:**

- Enhances phagocytic activity of neutrophils- myeloperoxidase enzyme
- Enhances phagocytic activity of macrophages – peroxidase.
- Increases lymphocyte toxicity
CONCLUSION

• Zinc and copper enhances cell & humoral mediated immunity
• Chromium stimulate immune response in stress conditions
• Vitamin E and Se stimulate immunity against intra mammary infection
• Beta carotene enhances both cell mediated and humoral response