Protein – Population – Politics: How protein can be supplied sustainably in the 21st century

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Introduction

The satisfaction of hunger and thirst are basic human needs noted in the United Nations Declaration of Human Rights. At the time the declaration was written in 1948, the world population was about 2 billion people. Now there are more than six billion inhabitants, and in the foreseeable future it could easily rise to ten billion.

Hunger is much more than not feeling full. Hunger can also mean a deficit of protein and amino acids as well as other micronutrients, such as macroelements, trace elements and vitamins. These nutritional deficits may cause illnesses and diseases, preventing affected people and populations from performing at their best and adding to the medical bill. Hunger and undernourishment can be seen as the fundamental causes of a spiral of underdevelopment – not tapping physical and mental potential – dissatisfaction and development of local and international tension.

According to United Nations statistics, the WHO and FAO estimate that out of the current 6.5 billion people living on Earth, approximately 0.8 billion are not getting enough calories. Many more suffer from a lack of certain micronutrients, such as vitamin A, iodine and iron. Reducing by half the number of starving (and impoverished) people by 2015 is a primary goal formulated by the Food and Agriculture Organization. At the current rate of increase, the world population will grow to about 8.5 billion within the next 25 years (UN 2003).

In this context, the production of high-quality animal-based food takes on a special meaning, along with more efficient plant production, based on progress in plant breeding, cultivation, pest control, harvest, food preservation and storage.

There is no question that animal-based foods are not absolutely necessary for a carefully balanced diet. Predominantly vegetarian diets could already feed more than ten billion people. But it is easier to eat a balanced diet when animal protein is on the menu. This is due to the fact that in addition to high-quality protein and amino acids, milk, meat, fish and eggs contain essential macroelements and trace elements as well as vitamins. It is estimated that about 20 grams of edible animal-based protein daily would be sufficient for a complete human diet (Waterlow, 2001; Young, 2001). According to FAO estimates, livestock food products globally contributed 17% of energy and 33% of protein to dietary intakes in 2003, and it is predicted that the global average diet will reach the OECD average of 30% of energy and 50% of protein intake (Steinfeld et al., 2006).

At present, an estimated average of 30 grams per day is available per person on Earth, varying from six to 80 grams between countries and even more on an individual basis within countries. The differences in protein consumption are due to many factors, including purchasing power and social standing, but also preferences due to ethnic and religious tradition. In addition to physiological dietary aspects, foods from animal sources have a considerable enjoyment value. Rising incomes in developing countries lead to elevated demand and consumption of meat, fish, milk and eggs (Keyzer et al., 2005). Sufficient feed is the most important prerequisite for efficient animal production. Food producing animals consume about seven times more dry matter than humans all over the world (Table 1).

Table 1: Estimated dry matter (DM) consumption by humans and farm animals

Species	Number (billions) FAO Stat 2005	Consumption (DM)	
		(kg/day)	(billion t/year)
Humans	6.3	0.45	1.0
Cattle, buffaloes, horses, camels	1.6	10	5.8
Sheep, goats	1.8	1	0.6
Pigs	0.95	1	0.35
Poultry	17.4	0.7	0.45
Total (animals)			7.2

Production of edible protein of animal origin

The sizeable conversion losses in food production from animal sources are a main point of criticism. On the one hand, these losses contribute to considerable resource consumption (e.g., 3 - 5 kg grain to produce one kg pork), on the other hand to the excretion of nutrients that pollute the environment (Flachowsky and Lebzien, 2006; Verstegen and Tamminga, 2006).

As shown in Table 2, protein production via milk and eggs is more efficient and more environmentally friendly than via pork and beef. As the feed conversion into food improves, the excretion decreases with higher animal performance.

Lower plant yields and lower animal performance require more land to produce a certain amount of protein of animal origin. The land area needed per inhabitant and year is calculated in Table 3 under consideration of plant and animal performances, the ratio of protein from meat and milk, and the level of consumption of protein of animal origin.

In addition to the traditional competition of land use between production of vegetarian food for human consumption and feed production for animal production, land area is increasingly being used for bioenergy/fuel production in response to the challenge of global warming (Keyzer et al., 2005). Possible strategies to overcome this situation include:

- Continued investments to increase plant yield and animal performance by traditional and innovative biotechnology.
- Improved efficiency of utilizing limited resources (land, water, fertilizer etc.).
- Lower consumption of animal protein by people with current overconsumption

About two thirds of the world's ruminants are kept in tropical and subtropical regions, but these animals account for only about one third of the ruminant protein intended for human consumption. The lion's share of the world's meat supply is produced by a much smaller number of animals in the world's temperate zones. Improvements in efficiency including optimal feeding of animals (e.g. to meet their requirements in energy and protein/amino acids) must be recognized as a top priority for farmers and researchers.

Table 2: Production of edible protein of animal origin and corresponding N excretion from different animal species with various performance at recommended N supply (Flachowsky, 2002)

Protein source (average body weight)	Production per day	Edible fraction %	Protein content in the edible fraction (g per kg fresh substance)	Estimated food competition to humans (% of feed)[3]	Edible protein g per day	Edible protein g per kg body weight	N-excretion edible protein	N-excretion kg per kg of intake
Milk Cow	10 kg	95	34	0	323	0.5	0.65	75
(650 kg bw)	20 kg			(20)	646	0.9	0.44	70
	40 kg			(40)	1292	2.0	0.24	65
Goat	2 kg	95	36	0	68	1.1	0.40	70
(60 kg bw)	5 kg		(30)	170	2.8	0.23	60	
Beef	500 g bwg[1]	50	190	0	48	0.12	2.5	90
(400 kg bw)	1000 g bwg			(20)	95	0.24	1.6	84
	1500 g bwg			(40)	143	0.36	1.2	80
Lamb	200 g bwg	50	200	0	20	0.5	1.5	85
(40 kg bw)	400 g bwg			(30)	40	1.0	1.0	80
Pork	500 g bwg	60	150	(30)	45	0.55	0.8	85
(80 kg bw)	700 g bwg			(50)	63	0.8	0.7	80
	900 g bwg			(60)	81	1.0	0.6	75
Poultry meat (1.5 kg bw)	40 g bwg	60	200	(40)	4.8	3.2	0.4	70
	60 g bwg			(70)	7.2	4.8	0.3	60
Eggs	50 % lp[2]	95	120	(35)	3.6	2.0	0.6	80
(1.8 kg bw)	70 % lp			(50)	5.1	2.8	0.35	65
	90 % lp			(65)	6.6	3.7	0.2	55

[1] Body weight gain [2] Laying performance [3] Depends on amount of roughage and by-products in the diets

Food security and food safety

Global food security means far more than providing enough food. The quality and safety of these products are equally important. Getting enough to eat in the immediate future is of primary concern for the starving, but even for these people at lowest end of the distribution food loaded with harmful substances cannot be an option, not to mention the fact that food-deficit countries would be excluded from international trade unless they meet the food quality and food safety standard of importing countries.

Table 3: Influence of the yield level of plants, the performance level of animals, the ratio of protein from meat and milk, and the level of consumption of protein of animal origin on land area needs (m² per capita)

Consumption (g protein/day)	10		20		40		60	
Yield level	A1)	B2)	A	B	A	B	A	B
Ratio between protein from meat[3] and milk (% of protein)								
70 : 30	260	105	520	210	1050	420	1560	630
50 : 50	225	95	450	190	900	380	1350	570
30 : 70	190	85	380	170	760	340	1140	510

1) Yield level A per hectare: 4 t DM of cereals, 10 t DM of forage; performance level A per day: 15 kg milk; live weight gain: beef cattle: 600 g; pigs: 400 g; poultry: 30 g
2) Yield level B per hectare: 8 t DM of cereals, 15 t DM of forage; performance level B per day: live weight gain: beef cattle: 1200 g; pigs: 800 g; poultry: 60 g
3) Ratio between protein from beef, pork and poultry (in %): ≈ 15 : 60 : 25

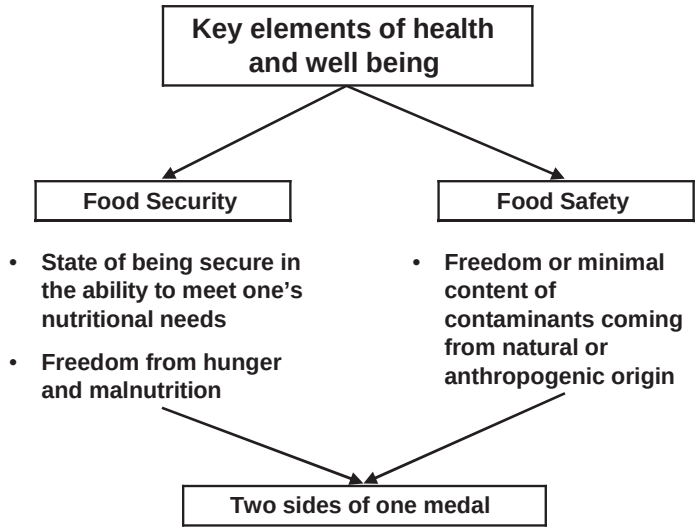


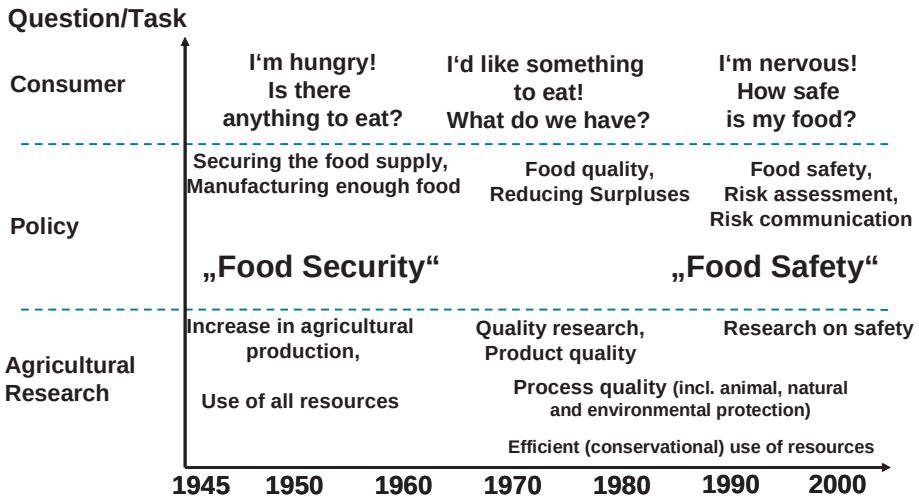
Figure 1:

Food security and food safety as elements of health and well being

Various consequences for politicians, agricultural producers and also scientists are illustrated in Figure 2. They include fair distribution of available food, increased food production in deficit regions (»helping them to help themselves«), application of current scientific knowledge and investment in research to secure food for a growing world population. Increasing demand for high quality animal-based protein should be taken into account as a reality.

Figure 2:

Main questions related to food as well as tasks for policy and agricultural research (Flachowsky, 2003)



The quantitative issue of food security and the qualitative issue of food safety are key elements of human health and well being, as shown in Figure 1 (from Flachowsky and Dänicke, 2005).

Protein – Population – Politics

The goals mentioned above can only be achieved through the efficient use of available resources such as water, fossil fuels, soil and raw materials such as phosphorus, a minimization of pollution in food production and effective conversion of available feed into animal-based food including new learning's in animal sciences (e.g., optimal feeding incl. feed additives). The many agricultural research disciplines, beginning with plant cultivation and including everything from genetic modification to agricultural economics, can and must make substantial contributions to ensure long-term, sustainable food security.

These and more were the topics of a large symposium held in Berlin entitled "Protein, Population, Politics". Scientists, farmers and politicians involved in aspects of global nutrition presented interesting papers on these themes.

Two well-known journalists, Dirk Maxeiner and Michael Miersch, moderated the Symposium, structured and illustrated the contributions und helped to put the scientific information into understandable language also for people outside the scientific community. The book, originally published in German, was recently translated into English to make it accessible for more readers (Wennemer et al., 2006). Main aspects of the 10 chapters are:

The 1st chapter deals with diet and evolution. The struggle for meat seems to be a driving force in the evolution of humankind. It required everyone to be cooperative within a group and ready to fight those on the outside.

Nearly all cultures favor animal protein over other foodstuffs and pursue meat at a cultural expense. A biological mechanism seems to be behind it all. Also today, meat is the determining part of the meal. For example, when choosing from a menu, most people will name the meat portion of the meal.

The 2nd chapter is entitled "The race between the stork and the plow" and deals with the question: How many people can the earth feed? Interesting figures characterize future developments concerning world population, food need and area per capita available in future. In 2050 only around 1750 m² of arable land will be available for every person. Much attention has been spent in this chapter to Norman Borlang and his success story with the green revolution (see also Hesser, 2006). Jaques Diouf, the General Secretary of the FAO stated in an interview about the second "green revolution": "There isn't any more land. We are exploiting the available production factors to a great extent. The environment is becoming more polluted. Increased production has to come from high-yielding farming". New technologies, including biotechnology cannot solve the problems of developing countries alone, but they can lay the essential groundwork for development.

The 3rd chapter deals with shepherds and rulers or how breeding animals changed the world. The animal species and their potential to improve the yields or to use feeds more efficiently are analyzed in this chapter. "Perestroika in the chicken coop" is the title of the 4th chapter. The human attitude towards animals is changing. More and more countries are experiencing an explosion in the public debate concerning animal welfare and animal husbandry.

The 5th chapter, written by Wolfgang Haber, deals with sustainable agriculture: "Accountable to people and the environment". Around 350 000 human generations got their food from hunting and gathering, taking a percentage of biomass that was produced naturally, without being manipulated by humans. But the basic diet became inadequate because of increased population and the humans recognized that they could use certain plant and animal species to their own ends by gardens and fields. Natural processes and systems could be transformed to increase the production of that part of the biomass that was desired as food. In Central Europe, only around 325 generations of farmers were needed to make this fundamental transformation. Humans and their needs are still increasing, which means they need increasing amounts of space and food. Ways for more efficient and sustainable production

of protein of animal origin are discussed. Supplementation of diets of non-ruminants with essential amino acids like lysine and/or methionine may substantially contribute to a more efficient conversion of feed into food of animal origin.

Chapter 6 deals with soybeans on the high seas. Feed, meat and even live animals have become international commodities. Pros and cons of shipping meat or feed are discussed. Chapter 7 is entitled "Competition vs. cooperation". Does feeding the world's livestock take food away from the poor? This is a difficult question, and various opinions are offered as tentative answers (e.g. Rifkin, 1992; FAO, 2002; Keyzer et al., 2005). Animal species, their level of production and amounts of roughage and by-products included in animal feed (see Table 2) influence the competition with humans.

Chapters 8 ("From fisherman to farmers of the sea") and 9 ("Meatless alternatives") are relatively short (6 and 3 p.) and deal with domesticating fish through aquaculture and alternatives in addition to widely used protein plants like soybeans. Exotic alternatives such as fungi, algae and insects add variety to the human protein palette. Fish farming will play an important role in satisfying the increasing protein demand. In 2020 more than 40 % of all fish on the market will be farmed (Delgado, 2000). Around 80% of the world's fish will be produced and consumed by developing nations. Today's fishermen will be tomorrow's farmers on the sea.

The last chapter (10) deals with the "Brave new swine". The desire for food of animal origin will continue to increase sharply in the coming decades. Much needs to be done to ensure a sustainable protein supply. More activities to improve plant yields and animal efficiency as well as to utilize local resources and by-products are necessary to produce safe food of animal origin (see Figure 1) with low demand of land (see Table 3) and low excretion of nitrogen (see Table 2), phosphorus, methane and other pollutions (see also v. Weizsäcker et al., 1997).

Finally an afterword on genuine dialogue is presented by the theologian Roger J. Bush. The author looks at modern livestock feeding and sustainable development from an ethical perspective. The main question is: how can the society find common ground on economic, ecological and social issues? The following ethically relevant areas and questions concerning animal feeds must be considered and answered by people working with animals:

- Animal ecology: Does behavioral research take into account describable, fundamental needs of the animals to be fed?
- Environmental ecology: What effects do feed systems have on the environment?
- The relationship between local and national, European and global "solutions" for using protein resources.
- Consideration of the rights of people to participate and to fulfill their potential in economically disadvantaged areas on Earth.

Altogether the authors of the book tried to find answers to the questions "Can the Earth feed everyone in the long term?"; or "Are we making efficient use of the Earth's natural resources?"; or "What role do animals play in all of this and how should they be treated?"

It is extremely difficult to find clear answers to such complex and difficult questions, but at least the book shows how feed production and feeding of animals can contribute to a more efficient production of protein of animal origin. Hopefully the book will not only be enjoyed by many readers, but also contribute to current public debate and give impulses to overcome deficits in worldwide human nutrition.

Some of the basic issues raised in this book are also discussed in a recent FAO publication, mainly from an environmental angle (Steinfeld et al., 2006). Clearly, environmental concerns will play an increasing role in animal production. Political decisions to use more land for bio-energy production contribute to the pressure to maximize the efficiency of feed conversion in animal production. Synthetic amino acids will play an important role in any plan to improve global human nutrition while minimizing the environmental impact of animal agriculture.

Summary

The production of edible protein of animal origin is the primary objective of livestock husbandry. The protein intake of people in developed countries is high (more than 50 g per capita daily from animal origin) and rising incomes in developing countries lead to elevated demand and consumption of meat, fish, milk and eggs.

On this basis, the following questions must be answered: “Can the Earth feed everyone in the long term?”, “Are we making efficient use of the Earth’s natural resources?”, “What role do animals play in all of this and how should they be treated?” Some answers are given in this paper.

In the first part, fundamentals are presented such as protein production of various animal species (depending on their performance), need for arable land per capita (depending on plant and animal yields), animal protein consumption per capita and the connection with food security and food safety.

In the second part, the book “Protein – Population – Politics” is reviewed in some detail. This book (10 chapters, 160 pages) was primarily written for people outside the scientific community and shows the responsibility of politicians, scientists and farmers for future developments to satisfy the physiological needs and wishes of humans under consideration of physiological, ecological, economical and ethical aspects. In some cases more questions are arisen than answers could be given. Future challenges for all those involved in animal production are shown.

Zusammenfassung

Protein – Population – Poltik: Wege zur nachhaltigen Eiweißversorgung im 21. Jahrhundert

Die Erzeugung von essbarem Eiweiß tierischer Herkunft ist eine der wichtigsten Aufgaben der Nutztierhaltung. Der Proteinverzehr der Menschen in den sog. entwickelten Ländern ist bereits hoch (> 50 g je Einwohner und Tag als Protein tierischer Herkunft). Mit zunehmendem Einkommen steigt aber auch in den Entwicklungsländern der Verzehr von Fleisch, Fisch, Milch und Eiern weiter an.

Auf der Grundlage dieser Entwicklung sind u.a. folgende Fragen zu beantworten: „Kann die Erde langfristig alle Menschen ernähren?“, „Werden auf der Erde die natürlichen Ressourcen effizient genutzt?“ oder „Welche Rolle spielen Nutztiere in diesem Zusammenhang und wie sind sie zukünftig zu betrachten?“.

Einige Antworten zu diesen komplizierten Fragen werden im Beitrag gegeben. Grundlagen sind im ersten Teil beschrieben, wie z.B. die Proteinerzeugung mit verschiedenen Tierarten und in Abhängigkeit von der Leistungshöhe; der Bedarf der Einwohner an Ackerfläche in Abhängigkeit von Pflanzenertrag und tierischer Leistung sowie dem Verzehr je Einwohner an tierischem Protein oder der enge Zusammenhang zwischen ausreichender Lebensmittelbereitstellung, deren Qualität und Sicherheit.

Der zweite Teil des Beitrages beschäftigt sich mit dem Inhalt des Buches „Protein – Population – Politik“ und beschreibt einige Aussagen der 10 Kapitel des Buches. Das Buch ist primär geschrieben für die allgemeine Öffentlichkeit, um Verständnis für die globale Herausforderung der „Welternährung“ zu wecken. Es zeigt die Verantwortung der Politiker, Wissenschaftler, Landwirte und all jener, die sich mit Ernährung für die zukünftige Befriedigung des ernährungsphysiologischen Bedarfs und der Wünsche der Menschen an Lebensmittel unter Berücksichtigung physiologischer, ökologischer, ökonomischer und ethischer Aspekte beschäftigen. Manchmal entstanden aus einer Frage mehr neue Fragen als Antworten gegeben werden konnten. Herausforderungen für alle Beteiligten werden aufgezeigt.

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