Ecoimmunonutrition: Contemporary Approaches to Optimal Nutrition

Sima P¹ and Vetvicka V²,*

¹Institute of Microbiology, Czech Academy of Sciences, Prague, Czech Republic
²University of Louisville, Department of Pathology, Louisville, KY, USA

*Corresponding author: Vetvicka V, University of Louisville, Department of Pathology, Louisville, KY 40202, USA; E-mail: vaclav.vetvicka@louisville.edu

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Abstract

Nutrition, appropriate in composition and in amount, is one of the basic elements for determining human health. Adequate nutrition plays an important role in well-being, including aiding in the prevention and therapy of diseases. Therefore, for more than 50 years, there is intense research devoted to optimization of the diet to fulfill nutritional needs at various circumstances of human life. In the current review, we are discussing the basic principles of immuno- and ecoimmunonutrition.

Keywords: Nutrition; Evolution; Immunity; Microflora

Introduction

The term immunonutrition usually refers to a special diet for seriously ill patients, designed to support their recovery and to prevent metabolic and inflammatory complications. It is thought to work by balancing immune system functions. The extended meaning of the term immunonutrition is a diet based on the knowledge of principles of the immune system and its functions, intended to help both its proper development in childhood and its maintenance up to elderly. Targets of immunonutritional programs are age-based or disease-based groups of people, according to the WHO guidance.

Econutrition reflects the nutritional needs of

<table>
<thead>
<tr>
<th>Table 1: Terminology</th>
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<tbody>
<tr>
<td>Term</td>
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<tr>
<td>Malnutrition</td>
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<tr>
<td>Immunonutrition</td>
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<tr>
<td>Econutrition</td>
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<td>Ecoimmunonutrition</td>
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</table>

¹ Immune system
² Nutritional Acquired Immunodeficiency Syndrome
³ Gastrointestinal Tract
tissues lining the digestive tract and of a gastrointestinal microflora. Econutrition is going to be replaced by ecoimmunonutrition, a diet enriched with supplements supporting the immune system and the gastrointestinal microecological equilibrium. Ecoimmunonutrition is the aim of the WHO program “Nutrition for the 21st Century,” designed to enhance the health state of populations by promoting the improved diet. Basic terms used are listed in Table 1.

**Historical background**

Over the last century, the life span in industrial countries prolonged due to many improvements, e.g. introduction of hygiene precautions, more effective treatment including an optimization of patient care, discovery of new drugs such as chemotherapeutics and antibiotics, vaccination and consequently eradication of some lethal diseases. Apart from these causes, there is another more fundamental cause, and that is: better nutrition.

On the other hand, the resistance to contagious diseases, especially those caused by air-borne pathogens, decreased within the last 30 – 50 years [1]. This may be attributed to the modern life style which includes social stress and reduced physical activity, intake of industrially processed food, chemicals used as preservatives, nutritional additives, and, last but not least, the over-usage of drugs.

**Changes in feeding habits during human evolution and the rigidity of a genome**

For about 100,000 generations of hunter-gatherers, followed by 500 generations living on agriculture, our ancestors kept the same feeding habits. Moreover, they were exposed to environmental and climatic conditions heavily different from the recent ones, that are artificially transformed and often damaged by industrial abiotic immision load. Since the advent of a modern industrial society, no more than 10 generations could be counted. The last period is even shorter: People take modern nutrients, processed by the contemporary high-technology food industry, for just about 2 generations – lets say 50 years.

Eaton and Konner say that human genes, controlling metabolisms of food components, could hardly reflect recent changes in life style, particularly in nutrition habits [2]. Genes, adapted through millennia under the selective pressure, cannot change within decades. Therefore, the gene pool of people nowadays is in fact almost the same as the one of our forefathers, adjusted to the conditions they lived in, and to the food they consume.

One of the most dramatic changes started in the 18th century, when refined sugar became part of daily nutrition. Since then, the average consumption of refined sugar has steadily increased, up to approximately 45 kg (55 kg in the USA) per person and a year nowadays [3]. This elevation represents an amount of energy equivalent to three marathon races weekly year around.

Besides the elevation of the energy intake, there are enormous changes in the composition of the diet. Fat consumption has risen from 20% of energy intake in 1950 up to 50% in recent years. Simultaneously, the consumption of food of plant origin has dropped to one half. The diet of our ancestors contained 5-10 times as much fiber, n-3 fatty acids, antioxidants, vitamins and other nutritionally valuable substances, whereas there was 3 times as much proteins as in modern food. On the other hand, the contemporary diet contains 4 times as much saturated fat and twice as much monosaturated fat as our ancestors used to consume [4].

Finally, the general fat intake rose due to the boom of n-6 fatty acids, including precursors of prostaglandins and leukotriens, whereas the fraction of n-3 fatty acids dropped. The changed n-6: n-3 ratio results in diseases based on atherosclerosis, e.g. myocardial infarction or stroke [5,6]. Changes in proportion of dietary fatty acids in relation to mortality on cardiovascular and cerebrovascular diseases are demonstrated in Table 2.

Although a number of people think that the vegetarian manner of feeding is healthier than meat-based, the general problem is much more complicated. Recently, the long-term influence of the different feeding habits on morbidity was exemplified on two African tribes, pastoralists-hunters and farmers (Table 3). Apart from the composition of the nutrition, the absolute volumes of its parts are also important. Proteins and fibers are especially essential components of nutrition.

<table>
<thead>
<tr>
<th>Population</th>
<th>Prevailing nutrition</th>
<th>n-6 : n-3</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunters-gatherers (paleolithic)</td>
<td>molluscs, fish</td>
<td>2 : 1</td>
<td>?</td>
</tr>
<tr>
<td>Fishermen-hunters (Greenland)</td>
<td>fish, game</td>
<td>1 : 1</td>
<td>7</td>
</tr>
<tr>
<td>Fishermen, farmers (Japan, Portugal)</td>
<td>fish, plants</td>
<td>10 : 1</td>
<td>12</td>
</tr>
<tr>
<td>Modern (Europe, North America, Japan)</td>
<td>industrialized food</td>
<td>50 : 1</td>
<td>45</td>
</tr>
</tbody>
</table>

Table 2: Mortality on cardiovascular and cerebrovascular diseases related to prevailing nutrition in different populations. Role of nutritional fatty acids.
very important tissue throughout all human life. Humoral immunity. All things considered, GALT is a strategically
mumomodulative effect of nutrition is aimed more on antitu-
tled, e.g. overshoot activity such as allergies. In adults, the im-
is also a time when inadequate reactions could be easily set-
natal development of the immune system, however, childhood

is the body contents of cells (Table 4) [8,9]. The microflora is
metabolically and digestive active, produces a lot of substances
(to name at least one of them, the vitamin K produced by in-
testinal bacteria) and forms the microenvironment of the GIT,
inhibiting the propagation of pathogens and supporting the
regeneration of the intestinal epithelium.

The GIT microflora is a balanced array of bacterial spe-
cies. The intestine harbors 10 times the amount of bacteria as
is the body contents of cells (Table 4) [8,9]. The microflora is

<table>
<thead>
<tr>
<th>Population</th>
<th>Energy intake (kJ/day)</th>
<th>Saccharides (g/day)</th>
<th>Fat (g/day)</th>
<th>Proteins (g/day)</th>
<th>Caries (%)</th>
<th>Bone deformations (%)</th>
<th>Airway diseases (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Masai pastoralists&quot;</td>
<td>12 500</td>
<td>390</td>
<td>160</td>
<td>300</td>
<td>8</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Kikuyu farmers</td>
<td>8 800</td>
<td>100</td>
<td>20</td>
<td>100</td>
<td>35</td>
<td>53</td>
<td>28</td>
</tr>
</tbody>
</table>

Table 3: Feeding habits in relation to morbidity, studied in two African tribes, the pastoralists-hunters and farmers, in the first half of the last century [7].

GIT microenvironment

The gastrointestinal tract is the second largest internal
surface of the human body, covering a total area of 300 - 400
m². It represents the place where nutrients are absorbed and
utilized by both the body and by GIT microflora, whereas poten-
tially dangerous components of the food, such as toxins and pathogens, are eliminated together with dead cells. The
turnover of mucosal cells is roughly 8.10¹⁰ of cells in every 3 - 4
days. This material, approximately 0.33 kg daily, is degraded by
microbes and reutilized.

The GIT microflora is a balanced array of bacterial spe-
cies. The intestine harbors 10 times the amount of bacteria as
is the body contents of cells (Table 4) [8,9]. The microflora is

<table>
<thead>
<tr>
<th>GIT (mainly mouth and large intestine)</th>
<th>1000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>200 g</td>
</tr>
<tr>
<td>Lungs</td>
<td>20 g</td>
</tr>
<tr>
<td>Vagina</td>
<td>20 g</td>
</tr>
<tr>
<td>Airways (nose)</td>
<td>10 g</td>
</tr>
<tr>
<td>Eyes</td>
<td>1 g</td>
</tr>
</tbody>
</table>

Table 4: Presence of bacteria in the human body

Connection to the immune system

Besides the GIT microflora, the microbial contamination
of the food and its antigen load is one of the strongest cues
to the immune system. Antigens that escaped digestion stimu-
late a defense response in the intestinal walls. Therefore, the
GIT-associated lymphoid tissue (GALT) developed in a highly
effective immune tissue forming the largest immune organ of
an endothermic vertebrate body. In humans, about 80% of the
total immunoglobulin producing cells of the body are located
in lamina propria of the GIT [10].

Nutritional antigen stimulation is crucial for the post-
natal development of the immune system, however, childhood
is also a time when inadequate reactions could be easily set-
tled, e.g. overshoot activity such as allergies. In adults, the
immunomodulative effect of nutrition is aimed more on antitu-
mor immunity. All things considered, GALT is a strategically
very important tissue throughout all human life.

In the past, paleolithic food was heavily contaminated
and naturally fermented by microbes. Our ancestors ingested
a million times more microorganisms beneficial for health as
people living today [11,12]. Over the paleolithic transition
from vegetarian to omnivorous feeding habit, the GIT micro-
flora changed. Furthermore, nowadays it is strongly inhibited
by chemicals present in the food and by antibiotics.

In addition to their suppressive effect on GIT micro-
flora, these substances also suppress the immune system and
some of them are even toxic. Trying to avoid preservatives
and artificial flavorings when buying goods is not up to the
mark, and the majority of people do not have such a choice.
Therefore, more pressure should be put on the food industry
to decrease the usage of chemical additives. A complementary
task is to enrich food with essential compounds beneficial for
health.

Fortification of nutrition and nutritional supple-
ments

Fortification of nutrition is an addition of essential nu-
trients to the food that contains them naturally, but originally
in smaller amounts. For example, the concentration of vitamin
E has been leveled up in cooking oil. To supplement the food,
means to add the micronutrients such as vitamins in pharma-
ceutical preparations, usually in situations of augmented needs
that could not be satisfied by a common food. Nutritional ad-
ditives and supplements support the immune system and pro-
tect it from impairment caused by chemicals.

For example, fortification of the diet with soluble fibers
promotes a production of mucus in the gastrointestinal tract.
Mucus, covering the luminal walls, supports the regeneration
of enterocytes and represents a barrier to pathogens, inhibiting
their adhesion and penetrance. Moreover, fibers, causing a
volumetric swelling of intestinal content, accelerate its passage
and inhibit the effect of toxins, both by lowering the time of
exposure and by trapping them chemically. Therefore, besides
other beneficial effects, the fibers are one of the most potent
protectors to colorectal cancer. It is important to note, how-
ever, that the subject of fibers and colorectal cancer is still not
fully understood and some doubts remain. Readers seeking
more details should read a comprehensive review [13.]. Some
ecoimmunonutrients used in fortification and supplementa-
tion of food, are listed in Table 5.

Furthermore, the combination of ecoimmunonutrients
brings better results than if they are used separately. For ex-
ample, soluble fibers taken together with membrane lipids have
excellent gastroprotective effects.
Nutrient                                  Effect                                    Consequences

Prebiotics – soluble fibers
Polysaccharides
(pectin and oat gum containing β-glucans)
Fructooligosaccharides
(inulin, phein)
Glucomannan, algal fibers

Modulation of absorption of nutrients
Antioxidative effect
Promotion of mucus secretion
Support to GIT microflora, especially for
bifidobacteria
Source for bacterial fermentation and
synthesis of vitamins (members of group B,
folic acid, nicotinic acid)

Protective effect in GIT
Stimulation of regeneration of enterocytes
Therapy of ulcerosis, diabetes, hypercholes-
terolemia and hypertension
Prevention of colorectal cancer

n-3 fatty acids
essential nutrients such as
linolenic acid, EPA, DHA

Downregulation of acute inflammatory
response
Modulation of immune signal network

Therapy of IS disorders
Protective effect on cardiovascular system,
Prevention of tumours
Preoperative care

Membrane lipids
(phospholipids, gangliosides, galactolipids,
phosphatidylycholine)

Prevention of inflammation in GIT Inhibi-
tion of bacterial translocation
Positive effect on cellular immunity

Prevention and therapy of ulcerosis, toxic
and inflammatory liver impairment, sepsis

Polyamines, Amino acids
arginine, glutamine, taurine

Protein synthesis enhancement
Urate metabolism modulation

Wound healing
Support of thymic functions

Nucleotids
Cell proliferation support
Immune signal induction

Regeneration and growth of all tissues, IS,
hematopoiesis

Antioxidants
Zn, Se
vitamins A, B, C, E
lycopene, lutein

Inhibition of reactive oxigen species
Stimulation of B-cell and T-cell linked im-
munity and cytotoxicity

Support of thymic functions
Role in ill health, elderly and starvation

Table 5: Ecoimmunonutrients and their effects.

Conclusion
A worldwide rise of bacterial strains resistant to antibi-
otics directs the WHO to demand a cutback of drug consump-
tion and the development of new therapeutic strategies.

Moreover, regarding human life prolongation, patient
care extends into the elderly population and becomes more and
more expensive. On the other hand, an age connected deterio-
ration of immune system functions, caused by a physiological
involvement of thymus and by a cummulative effect of exposi-
tion to antigens during life, could be partially compensated by
the specially designed diet.

The enhancement of health to the population by eco-
immunonutrition is cheaper in comparison to pharmaceutical
industry, and fits more to the metabolic demands of human
body. Ecoimmunonutrition respects the feeding habits settled
through ages of human evolution and help us to sustain the
recent change of life conditions, including a different pattern of
contagious pathogens.

Given the proven beneficial effect of nutrition on im-
munity, nutrition starts to play an important role in prevention
and therapy not just of metabolic diseases, but also of the con-
tagious ones, especially in the Third World. In western coun-
tries, the key role of nutrition in therapy of the most widespread
death causing diseases, i.e. metabolically based cardiovascular
and cerebrovascular ones, is already well known.

Acknowledgements
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