

14th
INTERNATIONAL
SYMPOSIUM

MODERN
TRENDS
IN LIVESTOCK
PRODUCTION



4 - 6 October 2023, Belgrade, Serbia

Institute for Animal Husbandry
Belgrade - Zemun, SERBIA

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INTERNATIONAL
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**MODERN
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2023
PROCEEDINGS

The year '2023' is rendered in a large, light blue, sans-serif font. The '0's are particularly large and rounded. In the center of the '0's, there are two balls of blue yarn. To the right of the yarn, there are line-art icons of a pig, a sheep, and a cow, representing different types of livestock.

4 - 6 October 2023, Belgrade, Serbia

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Ministry of Science, Technological Development
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ORGANIZER

Institute for Animal Husbandry

Autoput 16, P. Box. 23,

11080, Belgrade-Zemun, Serbia

Tel: +381 11 2691 611; +381 11 2670 121; +381 11 2670 541;

Fax: + 381 11 2670 164;

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Zdenka Škrbić, PhD, Principal Research Fellow

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Address:

Institute for Animal Husbandry,
Autoput 16, P. Box 23,
11080, Belgrade-Zemun, Serbia

Tel:

+381 11 2691 611

+381 11 2670 121

+381 11 2670 541

Fax:

+381 11 2670 164



E-mail: biotechnology.izs@gmail.com

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SUSTAINABILITY OF A PLANT-BASED DIET

Vesna Gantner¹, Maja Gregić¹, Čedomir Radović²

¹ Faculty of Agrobiotechnical Sciences Osijek, Josip Juraj Strossmayer University of Osijek, Croatia

² Institute for Animal Husbandry, Belgrade - Zemun, Serbia

Corresponding author: Vesna Gantner, vgantner@fazos.hr

Invited paper

Abstract: Considering that recently there are more and more different options and dietary trends, vegetarianism is presented as a possible solution for quality nutrition with less impact on the environment, it is necessary to analyze how true such a premise really stands. A plant-based diet implies the consumption of foods that come from plants with some or no components of animal origin. This diet could have some positive effects on the human health of adults (lower risk of chronic diseases such as heart disease, type 2 diabetes, certain cancers, and obesity) but only well balanced and supplemented while in infants, children, and adolescents could cause severe deficiencies in vitamin 9 and vitamin 12 affecting the growth, cognition, social development, and expression of depression. From the point of environmental sustainability, further research is necessary to distinguish the accurate footprint of a plant-based diet as well as of animal production. Finally, it is up to each person to decide, hopefully, based on knowledge and responsibility, what kind of diet will follow. From the point of those engaged in animal production, it is up to us to ensure efficient and sustainable production of high-quality animal products, because the market is only growing.

Key words: plant-based diet, environmental impact, sustainability

The basics of living beings

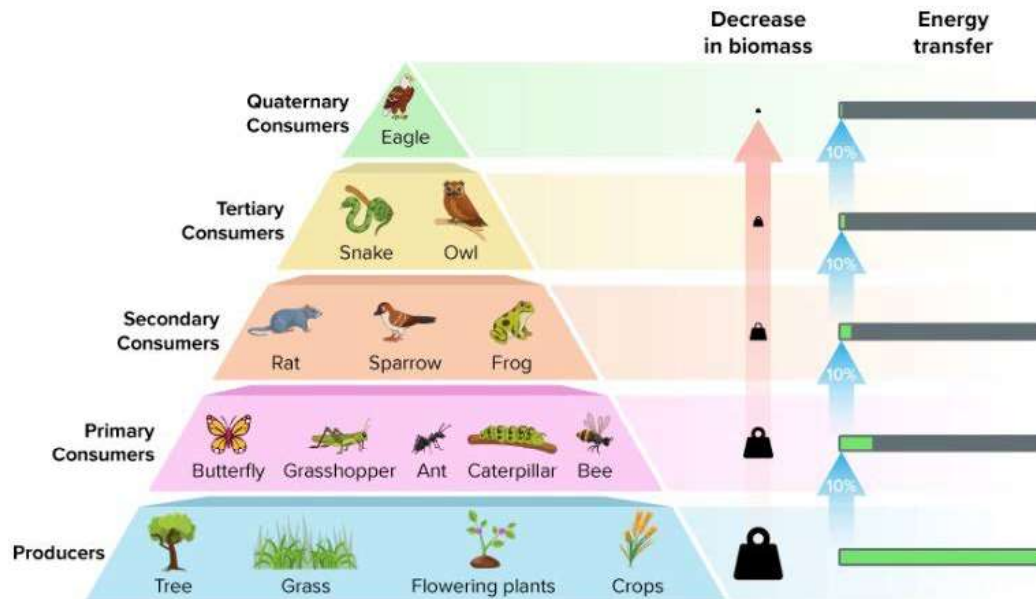
All living beings have several basic characteristics: cellular organization (all living beings are composed of one or more cells), genetic material (all living beings have genetic material, DNA or RNA), homeostasis (all living beings maintain a stable inner conditions despite changes in the environment), growth and development (all living beings increase in size and complexness), reproduction (all living beings reproduce, sexually or asexually depending on species and environmental conditions), adaptation (all living beings can adapt and evolve

accordingly to the environmental conditions), response to stimulants (all living beings can detect and respond to various environmental factors: light, sound, temperature, etc.), and metabolism (all living beings metabolize, that is they utilize necessary energy from their environment). All living organisms need energy implying that all living beings need to eat.

Furthermore, accordingly, to the source of energy they use, all living beings can be classified into distinct categories: autotrophs (organisms that can produce their food and energy using inorganic substances); photoautotrophs (primary source of energy is sunlight, photosynthesis), chemoautotrophs (obtain energy by oxidizing inorganic sulfur or iron compounds), heterotrophs (organisms that obtain energy by consuming other organisms or organic matter); herbivores (consume plant material as their source of energy), carnivores (consume other animals), omnivores (have a mixed diet and consume both plant and animal materials), decomposers (obtain their energy through decomposition of dead organic materials, crucial for the nutrients recycling).

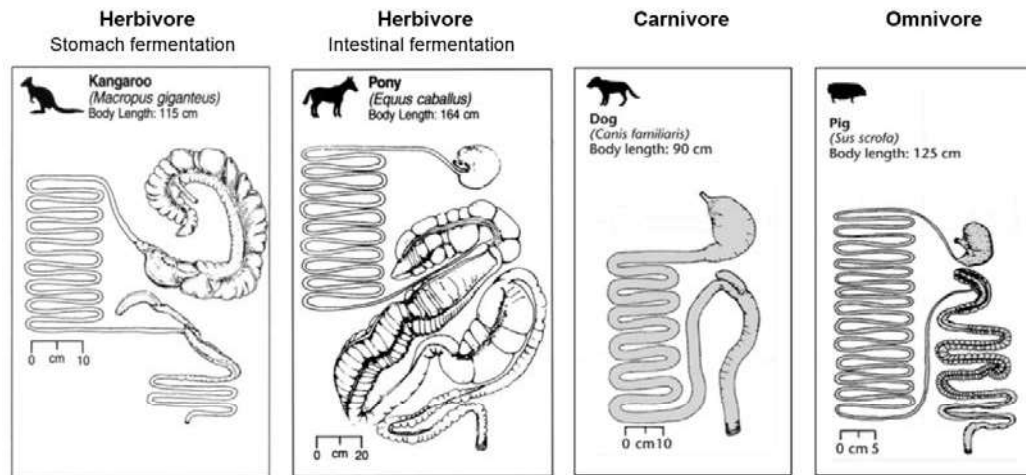
Furthermore, accordingly, to the source of energy they use, living beings in an ecosystem are classified to their trophic level that defines their place in the food chain. Each trophic level represents a different level of energy transfer within an ecosystem. Accordingly to trophic levels living beings are: producers (the first trophic level, primary producers, autotrophs: mainly plants and some algae), primary consumers/herbivores (the second trophic level, organisms that consume the primary producers (plants) as their source of energy, they extract energy from plants, secondary consumers/carnivores (the third trophic level, organisms that primarily consume other animals as their source of energy), tertiary consumers (the fourth trophic level, carnivores that feed on other carnivores). In all ecosystems, energy is transferred and transformed through the trophic levels. Each level extracts energy from the level below it, while some energy loses as heat. Therefore, the total biomass and number of individuals decrease as the trophic level increase (Picture 1).

Omnivores represent organisms that have a mixed diet and consume food of both plant and animal origin. The term "omnivore" comes from the Latin words *omnis* (all) and *vorare* (to consume), implying their ability to eat diverse types of food. The flexibility in food selections allows omnivores to adapt to diverse environments and use available food resources. In various ecosystems, omnivores play significant ecological roles. For instance, omnivores can contribute to the dispersal of plant seeds through fruit consumption, while controlling the overpopulation of smaller animals. Omnivores can be mammals, birds, reptiles, insects, and of course humans. Commonly, the human diet includes fruits, vegetables, grains, nuts, seeds, and animal-based products such as dairy, meat, eggs, and fish.



Picture 1. Variation in biomass and energy transfer regarding the trophic level (Ansari, 2023)

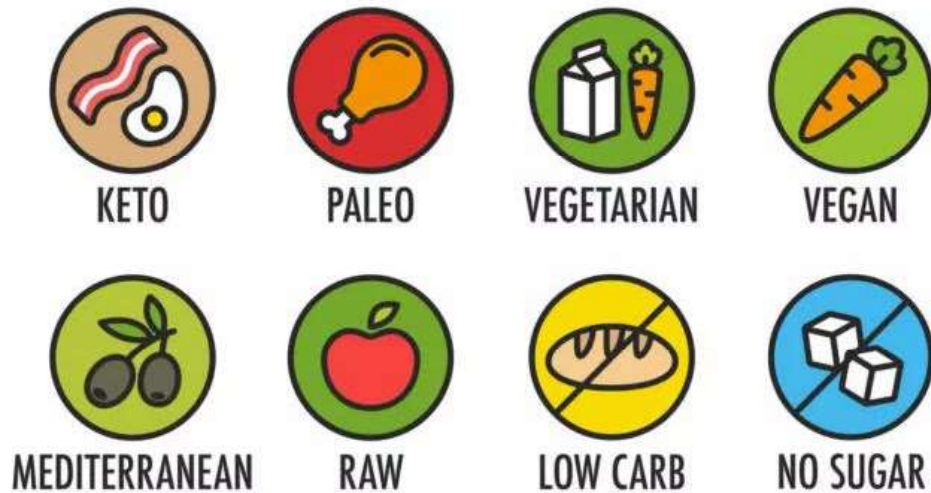
The structure of the digestive systems of heterotrophs varies significantly depending on their specific dietary habits and evolutionary adaptations (Picture 2). Herbivores have longer digestive tracts to facilitate the decomposition of plant material (longer tracts allow for more time and space for microbial activities and the breakdown of cellulose) and could have specialized compartments, some herbivores, like ruminants, have specialized pre-stomachs (microbial fermentation occurs before further digestion), and efficient nutrients extraction (due to large cecum or pre-stomachs). Carnivores have shorter digestive tracts compared to herbivores because animal tissues are normally easier to digest and need less processing, have high acidity of stomachs (for the decomposition of proteins and neutralization of potentially harmful bacteria), and reduced or absent cecum (in cecum primarily occur the fermentation of plant material). Omnivores have a combination of digestive adaptations from herbivores and carnivores. They have a moderate-length digestive tract, a lower acidity of the stomach compared to carnivores, and a shorter cecum compared to herbivores.



Picture 2. Differences in digestive system between herbivores, carnivores and omnivores
(Kiezebrink, 2022)

Human diet

The human diet can vary depending on cultural, regional, and individual choices. A balanced and healthful human diet is supposed to include the following components: carbohydrates (as an energy source; grains, starchy vegetables, legumes, and fruits), proteins (essential for growth and maintenance of body tissues; meats, eggs, dairy products, legumes, and plant-based proteins (tofu and tempeh)), fruits and vegetables (as a source of vitamins, minerals, and dietary fiber), healthy fats (source of energy, help absorb fat-soluble vitamins, and sustain overall health), whole grains (source of fiber, vitamins, and minerals; wheat, brown rice, quinoa, and oats), dairy (source of calcium, protein, and different essential nutrients; milk, cheese, yogurt, etc.), hydration (enough water). It is crucial to have a balanced diet that provides all the required nutrients, vitamins, and minerals for ensuring optimal condition and health.

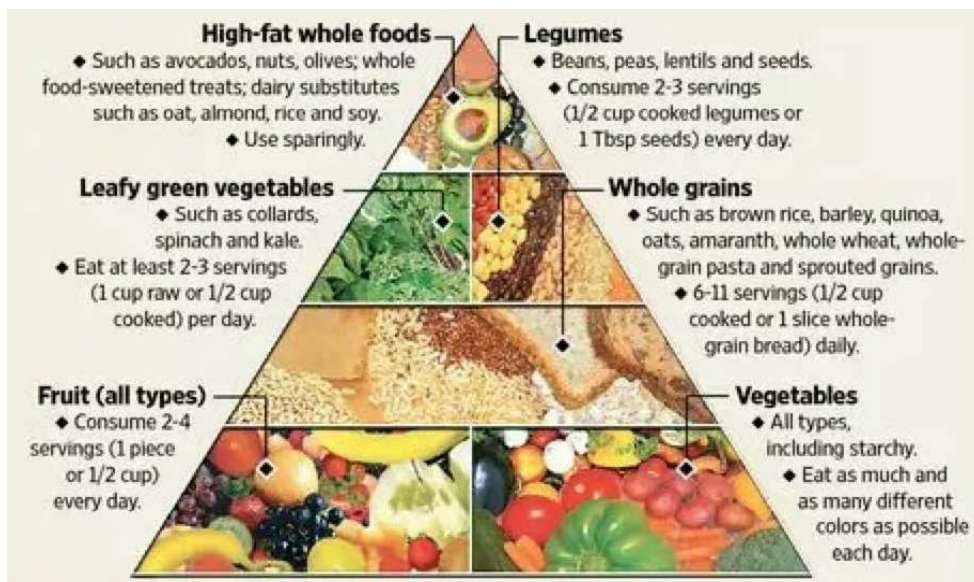


Picture 3. Different types of human diet (Karlsen, 2015)

There are various types of human diets that somebody could select for different causes: health, religion, ethical relations, or weight maintenance. Some of the frequently described and most fashionable types of human diets are Mediterranean, Vegetarian, Vegan, Paleo, Gluten-Free, Keto, etc... Mediterranean diet emphasizes fruits, vegetables, whole grains, legumes, nuts, seeds, olive oil, and moderate consumption of fish, poultry, and dairy products. A vegetarian diet (Klemm, 2021) excludes meat, poultry, and seafood but may include eggs and dairy products; lacto-ovo-vegetarian (includes plant-based foods, dairy products, and eggs); lacto-vegetarian (includes plant-based foods and dairy products, excludes eggs), ovo-vegetarian (includes plant-based foods and eggs, excludes dairy products). A vegan diet excludes all animal products and focuses on plant-based foods (fruits, vegetables, legumes, whole grains, nuts, and seeds). A pescatarian diet include fish and/or shellfish, while semi-vegetarians (or flexitarians) include some meat, seafood, poultry, eggs and dairy. A paleo diet or the caveman diet is based on consuming lean meats, fish, fruits, vegetables, nuts, and seeds while excluding grains, legumes, dairy products, processed foods, and refined sugars). A gluten-free diet eliminates foods containing gluten, a protein found in wheat, barley, rye, and their derivatives. A ketogenic diet represents a high-fat, and low-carbohydrate diet based on various meats, fish, eggs, avocados, nuts, seeds, and healthy oils, and excluding or restricting grains, sugar, fruits, starchy vegetables, and legumes.

Plant-based diet

A plant-based diet focuses on foods that come from plants (including vegetables, whole grains, legumes, nuts, seeds, and fruits) with some or no components of animal origin (BDA, 2023). As already defined, there are several types of vegetarians, but all of them primarily consume plant-based foods. There are a variety of reasons why to switch to meat-free (Klemm, 2021): personal preference, health considerations, ethical reasons (they do not want animals killed or harmed), environmental concerns (based on the premise that animal production has a high environmental impact), religious beliefs (Hindus, Buddhists, etc. ...).



Picture 4. A food pyramid in a plant-based diet (Plant-Based, 2023)

Many people switch to some kind of plant-based diet due to the expectation of potential health improvements. Accordingly to Klemm (2021), vegetarianism is related to health improvements through lower frequency obesity, reduced risk of heart disease, and lower blood pressure. Since plant-based diets commonly have lower calories level and a lower share of saturated fats in meals, with a higher share of dietary fiber and higher amounts of some vitamins and minerals comparable to a standard American diet, these diets could contribute to better health status. Accordingly to (BDA, 2023) plant-based diet is a way to improve health your health. This kind of diet could reduce the risk of diabetes type 2, hypertension, cardiovascular disease, and some cancers, and could result in

weight loss. Furthermore, in the case of excluding animal-based food from your diet, you need to pay attention to the possible deficit of some nutrients. You can easily satisfy *protein* needs by consuming protein-rich foods (lentils, beans, chickpeas, seeds, nuts, nut-butters, tofu, and tempeh). Meat substitutes (soya burgers and soya sausages, mycoprotein, and seitan) are high-quality protein sources but often could have a high content of salt and fat. Furthermore, long-chain *omega-3 polyunsaturated fatty acids* are substantial for human health and the richest source is oily fish (pilchards, salmon, and mackerel). In the case of excluding fish from the diet, the body can transform the essential fats from walnuts, flaxseeds, chia seeds, and hemp seeds into long-chain omega-3 fatty acids. *Vitamin B12* (present in eggs and dairy foods) represents one of the important segments of a balanced diet, so if you have a lack of B12, you could suffer fatigue, anemia, and nerve damage, as well as the risk of cardiovascular disease could increase. If you are vegan, the only reliable sources of vitamin B12 are fortified foods and supplements. Also, *Vitamin D* and *Calcium* are crucial for sustaining bone health. Dairy foods are rich in calcium, but if you are not consuming dairy you have to include fortified plant-based alternatives (figs, nuts such as almonds, leafy green vegetables such as kale, red kidney beans, sesame seeds, tempeh, and calcium-set tofu). *Iron* represents one of the most important minerals for human health, and the lack of Fe induces anemia and consequently poor general health. Animal-based products are rich in iron while in a plant-based diet, iron could be found in dried fruits, whole grains, nuts, green leafy vegetables, seeds, peas, beans, and lentils. Since the form of iron in plant foods have lower absorption efficiency it is supposed to be consumed with food rich in vitamin C (citrus fruits, strawberries, berries, green leafy vegetables, and peppers). Another important mineral that is necessary for the growth and development and the immune system is *Zinc* (which could be found in high amounts in eggs and milk). Adequate substitutes for animal-based products are wheat germ, beans, nuts, seeds, mushrooms, and some fortified breakfast cereals but the absorption efficiency is lower in comparison to animal-based products. *Iodine* is crucial for the functioning of the thyroid gland. The major sources of iodine in the human diet are dairy products and seafood, so in the case of a plant-based diet, you may experience the risk of deficiency. So, depending on the type of vegetarian diet, there is a possibility of a lack of the following micronutrients: vitamin B1, vitamin B6, vitamin B12, vitamin D, calcium, iodine, iron, omega-3, omega-6, and zinc. Therefore, as with any other diet, and in a plant-based diet, to ensure an adequate state of health and condition of the organism, it is necessary to know the characteristics of the food and the needs of the organism to ensure proper balance.

Although many sources suggest that plant-based diet does not represent a harmful choice for the human organism, certain studies indicate serious

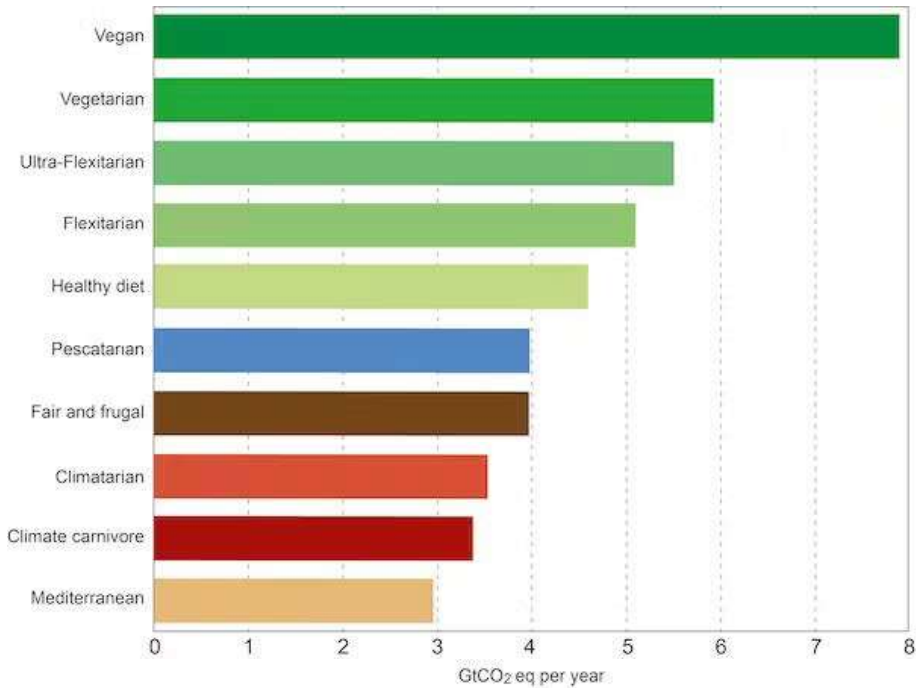
disadvantages and consequences of insufficient consumption of animal-based food. For instance, studies conducted in Guatemala on mothers and newborns (*Casterline et al., 1997*), as well as on school-age children (*Rogers et al., 2003*) documented a high deficiency of vitamin B12 concentrations as a consequence of inadequate dietary intake that is low or no consumption of animal-source foods. Severe deficiencies in folate (vitamin B9) and cobalamin (vitamin B12) have a significant negative effect on brain development during infancy, as well as on depression prevalence in adulthood (*Black, 2008*). Furthermore, *Black (2008)* emphasized that adequate folate intake during pregnancy reduces the risk of a neural tube defect (NTD) in infants while severe cobalamin deficiency has negative effect on behavioral and psychoeducational functioning of adolescences. The deficiencies in folate and cobalamin are mainly correlated to malabsorption or a vegetarian diet. *Black (2008)* concluded that vitamin B12 deficiency affects infant growth, cognition, social development, and symptoms of depression, therefore, it is extremely important to develop strategies to prevent deficiency of B12, especially in developing countries where nutrition is not a matter of choice but of lack of sufficient amount of food.

Environmental impact

A plant-based diet is often considered a more sustainable dietary choice due to its potential positive environmental impacts: reduced greenhouse gas emissions (plant-based diets generally have a lower carbon footprint since plant production needs fewer resources (land, water, and energy) than animal production), resources conservation (since fewer resources are required than in animal production, natural resources, ecosystems, and biodiversity could be preserved in greater extent), deforestation decrease (plant-based production requires less agricultural land contributing to the forest protection), water conservation (animal production requires substantial amounts of water for animal drinking, feed crops, and cleaning, while plant production is less water demanding), mitigation of pollution (animal production contributes to water and air pollution while plant-based diets can help mitigate pollution by lowering the environmental impact from animal production).

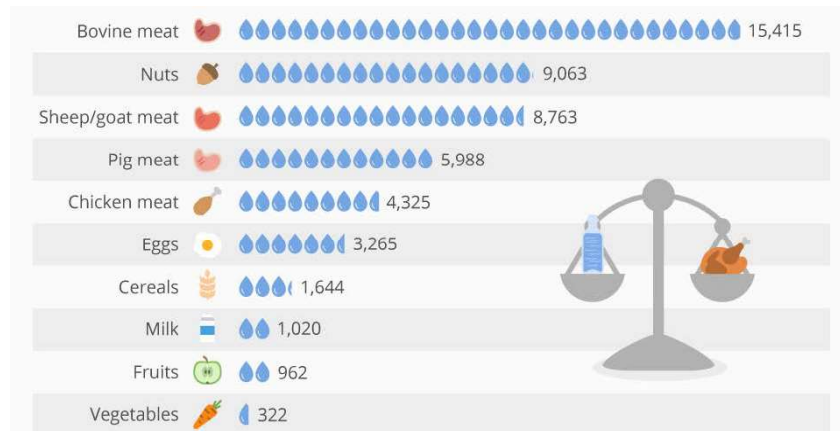
Maslin (2022) stated that the food we consume has a huge effect on our environment, therefore changing what we eat can help decrease carbon emissions and enable sustainable agriculture. Furthermore, the same author implies the necessity for a new diet, the climatarian diet (a diet that is healthy, climate-friendly, and nature friendly). As it is shown in Picture 5., a standard meat-based diet delivers about 7.2 kilograms of CO₂ equivalent per day, while a vegetarian diet

delivers 3.8 kg and a vegan diet 2.9 kg. So, in case the whole world shifted to vegan, it would result in 8 billion tonnes of CO₂e (60% of all food emissions from the current 13.7 billion tonnes of CO₂e a year).



Picture 5. How much CO₂e (in billions of tonnes, or Gt) would be saved if the whole world switched to each of these diets (Maslin, 2022; IPCC, 2023)

Furthermore, Maslin (2022) stated that if we want to preserve our planet we also have to think about water and land usage. Beef production requires about 15,000 liters of water per kg, while avocados and almonds also have a huge water footprint. Overall a plant-based diet requires about half the water consumption compared to a standard meat-based diet (Picture 6).



Picture 6. How thirsty is our food? Liters of water required to produce one kg of the food product (IO, 2019)

Is a plant-based diet really better for the environment?

Plant-based diets mainly rely on the soybean products (like tofu and tempeh) that are mainly growth in Brazil and India where it significantly contributes to overall deforestation and loss of habitats (Trauger, 2022). Accordingly to a new investigation (Jordan et al., 2022), more than 400 sq miles (1,000 sq km) of Amazon rainforest have been cleared out to expand soya-growing farms in the Brazilian state of Mato Grosso in 10 years.



Picture 7. Deforestation in Nova Xavantina, Mato Grosso state, Brazil (Photograph: Amanda Perobelli/Reuters)

Furthermore, accordingly to *Trauger (2022)* palm oil as one of the main components of plant-based diet is mostly produced and imported from Indonesia, Malaysia, Thailand, and Nigeria where local ecosystems there have been destroyed by deforestation and biodiversity loss since millions of hectares of forests are razed for palm oil production. Besides the environmental impact, the palm oil industry has been the subject of numerous allegations of human rights violations (child labor, rampant sexual abuse and rape, exposure to dangerous pesticides, etc.). Furthermore, *Sabajo et al. (2017)* stated that the expansion of oil palm and other cash crops causes an increase in the land surface temperature in the Jambi province in Indonesia. Similarly, *Wright et al. (2019)* reported that the world's demand for palm oil is driving deforestation in Indonesia.



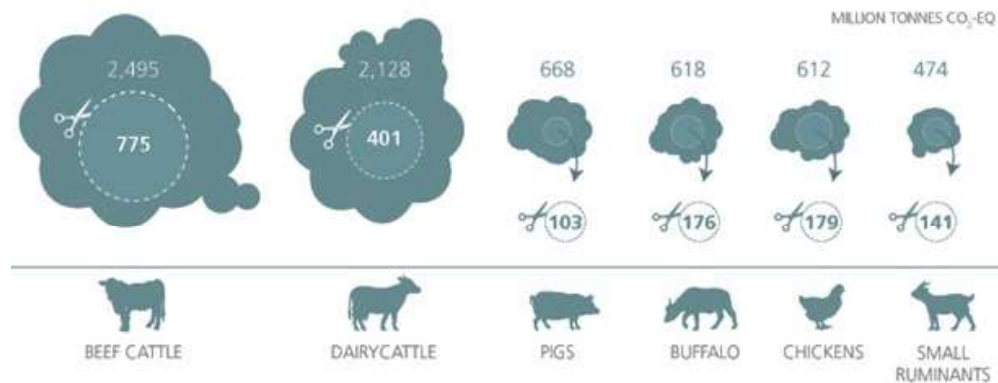
Picture 8. Deforestation in Borneo (*Future Environment Defenders, 2023*)

Mitigation potential of the animal production sector

The animal production sector, within agriculture, has to some degree impact on the environment. The global animal production sector contributes to anthropogenic GHG emissions, but on the other hand, the animal production sector has high mitigation potential. The animal production sector with 7.1 gigatons of CO₂-eq/year (the year 2005) emits 14.5% of all anthropogenic emissions (49 gigatons CO₂-eq for the year 2004; *IPCC, 2007*). Analyzing the species, cattle

contribute to 65% of sector emissions, while small ruminants have much lower emission levels in the interval from 7-10% of sector emissions (0.47 gigatons CO₂-eq). The main origin of GHG emissions in the ruminants' production systems represents enteric fermentation and feed production. Furthermore, meat production systems contribute more to the sector's emissions than the milk production system. Also, the grazing system, compared to the mixed one, produce more GHG. Also, in ruminant production systems, there is a strong negative relationship between productivity and emission intensity that is emission intensity decreases with the increase in animal production.

The decline of the impact of the animal production sector on the environment that is the decrease in sectors emission could be achieved by reduction of production and consumption, lowering the emission intensity of production, and by the combination of mentioned above. Technical options for the mitigation of GHG emissions in animal production could be divided into the several categories: options related to feed supplements and feed/feeding management (for CH₄ only), options for manure management (dietary management, storage, handling and application phases of manure management), and animal husbandry options (animal and reproductive management practices and technologies). Also, practices and technologies that decrease the GHG emissions usually results in productivity increase, consequently contributing to food security and economic development (FAO, 2013a). By the application of different mitigation techniques could result in large environmental benefits with a mitigation potential of 14 to 41% depending on the selected species, production system, and world's region (Picture 6).



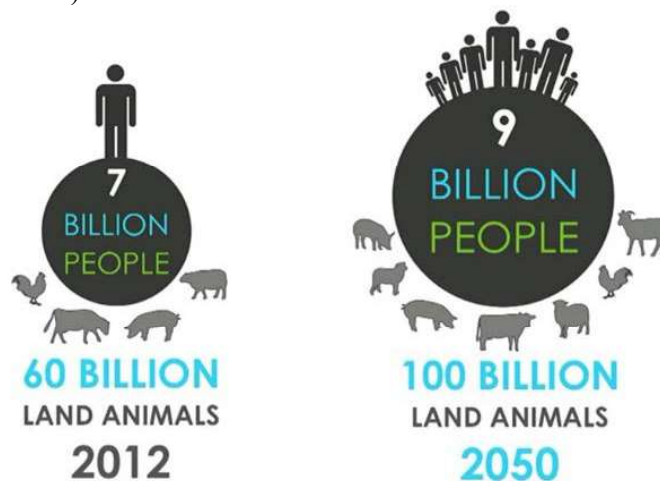
Picture 9. The potential for mitigation regarding the animal species (FAO, 2016)

Furthermore, it is very important to emphasize the role of domestic animals in soil preservation and improvement through nutrient cycling (animals consume

plant material and return nutrients to the soil through their manure that enrich the soil and enhance its fertility), soil aeration, and compaction prevention (grazing animals with their hooves create small channels in the soil, improving water infiltration and allowing air to reach plant roots), tillage and soil disturbance (chickens or pigs are scratching or rooting in the soil that improve soil structure, and promote better water infiltration and root penetration), weed and pest control, green manure and cover crops (these plants fix atmospheric nitrogen, enrich the soil with organic matter when incorporated, and provide erosion control and weed suppression).

The future of food production

It is unrealistic to expect that the human population will switch to the food of plant origin, especially in that part of the world population that, due to the expected increase in income, will finally be able to provide their families with food of animal origin. Accordingly to the forecasts, the world human population will increase to 9.6 billion by the year 2050 (*Census Bureau, 2016*) while in combination with expected rising incomes and urbanization, the demand for meat and milk will increase by 73 and 58% in the year 2050, comparing the levels in the year 2010 (*FAO, 2011*). The expected increase in the human population generates the need for significant increase in the number and productivity of domestic animals (Picture 10).



Picture 10. Expected increase of human and domestic animals' population (*FAO, 2011*)

Finally, some pros and cons of a plant-based diet could be emphasized. As pros following could be pointed out: health benefits (plant-based diets could be rich

in fiber, vitamins, minerals, and antioxidants with low levels of saturated fats and cholesterol resulting in lower risk of chronic diseases such as heart disease, type 2 diabetes, certain cancers, and obesity, environmental sustainability (plant-based diets have a lower environmental impact compared to diets rich in animal products; which showed to be questionable), and ethical concerns. Furthermore, the cons are as follows: nutritional concerns (lack of vitamin B12, iron, calcium, zinc, and omega-3 fatty acids and necessity for supplements), social and practical challenges, and probable higher costs of food.

Instead of a Conclusion

A plant-based diet implies the consumption of foods that come from plants (including vegetables, whole grains, legumes, nuts, seeds, and fruits) with some or no components of animal origin. This diet could have some positive effects on the human health of adults (lower risk of chronic diseases such as heart disease, type 2 diabetes, certain cancers, and obesity) but only well balanced and supplemented while in infants, children, and adolescents could cause severe deficiencies in vitamin 9 and vitamin 12 affecting the growth, cognition, social development, and expression of depression. From the point of environmental sustainability, further research is necessary to distinguish the accurate footprint of a plant-based diet as well as of animal production.

Finally, it is up to each person to decide, hopefully, responsibly and based on knowledge regarding the anatomical and physiological predispositions of the human population, the consequences of not consuming meat, and what constitutes a balanced meal for a certain age, what kind of diet will follow. From the point of view of those engaged in animal production, it is up to us to ensure efficient and sustainable production of high-quality animal products, because the market is only growing.

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