# **New Meat without Livestock**

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# ABSTRACT

This chapter summarizes the global problems associated with livestock production and meat consumption and shows solution strategies through replacing animal products with plant-based alternatives. The positive effects of plant-based alternatives on human health and the environment are reviewed together with approaches for reducing world hunger. Psychological strategies for nutritional transitions towards more sustainable consumption patterns and criteria for market success of meat alternatives are presented. This is followed by an overview of meat alternatives – from soy<sup>1</sup>, lupine or wheat based, to bleeding burgers and artificial intelligence concepts. Marketing strategies and best practice policy suggestions complete the chapter.

Keywords: Climate Change, Cultured Meat, In Vitro Meat, Meat Alternative Marketing, Soy Meat, Tempeh, Tofu, Textured Vegetable Protein (TVP), Quorn, Vegan, Vegetarian

## INTRODUCTION

Global mass production of livestock and the consumption of animal products are the major cause of a wide range of serious problems – environmental, health-related, concerning animal welfare and world nutrition. Environmentally, livestock production is a, or the, leading factor in land use, water consumption, pollution, rainforest destruction, climate change, loss of biodiversity and soil erosion (Steinfeld et al., 2006). The main reason for most of these problems is the inefficiency of livestock, where the largest share of the feed calories is used in the animals' metabolism and converted to excrements instead of food for human consumption. Such lengthened food chains, namely plant to animal to human, are heavily inefficient in resource use compared to short food chains, namely plant to human (see Figure 1). This inefficiency also explains why mass production of livestock is associated with world hunger (see later for more detail).

Most of the 65 billion animals (excluding sea creatures) produced annually for food consumption live in confined conditions raising severe concerns for their welfare. Although animal welfare is beyond the scope of this chapter, it is a major consideration for the wellbeing of all living beings on this planet. Intensive livestock production is a major risk factor for new global pandemics originating from industrial types of facilities as well as for antibiotic resistances while excessive consumption of meat, eggs and dairy is associated with lifestyle diseases, such as obesity, type 2 diabetes, cancer and heart disease (Schmidinger, 2012).

Given the convincing evidence about the negative impacts of animal-based dietary choices (Raphaely & Marinova, 2016), the question arises how to make consumers consume less of such food and whether a meat-free future is possible. This chapter explores plant-based alternatives to

meat and other animal products together with strategies to encourage their acceptability. It also outlines criteria for market success which can trigger positive responses from the consumers and beneficial outcomes.

Figure 1. Livestock's long food chain



Note: Lengthening the food chain by livestock production leads to a loss of a big share of calories from plants within the metabolism of the farmed animals, only a small share of the plant calories is converted to animal products, the major share is converted to excrements and lost for human nutrition.

# MAKING CONSUMERS EAT LESS ANIMAL PRODUCTS

Promoting plant-based food diets has a solid environmental and especially health case and is increasingly finding space in the EU countries. This is the case in the food guidelines of Sweden (Fischer et al., 2016), France (ANSES France, 2017), the UK Eatwell Guide (Public Health England, 2017) and Germany (DGE, 2017). Producing, distributing, selling and promoting meat is a seriously lucrative business, which relies heavily on the well-established forms of animal mass production at a minimum cost for the producer and especially on the ever-increasing consumption of meat and other foods of animal origin. The existing marketing and advertising efforts aim at bolstering further the intake of animal-based proteins (Bogueva and Phau, 2016). This is despite the clear evidence about the positive consequences, for both human health and the environment, of dietary changes toward healthier and more sustainable plant-based intake (Raphaely and Marinova, 2016; Bogueva et al., 2017; Springmann et al., 2016) and meat alternatives (Schmidinger, 2012). A major shift is clearly necessary.

In principle, a shift could be achieved with existing foods which do not contain animal products, but new plant-based innovations can assist such a transition and make it more realistic (Aiking and de Boer, 2006). As it stands, at the moment the consumption of new alternatives has a long way to cut across existing habits before achieving mass popularity globally. Within any given society, the majority of people tend to adhere to an average diet. In traditional societies, this diet uses more plant-based ingredients, but globalisation triggers widespread westernisation of consumer tastes and with it higher intake of animal products (Hossain, 2016). Furthermore, improvements in people's earning capacity in developing countries also result in preferences for animal-based food (Raphaely & Marinova, 2014). On the other hand, people are influenced by the food choices made by others – relatives, friends, peers, celebrities, as well as advertising, availability and accessibility of products.

# Stability/Energy Minimum Hypothesis

The *Stability/Energy Minimum Hypothesis* is a model derived from the theory of Balluch (2009). Adapted to nutritional aspects it shows the need for concerted actions instead of relying only on behaviour changes by billions of individuals.

The basic assumption of this hypothesis is that most individuals in a society try to live in a way that requires least effort or minimum energy. In Figure 2 this is represented by the trough, the area around the minimum of the curve. Applied to eating habits, this means that people tend to eat what is cheap, widely available, socially accepted and tastes well. In industrialised societies, this overwhelmingly involves animal-based products. Living as a vegan, an individual might be excluded from eating in certain restaurants. It may also cause stressful situations when attending business lunches or being invited for dinner or barbecue where vegan options are not served. Furthermore, it may cost more energy and longer shopping times to find the right foods. When abroad in a country with a foreign language, it will be harder to identify all ingredients of food products or dishes. It could be harder for vegetarian parents to find all-day school places offering a varied vegetarian menu for their children. Furthermore, for the children it might cost more energy to avoid becoming an outsider by not joining their friends in going to fast-food restaurants and eating non-vegetarian burgers.





Note: This graph shows how much energy an individual needs to keep up a certain diet. The political and economic system shape the curve. The trough (in red) is the minimum energy area. Outside the minimum, the individuals have to invest perpetual energy not to "roll back" into the trough, so their position is not stable.

Many individuals who originally were willing to change, tend to "save energy" and revert back to behaviour that makes their lives easier and matches that of the majority of the society to which they belong. In Figure 100, the red minimum represents the behaviour which requires the minimum energy associated with heavy use of animal-based foods in industrialised societies. The right side from the curve's minimum represents a more sustainable/ethical diet, while the left side is a less sustainable diet. Both require more individual energy than adhering to the

average diet of a western society. The problem of minimum energy arises from both sides of the curve. A vegan or vegetarian diet is an example from the more sustainable right hand-side of the curve. Eating dogs may be acceptable in some parts of the world (see Figure 3), but would require more energy in the West where such animals are considered pets and domestic companions. This is an example of a less ethical diet from the left hand-side of the curve.

Figure 3. Dog meat sold in the streets of Hanoi, Vietnam, March 2017



Living outside the trough around the minimum of the curve (see Figure 2) costs energy and requires more effort than following the nutritional mainstream. Such individuals need a lot of motivation and perseverance not to roll back and keep their position stable in the long term.

# Shifting to a More Sustainable Diet

In Figure 4, the trough of the curve is pushed to the right, towards a more sustainable form of eating within a society. A wider range of new and attractive plant-based foods offered in markets, supermarkets, shops, restaurants and canteens can help push the trough towards a more sustainable consumption if these new choices become easily available, cheaper and their marketing is successful. The reminder of the chapter presents ideas how to make possible and pleasant to eat more sustainably, which pushes the minimum energy trough to the right and with it the majority of individuals in a society towards a more sustainable nutrition.





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Figure 5 shows a further variation of this model taken from Schmidinger (2012). In it, communities within a society define their own, more sustainable "rules" of nutrition, and the process of adhering to these agreements leads to social acceptance and affirmation creating local troughs in the right part of the curve. Examples are the vegan movements in Europe or the US since 2012 - it has become trendy to live without animal products (e.g. Harvard Medical School, 2016). Being part of such movements and adhering to their vegan agreements form local troughs in the curve on the right of the status quo minimum.

Figure 5. Push to a more sustainable diet



Note: Local minimums might also attract groups of individuals to practise a more sustainable diet. The more popular such a diet becomes, the deeper and relatively more stable the local minimums are. An optimum final consequence might be that such a new local minimum becomes deeper than the original minumum, making people roll over from the old to the new (more sustainable) minimum trough as shown in Figure 4.

Let's use the example of the vegan movement and illustratively draw an optimistic picture for its future: The more like-minded people form such vegan groupings, the easier it is for each individual to stick to the lifestyle of the group. Figuratively, the more individuals such a social grouping consists of, the more "weight" will be exerted on the curve and the deeper such a local minimum will become. The markets will respond with new varieties of vegan products and food offers, labelling them as vegan. Politics will change due to the influence of vegan voters; the media will react, making the vegan lifestyle even more attractive, and the vegan energy minimum (the trough on the right of the curve) will become deeper and deeper. Such local minimums could eventually also lead to a shift of the energy minimum to the right as shown in Figure 4. Ideally if the more sustainable local minimums become deeper than the current minimum, many individuals from the current trough will roll over to the new minimum to the right of the curve. This will make the old trough disappear with not many individuals there and less weight and the curve from the old minimum will go directly up. Finally, this will lead to a new trough further right than before, and thus a more diet is achieved.

If broad target groups of people or even the majority of society are to shift to the right of the respective curves as postulated by the Stability/Energy Minimum-Hypothesis, many actions would be required. Given the seriousness of the problems associated with the consumption of animal-based products, it is important that such a transition occurs smoothly with wide social acceptance. People however are generally reluctant to make drastic changes in their diets, even when their personal health is threatened (Blanchard et al., 2008). What criteria should the new plant-based food options fulfil? What requirements should the new plant-based alternatives to animal products, including alternatives to beef, veal, pork, poultry, lamb, mutton, venison, eggs and dairy products, satisfy to be accepted by the majority of consumers? Would even cultured meat grown in vitro in labs become an acceptable alternative? The section below lays out criteria for the success of alternatives to animal products in order to shift the average consumer diet towards more sustainable nutrition.

# SUCCESS CRITERIA FOR ALTERNATIVES TO ANIMAL PRODUCTS

The original definition of "meat" refers to the core of a food as distinctive to its husk, shell or to a drink (Merriam–Webster, 2017). More recently however the word "meat" began to be associated with the flesh of an animal used for food. Irrespective of the term's etymology, what is important in this day and age is to break the largely spread assumption that when we eat meat we need to consume animal-based products. We need to reclaim the word together with encouraging food choices healthier for consumers and the planet. Hence, we refer to the entire spectrum of sustainable food options which do not involve livestock as the *new meat*. This includes traditional fruit and vegetables, classical products using tofu as well as new plant-based products, such as vegetarian sausages and soy mince, and meats produced in laboratory conditions. They all share the common characteristic of being animal-free food products.

In order for the new meat to be socially acceptable and to become a preferred option for consumers, it needs to satisfy several criteria. Below is a list of five main criteria informed by the work of Molnár (1989), de Boer and Hoek (2006) and Schmidinger (2012) developed predominantly for western consumers and individuals who are in a position to make food choices.

## 1. Sensual properties and flavour - taste, texture, satiety feeling and aroma

In the perception of the majority of people within society, the flavour of alternatives to animal products should completely satisfy their preferences. Textures can be fibre-like – such as in meat products, gel-like – such as in yoghurt, coagulated – such as in cheese, and so on (O'Kane, 2006). Hence the alternatives to animal products must fulfil various texture tasks. Meat-like sensory properties and luxury aspects are relevant for plant-based alternatives with higher protein content in a product improving satiety sensations (Hoek, 2006). For example, favoured properties for vegetarian meat products are: brown, soft, smooth, crispy, seasoned, spicy and meat-like flavour (Elzerman, 2006).

## 2. Price

Alternatives to animal products should be affordable, preferably cheaper than the livestock-based products. The lengthened food chain and the losses of plant food calories through metabolism make animal products costly in principle. Model calculations for

pea-based meat alternatives show that they should be cheaper than pork (Apaiah, 2006). Applications for the byproducts of, for example, pea- or soy-based meat alternatives exist (Willemsen, 2006), but should be economically optimised. Efficient alternatives to the byproducts of livestock production, such as leather, gelatine or pet food, need to be found (Willemsen & Apaiah, 2006), although many already exist while others need to be improved and made economically viable.

## 3. Marketing, target groups and advertising

Alternatives to animal products should appeal to a wide target group, not only to vegans, vegetarians or health-conscious people! In fact, the target should be the general or average consumer. Information about new foods should "evoke feelings like comfort, familiarity, happiness, ease, low price and popularity" (Goodland & Anhang, 2009, p. 17). Advertising campaigns should "pitch the theme of eating all week long a line of food products that is tasty, easy to prepare and includes a superfood, such as soy" that will enrich the consumers' lives (Goodland and Anhang, 2009, p. 17). Availability in supermarket and discount stores as well as advertising, especially at the point of sale, are essential and have massive room for improvement (Ruiz, 2007). Also, plant-based alternatives should be placed side by side on the same shelf with livestock products to achieve the same exposure to consumers (Goodland and Anhang, 2009).

## 4. Health

Fruits and vegetables have numerous health benefits and their consumption should continue to be encouraged. The new plant-based foods should also be healthier than the animal products in an overall health appraisal. This should be valid at a personal level as well as being a public health consideration. Their use could minimise the risk of formation of new pandemics, antibiotic resistance (Raphaely et al., 2016) and development of salmonella, E. coli and other infections (Review of Antimicrobial Resistance, 2015). They should also be able to outperform animal products in terms of personal health issues. With reference to cultured meat, for example, it should be possible to optimise the fatty acid or amino acid composition of the final product and leave out cholesterol, Neu5GC and other unwanted compounds, making a healthier meat than those currently existing.

## 5. Shelf life and hygiene

Existing plant-based meat-, egg- or dairy-alternatives typically have a longer shelf-life than their equivalent livestock products – a fact that easily can be verified in any supermarket. For example, dried products, such as textured vegetable protein (TVP) chunks, have shelf lives of a year or longer. In fact, manufacturers of meat products use plant-based solutions as a natural way to extend shelf life, control bacteria development and improve food safety (Pelligrini, 2014). With the majority of foodborne diseases originating from animal products, plant-based foods carry lower risk and hence, their shelf life is longer representing weighty advantages for the consumer and the food industry alike.

## PRODUCTS MAKING THE CHANGE POSSIBLE

There is plenty of more or less well-known plant-based alternatives to meat, milk and eggs on the market, but certain innovations – recent or still being developed, could have a bright future.

Some common or promising livestock-free solutions are presented below. The focus is on meat alternatives (sometimes even difficult to distinguish visually as shown in Figure 6), but similar innovations are also available to replace egg or dairy products.

Figure 6. Plant based chicken drumsticks



## **Classic Plant-Based Meat Alternatives**

The most common base materials for meat alternatives are *wheat gluten* (also called *seitan*) and soy-based ingredients, such as *tofu* and *textured soy protein* (abbreviated as TSP or TVP), also called *soy meat*. Seitan is obtained simply by rinsing wheat dough and washing out the starch until the protein components gliadin and glutenin are isolated from the wheat. Tofu is a worldwide well-known traditional Asian foodstuff, where a coagulant (traditionally nigari salt) is added to soy milk and the resulting protein solids are pressed into a desired form. Soy meat is produced using hot extrusion of defatted soy proteins, resulting in expanded high protein chunks, nuggets, strips, grains and other shapes. The fibrous, insoluble, porous soy meat can soak up water or other liquids a multiple of its own weight.

Unlike tofu, seitan and even more soy meat show consistencies which are remarkably similar to the stringy fibres that make up animal-based meat. Often, you find products made of mixes of soy- and wheat-based protein ingredients. The disadvantage of this mix is that these products are not suitable for consumer groups suffering from soy allergies or gluten intolerance (coeliac disease). For the other consumers, such mixes represent perfect meat-like textures as well as optimised protein contents and quality. The protein quality can be explained by the fact that the profiles of the essential amino acids contained in soy and wheat complete each other well and compensate the deficiencies of their individual amino acid profiles.

Another classical plant-based meat alternative is *tempeh* which has a very old tradition in Indonesia. Controlled fermentation of soaked, hulled, hacked and damped soybeans with a Rhizopus mold binds them together into a compact, firm white patty form. The protein content makes tempeh a suitable ingredient for meat alternatives, whereas its texture is not meat-like.

Experiments to produce tempeh based on barley and oats instead of soy have also been made (Swedish-Research-Council, 2008).

## **Other Meat Alternatives**

These ingredients are innovative, some already available on the market, others on the way to being commercialised. The list of such alternatives is long and expanding in response to rising consumer interest, mainly from vegans and vegetarians. Below is a selection of such new meats.

*Quorn*, based on the so called Mycoprotein, is a commercially successful meat alternative range introduced by the English company Marlow Foods. Mycoprotein is a fermented fungus which is processed and textured to produce meat alternatives. Quorn products include steaks, burgers, chicken breasts as well as sliced meats and ready meals. It is marketed in European countries, USA, South Africa and Australia.

*Sweet lupines* have become another, increasingly popular base ingredient for meat or dairy alternatives, especially in Europe. Meatless was one of the first companies to use lupine-based fibres for the production of meat substitutes. The already completed Like Meat project funded by the European Union similarly used lupines as one of its experimental base materials.

*Sprouted soybeans* are used commercially, even though on a small scale, especially by the Hungarian company Yaso. *Rice protein* and *pea protein* have also been introduced for the production of meat alternatives together with *vegetable fibres* used by companies like Wiefleisch or the former company Proviand, taken over by the German veggie meat specialist Like Meat.

Using *fresh mushrooms* could be another option, as the company Fresh'shrooms has shown. *Algae* similarly holds huge potential for meat alternatives. *Nuts* (e.g. pecans) and *garbanzo beans* are the main ingredients for meat alternatives produced by Neat.

## **Science-intensive Plant-Based Alternatives**

This category of new meats includes innovations underpinned by scientific work which aims at reproducing the appearance of animal products to our senses A plant-based, perfect *bleeding beef burger* is the flagship of Impossible Foods in the USA, using heme (haem) from plants as a "bloody" juice. The burger exhibits a meat-like exterior fulfilling the equation: plants + science = meat. With funding from Google and Bill Gates (Woods, 2015), the company was able to create plant-based meats that give people the texture, flavour, aroma, taste and nutritional benefits of animal meat, without the negative health and environmental impacts of livestock products (Belvedere, 2016; Herships, 2016; Fellet, 2015; Gates, 2013).

The Not Company in Chile also explores path-breaking ways. Currently it focuses on dairy alternatives, but the same ideas will be applied to meat analogues. The company uses Guiseppe – the smartest food scientist on earth, who studies the perceptions about foods by humans (Sunder, 2016). However, Giuseppe is not a person, but an artificial intelligence robot that replicates the taste, texture and even smell of animal-based products by copying their molecular structure. Guiseppe uses plant-based ingredients for its food creations with the aim to achieve high nutritional values with low ecological impacts. Unlike humans, Giuseppe's knowledge is ever-increasing as the robot never forgets anything it has learned.

# Real Meat of the Future out of the Lab

Besides plant-based meat alternatives, there are even more futuristic approaches. The concept is called *in vitro meat* or *cultured meat*, and the process is in principle as follows. Starting cells are taken painlessly from live animals; they are put into plant-based culture media, including growth factors, where they start to proliferate and grow independently from the animal. This all should happen in large bioreactors which can be monitored and controlled. To achieve a fibrous and three-dimensional texture, various concepts are applied – using edible scaffolds to which the cells could attach, 3-D-printing to print meat or electrical stimulation on the cells as a training to build muscle-like fibres.

Mark Post and his team in the Netherlands were the first to produce a burger in vitro, with financial support from the Google founder Sergey Brin. The burger was presented in 2013 in London and while still extremely expensive at an estimated cost of around US\$ 300,000, it was a striking achievement (Shen, 2013). Memphis Meats recently produced several cultured meat balls. Modern Meadow are US-based projects also working on cultured meat. In Israel, Supermeat with Yaakov Nahmias and the Kitchen FoodTech Hub similarly pursue cultured meat efforts. The list of organisations and initiatives which are active in this domain includes New Harvest, the Good Food Institute, Future Food and the Modern Agriculture Foundation. They are making good progress with a lot of publically available information.

## MARKETING OF FUTURE FOOD ALTERNATIVES

Currently worldwide there exist many plant-based meat alternatives and plant-based protein products – enough to fill up a meatless butcher shop. The producers are concentrated mainly in (Shurtleff & Aoyagi, 2014; Schmidinger, 2012): USA and Canada in North America, Germany, the Netherland, UK, Italy, Czech Republic, Austria, France and Hungary in Europe, Australia and New Zealand in the Asia Pacific, Taiwan, China and Thailand in Asia, Brazil and Argentina in South America. Meat alternatives are projected to be soon stretched out of their niche market segment and as per the Allied Market Research (2016) forecast this trend is going to grow substantially offering many business opportunities (The Economist, 2017). Similarity to animal flesh-food composition, appearance and flavour is one reason for these plant-based food alternatives starting to make their way and gradually becoming popular amongst consumers. Another reason is their improved performance in relation to human health - they are cholesterolfree, have lower risks for numerous chronic diseases, such as cancer and cardiovascular disease. They also perform better in response to environmental concerns. In countries, such as USA, Germany and UK, these new meat alternatives are gaining good market shares and are no longer limited to a display at the back shelves of the supermarket. Nevertheless, the new meat alternatives still require more intense and competitive market strategies to establish themselves in the consumers' mind and to break out of their niche label into the mainstream.

Marketing strategies used by new meat producers usually follow the traditional mix around the 4p –product, promotion, place and price (Luca & Suggs, 2010; Thackeray & McCormack Brown, 2010), focussed on increasing awareness about the existence of new cutting edge innovative plant-based products and promoting them among consumers. Some however are utilising novel approaches. Injecting culturally relevant concepts which resonate with people, through social media (e.g. Facebook) into brand communication was used by the advertising

campaign of Alternative Meat Co (2017). The campaign ridiculed the Lambasador used by livestock advertisers to create a cultural identity of the multicultural Australian society around eating lamb on Australia Day. Alternative Meat Co used a mocking advertisement highlighting the increasing number of Australians who represent the changing food trends towards reduced meat consumption. The advertisement encourages people to try an alternative, e.g. vegetables, on Australia Day in line with the social trend away from animal-based products. The online advertisement received more than 1.1 million views, 13.5 thousand shares, 11 thousand likes and 5 thousand comments (Australian Meat Co, 2017). *Tofurky* can replace the turkeys traditionally consumed on Thanksgiving in USA (Shurtleff and Aoyagi., 2014).

*Endorsement by celebrities* is a marketing strategy employed by the California-based start-up Impossible Foods (Woods, 2015; Belvedere, 2016; Herships, 2016; Fellet, 2015). Promoting famous vegetarians who symbolise strength and masculinity is also a good way to increase the attractiveness of new meats. The list of names includes Mike Tyson – the undisputed heavyweight boxer champion, Carl Lewis – the nine-time Olympic gold medallist athlete, Brendan Brazier – the Ironman triathlete, Daniel Sturridge – premier league club Liverpool footballer, Serena and Venus Williams – the superstar tennis players and athletes, and many others.

Sensing the consumer shift to protein alternatives, major global meat producers are keen to stay in the game by participating in the new meats market. Tyson Foods in USA acquired a 5 percent share in the plant-based protein food manufacturer Beyond Meat. Similarly, the German meat packer company Rügenwalder Mühl and the Canadian Maple Leaf Foods are tailoring their marketing strategies to establish a strong platform in the plant-based proteins market (Strom, 2016).

A major component of the attractiveness of animal meat is its taste, smell, textural properties, fibrous structure, deliciousness and juicy mouth-feel – attributes stated by Australian Sydney residents (Bogueva et al., 2017). Using new meats' resemblance to these qualities, can be a successful marketing strategy for a transition to healthier, environmentally better and morally higher diets.

The qualities of the new meats will continue to improve and their prices will become increasingly compatible. Any marketing and advertising campaigns will need to use this to reform and rebrand the consumer perceptions about food. However, there is a role for government and other institutions to play in supporting and facilitating these changes.

Against the ample evidence about the need to move towards healthier and environmentally respectful dietary patterns, the new meats alternatives are perfect novelties that must be supported as a trendy shift. Instead of lagging behind, government bodies should take an active stance and start developing and disseminating official dietary guidelines and recommendations, embedding health and sustainability objectives and creating policies fostering them (Fischer et al, 2016).

In addition to financial support for the new meats and removal of any funding benefiting the livestock sector (Hamilton, 2016; Di Croce et al. 2016), the government needs to engage in

promoting the alternatives. In a similar way to dealing with tobacco and cigarettes, this should include freeing up the public advertising space from undesired messages and instigating social marketing of better alternatives. New meat options should be made available in public institutions, such as school canteens, hospitals and promoted in supermarkets, foodcourts and restaurants. Marketing strategies using the 4s model – sustainability, strength, self-confidence and sharing (Bogueva et al., 2017) can encourage transitioning to more sustainable diets.

# WORLD HUNGER AND FOOD ALTERNATIVES

Although nearly half a billion people in the world identify themselves as vegetarians (Meat Atlas, 2014), the consumption of animal products continues to be strong in Western countries, including Australia, USA and Europe. Moreover, traditional diets are changing in places such as China and India exacerbating the seriousness of the climate change challenges (Myers & Kent, 2003; Vidal, 2013; Yu, 2015). Adding to this is the world's hunger problem of 1 billion people, among them 3 million children and 20 million people dying from starvation each year (Lappé & Collins, 2015). Global hunger will not be resolved by using the inefficient lengthened plant–to animal–to human food chains.

As seen in Figure 1, the losses of calories for global nutrition due to livestock production are enormous – 36 percent of the global cereal harvests (Schmid & Goldhofer, 2016) as well as 70 to 75 percent of the global soy harvests (Brack et al., 2016) are used for livestock. In 2016, 320 million tonnes of meat have been produced (FAO, 2016). According to Alexander et al. (2017), 1060 million tonnes of feed from crops plus 440 million tonnes of forage crops (e.g. alfalfa and forage maize) plus additional grass from grassland make up just 240 million tonnes of animal products in dry matter.

An average German person wastes about 400 kg of plant food just by eating meat. This is based on an average of 7 to 8 calories of plant-based feed to produce 1 calorie of meat (an estimate based on Smil, 2002 and Garnett, 2009). Milk and eggs are not even included in these figures. This waste of food for meat consumption alone is much higher than the annual 179 kg of wasted food per capita in the EU from private households, producers, supermarkets and gastronomy all together (European Commission, 2010)! The world produces more than enough to feed all humans on the planet Earth but not through inefficient food chains.

In response to the myriad of negative consequences triggered by livestock products, many are opting for plant-based alternatives (Market and Markets, 2016; Roy Morgan Research, 2016). This is also where the future of food lies and the quicker the transition, the better will be the outcomes for all.

## CONCLUSION

The consumption of animal-based products is associated with serious impacts on human health, the natural environment and world hunger. The Stability/Energy Minimum hypothesis explains people's dominant eating behaviour as the one which conforms with the majority preferences within the society, circle of friends or at home and requires the least effort. A push towards more sustainable dietary choices needs to be facilitated by making plant-based options attractive in terms of flavours, textures, price, availability and varieties. By satisfying

the five criteria related to taste, cost, health, shelf life and marketing, the alternatives to animal-based products can find their way into society and contribute to the creation of new more sustainable minimum energy conditions that encourage better health and environment related options.

As diets are expressed as a personal choice, the new meats based on fruit, vegetables, plants, TPV, cultured meat and other innovations can enrich the options available to the consumers who opt to exclude animal-based products from their dietary preferences. When wisely and properly marketed, these new meat food products will help shift the average diet and make it more sustainable. On a global scale this will free up a lot of waste associated with the current inefficient lengthened food chain, which feeds livestock first before feeding people, and allow world hunger to be eliminated. The future of food lies in many plant-based innovations as well as other options away from livestock products. Meat without livestock is the alternative we need to embrace if we are to dream for a brighter future.

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## ENDNOTE

<sup>1</sup> The terms soy and soya refer to the same bean – a legume type, with the preferred spelling in the USA being "soy" and in Europe – "soya". We have opted to use "soy" in this chapter; however, all products described here may also appear in the literature and on the market as "soya".

## **KEY TERMS AND DEFINITIONS**

**Cultured Meat:** Meat grown in vitro in laboratories which does not involve the slaughter of animals.

Meat Alternative: A substance with a high protein content used to replace animal flesh as food.

**New Meat:** Covers the entire spectrum of traditional and new food options which do not involve livestock.

Shelf Life: The recommended time for the sale of a food product.

**Stability/Energy Minimum Hypothesis**: A model which explains eating behaviour as a process conforming with the majority preferences in a society.

**Textured Vegetable Protein (TVP):** Dried vegetable matter with a high protein content byproduct of extracting soybean oil used as a new meat in vegetarian and vegan food products.

**World Hunger:** Inefficient use and distribution of food resources, including feeding livestock instead of directly feeding people.