Is agricultural education sufficient motivation for the public to limit or avoid the consumption of animal products?

Presented by

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1. Abstract

The agriculture industry has a significant impact on the environment and especially in the case of rearing livestock for food, it is attributed as a major contributor to the most prevalent global environmental issues present today, such as climate change, global warming, water pollution, deforestation and loss of biodiversity. While the sector needs to work towards achieving sustainability, organisations such as the IPCC have stated that sustainable agriculture cannot be achieved without a reduction in the global animal product demand. Consumers generally lack the education and understanding of the process and consequences behind animal products and this project aimed to look at the potential of education on agriculture's environmental impact as a motive in the public towards limiting or avoiding animal product consumption by reason of sustainability. A survey was used that contained three different conditions, two of which presented information and then there was the control group. The results indicated that the condition had a significant affect on the intention to limit the respondents' consumption but not necessarily to completely avoid them. They also displayed mostly high levels of environmental concern, yet the condition had no significant impact on the concern expressed. The findings add to those of previous studies that suggest how concerns about the environment are increasing the higher the knowledge on the subject becomes and can motivate reduction in meat consumption but not a more drastic change of behaviour, such as completely avoiding it. Future studies to determine attitudes towards dairy products and effective approaches on limiting or avoiding their consumption could be conducted due to their high consumption and environmental impact and the fact that the topic is very limited in the literature.

Table of Contents

2. Introduction

It is a prevalent fact amongst the scientific community that agriculture has a significant environmental impact, thus achieving sustainability in the sector has become a fundamental element of the United Nation's Sustainable Development Goals (Karthikeyan, Chawla and Mishra, 2020) alongside the Paris Agreement (Doelman et al., 2019). Barely exceeding a two-century time span, human industrialism as a whole has caused substantial changes to the earth's climate (Howard-Grenville et al., 2014), to which some of the consequences are already being witnessed, such as the ascension of sea levels and adverse weather conditions in certain nations (Mahmoud and Gan, 2018).

2.1. Agriculture and Greenhouse Gases

Although transportation and the burning of fossil fuels have typically been regarded as the chief contributors to GHG emissions and climate change (Koneswaran & Nierenberg, 2008), the Food System today is responsible for approximately 24% of industrial greenhouse gas emissions (GGEs) (Rohmer et al., 2019). From that percentage, livestock production for food alone accounts for 18% of all greenhouse gas emissions caused by human activity (Zhuang, Gongbuzeren and Li, 2017), which exceeds the total 13% contribution of the transportation industry (IPCC, 2014). Furthermore, agriculture accounts for 9% of all emissions in the UK, which is the nation’s second-largest contributor to greenhouse gases (Jeswani et al., 2020).

The phenomenon of the greenhouse makes the possibility of life sustenance, due to its maintenance of suitable surface temperatures (Signor and Cerri, 2013). The primary gas contributor to climate change is carbon dioxide (FAO, 2006).

Although there is no exact numerical figure on the contribution of agriculture towards global CO_2 emissions, it is known that carbon dioxide can remain in the atmosphere for an infinite amount of time (Lynch et al., 2019).

Another major greenhouse gas is methane, to which livestock are the main source of human-induced emissions (FAO, 2006), naturally produced through the digestive process of cattle and other ruminants, representing 44% of total methane emissions, 48% of the UK’s (Richardson et al., 2019) and 30% of the US’s (Rotz, Montes and Chianese., 2010). The concern with methane is that it remains for a smaller period of time in the atmosphere compared to CO_2, around 12.4 years (Crow et al., 2019) and has a 26-time stronger warming effect on the planet than CO_2 in the span of 100 years (Nguyen, Trihn and Bach, 2020). Moreover, livestock is responsible for up to 65% of global nitrous oxide emissions, are around 40% of the UK's contribution (Matthews et al., 2010) and 75% of the US’s (Rotz, Montes and Chianese, 2010). Nitrous oxide has around 300 times the warming effect of carbon dioxide (Matthews et al., 2010) and remains in the atmosphere for around 121 years (Lynch, 2019).

2.2. Use of Natural Resources in Agriculture

No other sector is as dependent on the earth's resources as agriculture (de Boer and Aiking, 2019). The industry is currently occupying 38% of the world's terrain (Alexander et al., 2019) (Fig.1), to which 40% of that is occupied by livestock and crops intended to be used as animal feed (Karlsson and Röös, 2019). Cropland within the period of the mid-18th century up to 2010 underwent a dramatic rise from 350 million hectares to over 1.5 billion hectares (Smil, 2011). Additionally, within half a century, agricultural product sales increased by 330% for the animal products themselves and by 300% for the animals' feed crops (Davis and D'Odorico, 2015). In previous years, the expanding demand for food was originally achieved by improving the efficiency of the occupied land, however, this seems to have transitioned onto increasing agriculture's land coverage (Karlsson and Röös, 2019).

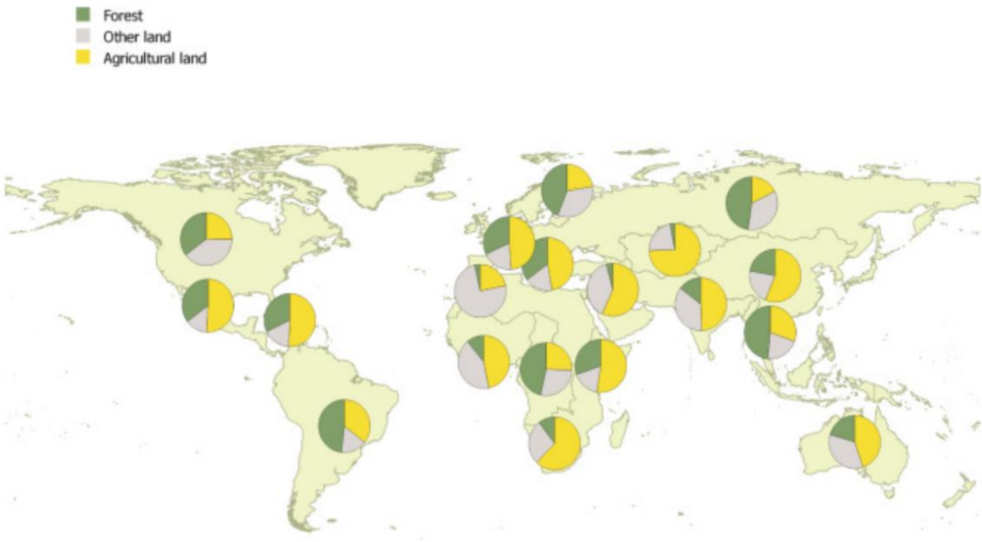

Fig.1: “Proportion of agricultural land in different regions of the world” (Source: FAOSTAT, 2017, cited in Green, 2019, p.532).

In addition to land use, agriculture is using up to 80% of the world’s freshwater resources, most of which is used for growing feed crops, rather than crops that are grown for human consumption (Mekonnen and Hoekstra, 2012). This consumption exceeds that of other uses (Brindha, 2017). Specifically, livestock feed crops constituted 98% of total water consumption in animal agriculture between 1996 and 2005 (Mekonnen and Hoekstra, 2012). Moreover, in a study that focused on the Water Footprint of the EU on the aspects of water for production and water for consumption, it was found that agriculture accounted for the greatest usage of both categories, at 91% for the former and 89% for the latter (Vanham, Hoekstra and Bidoglio, 2013).

2.3. An Increased Animal Product Demand

2.3.1. Environmental Destruction

Other global environmental concerns associated with food production are those of eutrophication, increased acidity in saltwaters and the mass extinction of wild fauna and flora (Vermeuelen et al., 2012).

A common practice in the industry is the use of chemical nitrogen fertilisers, annually applying around 100 million tonnes of the fertiliser on the soil (FAO, 2006). Both nitrogen and phosphorous fertilisers are commonly attributed to their effectiveness within the food system towards increased yields to meet growing demands for food (Leite et al., 2020). Furthermore, nitrogen is also present in livestock excreta (Signor and Cerri, 2013).

Notwithstanding, agriculture is responsible for a staggering 95% of hypertrophication in aquatic environments (Poore and Nemecek, 2018), making it one of its most extensive environmental impacts (Ortiz-Reyes and Anex, 2018). From the fertiliser applied, a proportion of the concentrated compounds will remain in the soil or be utilised by the crops but, nonetheless, the initial amount actually surpasses crop requirements (D' Ambrosio et al., 2018), meaning that a substantial amount will undergo eventual drainage into inland waters, along with other agricultural waste, such as manure (Fig. A.1 and A.2). Eutrophicated waters cause the local algae populations to consume more oxygen than normal, which decreases total oxygen concentrations (Monteagudo, Moreno and Picazo, 2012) to which, in turn, can prove fatal to local aquatic species (Koweek et al., 2020).

Adding to eutrophication, agriculture accounts for 79% of global Oceanic Acidification (OA) (Poore and Nemecek, 2018). The ocean is typically capable of stabilising carbon concentrations within the atmosphere (Xue and Cai, 2020), whilst maintaining a relatively stable pH level (de Carvalho-Borges et al., 2018). Nevertheless, the additional carbon from human activity is surpassing the ocean's carbon buffering capacity, causing its pH to drop and increasing the water's acidity (Greenhill, Kenter and Dannevig, 2020). This phenomenon can cause alterations in the ocean water's composition as causes imbalances in the nitrogen, carbon and phosphorous cycles, which firstly impacts calcifying organisms and aquatic flora and then the dynamics and framework of entire corresponding ecosystems (Qu et al., 2017) (Fig. A.2).

Finally, agricultural expansion has resulted in more land being cleared, more notably in the tropical regions (Sun et al., 2019) (Fig. A.3). Within the last decade, the Brazilian Amazon has suffered an annual forest loss of just over 6,4m acres (Reynardo, Fernandes and Telles, 2019), with grazing beef and dairy cattle responsible for 63% of deforestation between 2000 and 2013 (Vale et al., 2019). Between 2002 and 2011, soy production, another major motive behind rainforest destruction (Global Forest Atlas, n.d) was responsible for 32% of land clearing (Reynardo, Fernandes and Telles, 2019). However, up to 80% of the soy grown in the Amazon, is destined to become animal feed (Global Forest Atlas, n.d).

This deforestation is substantially contributing to biodiversity loss and the general consensus is that the number of disappearing species and continuing rates of extinction is staggering and researchers are implying the sixth largest extinction phase in global history (Ceballos et al., 2015). Moreover, a lower rate of heterogeneity is associated with a decreased potential of an ecosystem being able to cope with repeated anthropogenic disruptions (Worm et al., 2006). Lastly, this means that especially in the case of setting the forest on fire, the stored carbon explodes in mass and returns to the atmosphere (FAO, 2006), contributing further to agriculture's greenhouse gas emissions.

2.3.2. Plant vs Animal Products

The primary contribution of environmental destruction from agriculture revolves around protein and its levels of consumption amongst the population, including the original source of those proteins (plants or animals) (de Boer and Aiking, 2019). Currently, animal products deliver 25% of total protein 18% of total calories worldwide (Mottet et al., 2017). While animal products and certain crops like legumes require approximately the same amount of energy throughout the manufacturing process, the former has shown to be weaker in terms of protein conversion (Sabaté & Soret, 2014) (Table 1). From the amount of nitrogen fertiliser used (75%), 30% gets utilised in plant protein production (Di Paola, Rulli and Santini, 2017). However, only a small percentage of those proteins are converted into animal protein, approximately 15%, constituting an 85% loss of directly consumable plant-based protein (ibid).

Moreover, animal products typically have a higher water footprint than plant products, due to the water required for the feed crops consumed by the animals, the water for drinking and water for maintaining hygienic husbandry conditions (Hoekstra and Chapagain, 2006) (Table 2).

Table 1: Animal production in the United States and the fossil energy required to produce 1 kcal of animal protein.

Livestock and animal products	Production volume[1]	Ratio of energy input to protein output[2]
	× 10⁶	*kcal*
Lamb	7	57:1
Beef cattle	74	40:1
Eggs	77000	39:1
Swine	60	14:1
Dairy (milk)	13	14:1
Turkeys	273	10:1
Broilers	8000	4:1

(Source: US Department of Agriculture^1, 2001, Pimentel^2, 1997, cited in Pimentel and Pimentel, 2003, p. 662S).

Table 2: The global-average water footprint of animal products vs crops.

Animal product	*litre/kg*	*Crop*	*litre/kg*
Bovine leather	16,600	Rice	3400
Beef	15,500	Groundnuts (in shell)	3100
Sheep meat	6100	Wheat	1300
Cheese	5000	Maize	900
Pork	4800	Apple or pear	700
Milk powder	4600	Orange	460
Goat meat	4000	Potato	250
Chicken	3900	Cabbage	200
Eggs	3300	Tomato	180
Milk	1000	Lettuce	130

(Source: Hoekstra and Chapagain, 2008, cited in Hoekstra, 2010, p.25).

In order to produce meat, 75-90% of the feed consumed is required to maintain body weight and other functions, with a certain amount excreted through waste or absorbed by the bones and skin (Eldesouky et al., 2018) (Fig. C.1). Example ratios of needed crops for meat production per kg of bodyweight are 5:1 for chicken and 12:1 for beef. Nonetheless, it needs to be noted that not all the percentage of the meat is suitable for human consumption, with the mean suitable conversion rate at 60% (Cassidy et al., 2013).

2.3.3. Demographic Factors

There is a current human population of 7.6 billion (Villanueva, 2018) and this is estimated to rise up to 9 billion by 2050 (Mc Allister et al., 2011). Moreover, widely populated countries that have traditionally consumed a plant predominant diet, particularly in Asia (Vranken et al., 2014), have begun to adopt western dietary habits, meaning a diet higher in livestock products (Gerbens-Leenes, Mekonnen and Hoekstra, 2013). Lastly, urbanisation is expected to rise up to 68% (Armanda, Guinée and Tukker, 2019) and the combination of the three factors, indicate the possibility of a rise for both feed and human crops by 60-

120% (Cassidy et al., 2013) and animal products by 50% within the next 30 years (Mc Allister et al., 2011) according to literature estimates.

2.4. Mitigation Strategies

2.4.1. Supply

Supply mitigation strategies primarily focus on lowering the number of greenhouse gases emitted from agriculture, (Daddi et al., 2020), as they are inevitably produced in all phases of the food system (Garnett, 2011).

The first was through intensification of farming practices. Outcomes associated with these farms are higher productivity in crops, due to the previously mentioned nitrogen and phosphorous fertilisers, a larger crop heterogeneity and the use of synthetic pesticides (Schrama et al., 2018). Furthermore, more animals are able to be reared (Davis and D'Odorico, 2015), both achieved while lowering the land footprint, though it's level of sustainability has been debated (Garibaldi et al., 2017). This is due to damage causation of the soil's composition and quality, which can lead to permanent lower yield outputs down the line as well as higher water pollution and threatening fauna and flora that are essential to food production (Pérez et al., 2019).

In opposition, many researchers have suggested the solution of organic farming (Gaffney et al., 2019), which by 2014, was occupying 43.7m hectares of arable land (Dal Ferro, Zanin and Borin, 2017). These farming systems avoid the application of industrial materials and are instead dependent on materials that are outcomes of natural cycles (Boone et al., 2019) which are maximally used and then recycled, reducing overall waste and ensuring soil fertility (Pérez et al., 2019). Organic farming is also associated with higher competence in energy use, species preservation and lower greenhouse gas emissions (Jouzi et al., 2017).

On terms of output, nevertheless, organic farms tend to have 25% smaller yields in comparison to intensive farms, though this percentage can vary as it is heavily reliant on geographic location and current circumstances (ibid). The lower yields make the land footprint of organic farming larger than that of industrial (Boone et al., 2019), therefore, adopting a predominant organic farming system could be argued, especially in the case of meeting growing demands for food (Dal Ferro, Zanin and Borin, 2017).

The final proposed theory is through selective breeding (Barwick et al., 2019). Adaptations in this aspect include enhancing how effectively livestock use feed, meaning increasing livestock productivity using the minimum amount of feed, as higher consumption in livestock is greatly associated with higher greenhouse gas emissions (Hayes, Lewin and Goddard, 2013). This essentially implies decreasing the amount of required natural resources and livestock numbers whilst meeting the growing meat and dairy demand (Davis and White, 2020). Especially in the case of methane, there is the potential of lowering emissions by 20-30%, where feed conversion efficiency is increased by 10-15% (Kumari et al., 2020).

2.4.2. Demand

While the supply mitigation strategies and solutions may be somewhat effective, there will not be any significant change without a global dietary transition (Scarborough et al., 2014). Dietary habits play just as a substantial role because they determine product type production and the extent of its availability (Benvenuti et al., 2019).

The Intergovernmental Panel on Climate Change (IPCC) (2019) discussed just how a 15% decrease in animal product consumption by developed countries within 30 years could prevent the obligation of increasing agriculture's land occupancy to provide sufficient amounts of food. A report written by Westhoek et al. (2014, in Sans & Combris, 2015), showed that if the EU were to reduce animal product consumption by 25 to 50%, livestock breeding would decline by 50% and the total animal product demand as much as 40%. When comparing different diets, Rabès et al. (2020) found that a vegan diet decreases the land footprint by 67%, reduces greenhouse gas emissions by 78% and spares 53% of energy, all when in comparison to a diet containing animal products. This is because even the animal products with a minimal environmental footprint strikingly surpass that of most plant products (Poore and Nemecek, 2018). Another study by Tilman and Clark (in Milford et al., 2019) supported the potential of a diet excluding meat alone lowering emissions as far as 55%.

Even if the entire population does not adopt a diet free from animal products, where many small shifts are gradually applied, this can result in a significant change in the food system (Alexander et al., 2019) and achieving sustainability. Moreover, were the population to transition onto a meat-free diet, 600m hectares could be spared of the estimated crop demand (Stoll-Kleemann, S. and Schmidt, 2019) and a minimum of a billion hectares of destroyed land is projected as capable of being revived (Urzedo et al., 2020).

2.5. Aims and Hypotheses

The amount of food currently produced exceeds that of what is globally required (Garibaldi et al., 2017) but, nonetheless, livestock is currently being fed 40% of the world's crops (Bowles, Alexander and Hadjikakou, 2019). Animal agriculture's outcome in terms of environmental conservation and greenhouse gas emissions has generally been shown to be counterproductive (Hoekstra, 2014). The conflict between the earth's preservation and having sufficient food availability would not be so prevalent if a higher number of crops were by default grown for human consumption (Stoll-Kleemann, S. and Schmidt, 2019) (Fig.2).

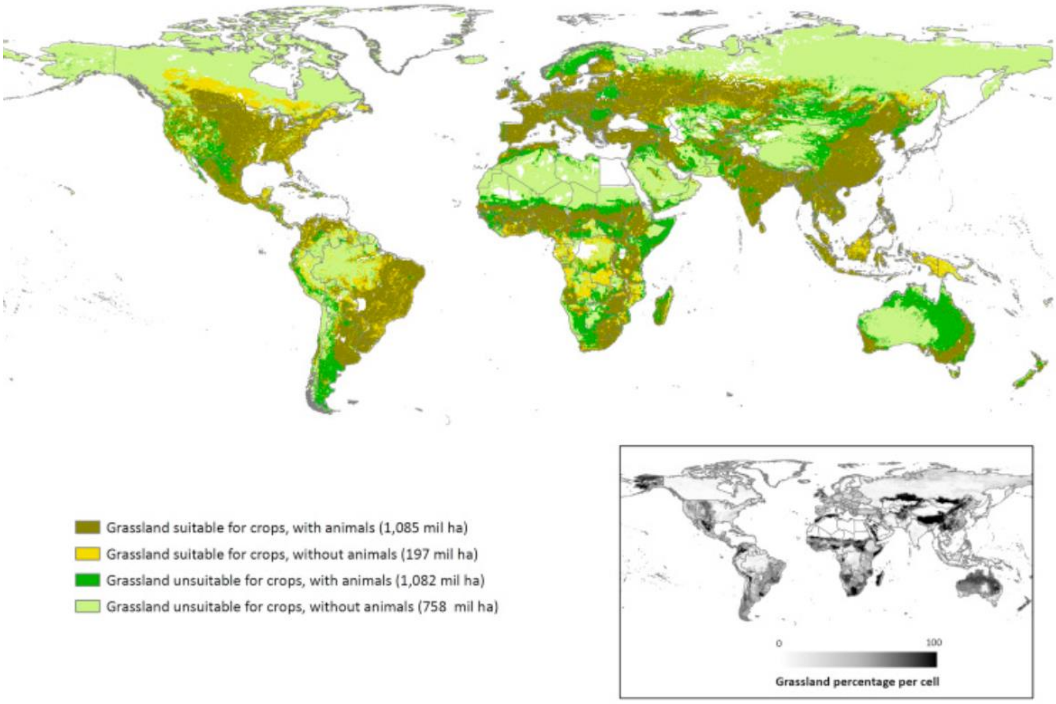

Fig.2: "Global grasslands suitable and unsuitable for crop production and share in land-use" (Source: IIASA/FAO, 2012 and Robinson et al., 2014, cited in Mottet et al., 2017, p.6).

The purpose of this project was to assess the potential of education on agriculture's environmental impact as a motive towards dietary behaviour change in members of the public, a dietary change in the form of decreased or eliminated animal product consumption.

The project comprised of the following hypotheses:

1. There will be a positive correlation between the extent of animal products consumed and the intention of limiting their consumption for sustainability.
2. There will be no correlation between the extent of animal products consumed and the intention of avoiding their consumption for sustainability.
3. There will be a positive correlation between the condition presented and the intention of limiting animal product consumption for sustainability.
4. There will be no correlation between the condition presented and the intention of avoiding animal product consumption for sustainability.
5. The condition will have a significant effect on the level of concern the participants will have about the environment.
6. Both the intention to limit and the intention to avoid will have a significant effect on the awareness of cognitive dissonance in the 3rd condition.

3. Materials and Methods

3.1. Ethics Approval

This project was granted approval by the Ethics Committee at Plumpton College.

3.2. Questionnaire

Using Qualtrics software, three conditions were constructed in a single questionnaire. All conditions comprised equally of 4 blocks, to which 3 were common blocks (consent, demographics and additional information) and then had their own distinct block.

The first condition was the control, the participant is not presented with any evidence on the environmental consequences of animal agriculture but is confronted with relevant questions. In the second condition (named science), a text is presented concerning some of the environmental consequences of animal agriculture, in conjunction with two graphs. The final group (named psychology) is presented with the same facts as the latter group but included additional facts on the cognitive dissonance theory (elaborated in the discussion) and dissonance reduction as a common defence mechanism against dietary behaviour change.

The facts that were mentioned in the text concerned the following aspects (in order): The Intergovernmental Panel on Climate Change's (IPCC) stance on the global food system, greenhouse gas emissions of animal agriculture, the warming effect potential of carbon dioxide, methane and nitrous oxide, the land and water footprint of animal agriculture, the human population and its impact on the food system, amazon deforestation and finally, the consequences of an increased animal product demand on the environment.

The first graph presented the environmental impact of dairy milk in comparison to the alternatives of rice milk, soy milk, oat milk and almond milk (on terms of greenhouse gas emissions, water footprint and land footprint). The second graph displayed three different percentages, the first referring to the impact of food on terms of greenhouse gas emissions, the emissions' percentage accounted by animal products alone and the percentage of emissions accounted exclusively by ruminants.

The final section of the survey was provided with additional links to relevant such information, to which was set with a timer that recorded both the number of clicks and time respondents remained in that section prior to final submission.

3.3. Data Collection

The questionnaire was distributed via an anonymous link on the messaging apps of Messenger (Facebook), WhatsApp and Snapchat. There were no specific social media groups targeted, however, the survey was intended for individuals exclusively over 18 years of age. To ensure that this was the case and to gain overall consent, a standard informed consent page was placed. The link was forwarded by initial respondents onto other unknown members of the public. The target response rate was ~ 50 per condition and equal distribution of the conditions was initially intended.

From conducted research, there were similar data collection methods to this project. It was found that Cheah et al. (2020), altered an already existing survey to determine motives and barriers concerning reducing meat consumption in the public, including environmental concerns and the intentions on reducing meat consumption. Furthermore, Carfora, Bertolotti and Catellani (2019), used three surveys to which the first randomly allocated university students into three different conditions, which correspondingly, were groups with daily emotional messages, informational messages and the control group. The messages received concerned the environmental and health impacts of consuming "red and processed meats" and the final survey searched for any effectiveness via any perceived intentions on reducing their consumption.

3.4. Data Analysis

Genstat was used for all statistical analyses.

The respondents were asked in the demographics section about their consumption patterns of red meat, white meat and dairy products, in three distinct multiple-choice questions, to which a score was assigned based on their answers. This was called the 'animal product consumption' score. Each question had 7 answer choices, to which were added together and the higher the overall score, the higher the consumption of animal products.

Four chi-square tests of association were performed, to which the first two were to determine the relationship between the level of animal product consumption (using the score) and the intention of firstly limiting their consumption and then avoiding them altogether. The last two were to determine the relationship between the condition presented and the intention of limiting and then avoiding animal product consumption.

All conditions included common multiple-choice questions and were based on current knowledge and/or concern regarding agriculture's environmental impact, to which a second score was created, called the 'knowledge/concern' score. There were 8 questions in total, to which one of them had 3 answer choices and the rest had 5 with the exception of the first condition, which had 6 in 6/8 questions. The excess "I am not sure" option in those questions, however, had a converted value of 0 when selected. The higher the overall score, the higher knowledge/concern present about agriculture's impact on the environment. A one-way ANOVA was performed to check for the effect of the conditions and the level of knowledge/concern in the respondents.

A third and final score was created and applied exclusively to the third condition. On the cognitive dissonance theory, three slider questions were included which displayed an awareness of the cognitive dissonance experience. The first slider ranged between the numbers of 1 and 7 and the final two between 1 and 5, added together to create the 'dissonance knowledge' score. A higher score was associated with higher knowledge and awareness of the experience. A two-way ANOVA was completed to test the awareness of cognitive dissonance on the respondents' intention of limiting or avoiding animal product consumption.

Statistical significance was measured at $p<0.05$.

4. Results

4.1. Demographics

The total number of survey participants were 186, to which 70% (n= 131) identified themselves as female. The two most common age groups were between 18-24 (n= 79) and 45-54 (n= 45). The initial number declined to 178 due to missing responses, to which 45% (n=80) expressed a high level of concern about the environment’s current status regarding degradation and 46% (n=82) expressed a moderate level of concern (Fig.3).

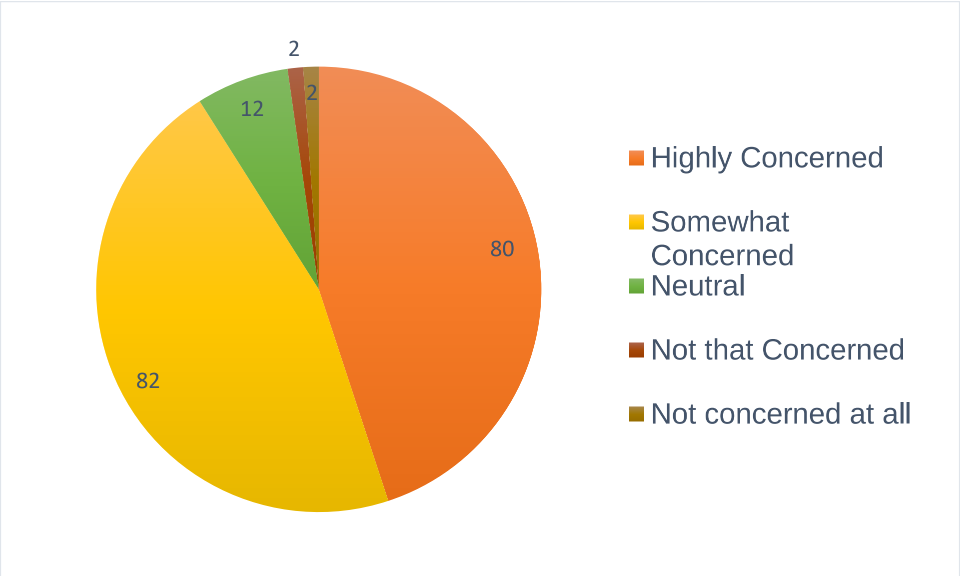

Fig. 3: The level of overall environmental concern and number of respondents.

4.2. Conditions

In all three conditions, out of 162 respondents, 87 expressed the opinion that there definitely needs to be a change in global food consumption patterns for sustainability (Fig. 4). Moreover, a potential limit in animal product consumption was the common answer in all three conditions (Table 3). There was a similar response when asked about the intention of complete avoidance of animal products, only there were conflicting responses suggesting a non-probable intention of doing so (Table 4).

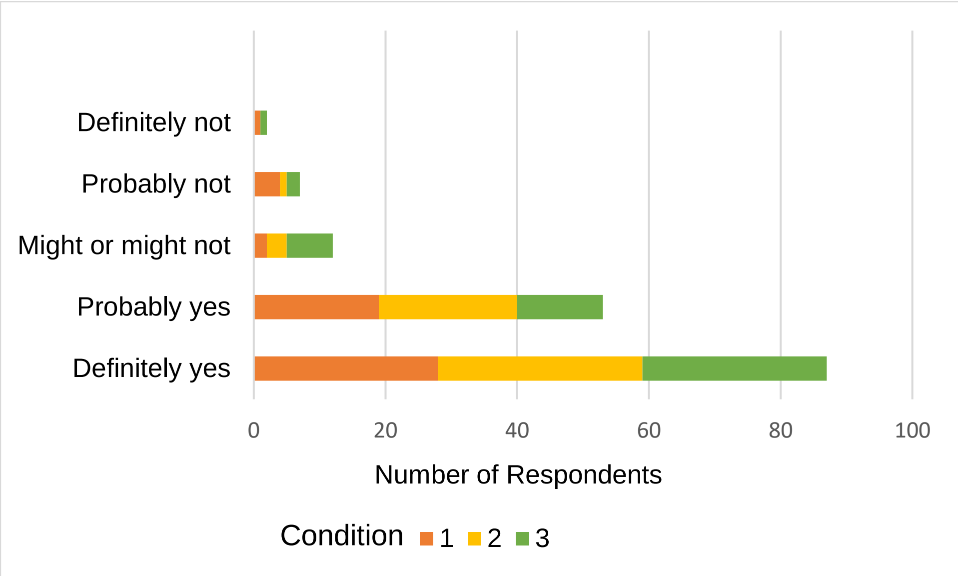

Fig.4: The responses concerning whether there should be a global dietary change for sustainability in each condition.

Table 3: Intention of limiting animal product consumption among the respondents in each condition, including each condition's mean.

Limit consumption	Number of Respondents						Total	Mean
Condition	Definitely yes	Probably yes	Might or might not	Probably not	Definitely not	I don't eat animal products/ N/A		
1	15	15	7	5	3	10	55	2.93
2	12	20	10	10	2	2	56	2.57
3	6	23	8	3	5	-	45	2.51

Table 4: Intention of avoiding animal product consumption among the respondents in each condition, including each condition's mean.

Avoid Consumption	**Number of Respondents**						**Total**	**Mean**
Condition	Definitely yes	Probably yes	Might or might not	Probably not	Definitely not	I don’t eat animal product/ N/A		
1	5	11	9	13	7	10	55	3.65
2	6	16	8	17	7	2	56	3.16
3	5	12	10	9	9	5	50	3.40

4.3. Statistics

Statistically significant results were found for chi-squares 1,2 and 3, with corresponding p values at < 0.001, < 0.001 and 0.002 (Fig. D.1, D.2 and D.3). No statistically significant result was found for chi-square 4 at p=0.369 (Fig D.4.).

There was no statistically significant result found in the one-way ANOVA at p= 0.590 (Fig. D.5). For the two-way ANOVA, there was one statistically significant result for “IntentionAvoid ignoring IntentionLimit” at p= 0.013, whereas “IntentionLimit avoiding IntentionAvoid” and “IntentionLimit.IntentionAvoid” were not statistically significant at p= 0.200 and 0= 0.689 (Fig. D.6).

5. Discussion

5.1. Animal Product Consumption

The first and second results displayed significant associations between the amount of animal products currently consumed and the intention of both limiting and avoiding that consumption for sustainability, meaning the first hypothesis can be accepted and the second is rejected.

The first potential reason for this is due to the dominant gender present in the survey. Stoll-Kleemann and Schmidt (2019) have mentioned how gender has shown a role in environmental behaviour change, with women having a tendency to be more receptive towards such a solution due to their higher apprehension of environmental issues and 70% of the respondents in the survey were female. This female-dominant result could also act in accordance with the norm activation theory, which when put into context, describes how reducing meat consumption for sustainability is more likely to be followed through with when one observes and reconsiders their meat consumption patterns (Cheah et al., 2020). Furthermore, Vranken et al. (2014) spoke about how the younger generations tend to be more flexible with their dietary habits than their elder counterparts, with 79 out of 186 total survey respondents belonging into the 18-24 age group. However, this could be the case due to their more impressionable nature and the fact that they tend to have a lower level of environmental knowledge (Casaló, Escario and Rodriguez-Sanchez, 2019). Therefore, providing agricultural education and promoting a reduction or complete avoidance of animal products from an early age could possibly have a productive outcome.

The results acted in opposition to Tobler et al.'s study (2011) (in Vranken et al., 2014), to which portrayed a decreased likelihood of limiting meat consumption for sustainability due to its dependency on the prevalence of its consumption in individuals. This could be due to meat consumption being highly culturally accepted amongst the population (Gómez-Luciano, de Aguiar, Vriesekoop and Urbano, 2019) and Wellesley et al. (2015, in Bonnet et al., 2020) mentioned how typically, there is a low level of understanding amongst the public as a whole on terms of meat consumption and its environmental consequences. This could mean that a reduction or complete avoidance of animal products, especially meat, is unlikely unless there is a critical reason to do so and a solid understanding of that reason. Gkargkavouzi, Halkos and Matsiori (2019), expressed how an intention can be a respectable indicator of future behaviour, provided that the underlying reason is fully understood.

5.2. Condition and Concern

The condition seemed to have had a significant effect on the intention of limiting animal product consumption for sustainability. However, the same effect on avoiding their consumption has appeared to be the contrary, so the third and fourth hypotheses are accepted. The information provided in the second and third conditions may have indeed had a positive impact on future reduction of meat and dairy consumption but probably was not sufficient in convincing the public to avoid such products altogether. A lifestyle that has less of an environmental impact is fundamentally what the purpose of providing environmental information is (Garnett, 2011) and promoting such a change especially during this time is critical if the most detrimental environmental issues are to be addressed and mitigated (Ling and Xu, 2020). Therefore, the presentation of information on agriculture’s impacts on the environment can potentially be a good starting point in at least encouraging limiting animal product consumption.

Being educated on the environment is treated as an essential component towards environmental behaviour change (Casaló, Escario and Rodriguez-Sanchez, 2019), as the chances of being concerned or acting in a way that is beneficial to the environment is poor if there is no awareness on the current issues (Liu, Teng and Han, 2020). Interestingly, in a study conducted by Peneau et al. (2013), those with less agricultural knowledge tended to be more unsure of their food purchasing decisions, with those who had confirmed their uncertainty, had reduced their meat and dairy consumption. In the UK in 2017, a survey showed the opposite effect, how there has been an increase in the number of public members that are more conscious of the environmental impacts of meat production than there were just three years prior (Horgan et al., 2019) yet just 19% of those consumers limited their meat consumption within that year. Furthermore, there has been prior evidence to suggest that education does not necessarily equal in subsequent behaviour change (Roczen et al., 2013). Macdiarmid et al. (2016) (in Sahakian, Godin and Courtin, 2020) showed how research in Scotland found that even awareness on the worst environmental effects of meat production was not sufficient motivation for a reduction in its consumption and this could further enhance how agricultural education may not be sufficient motivation for avoiding animal products.

The results of this study showed moderate and high levels of environmental concern in the respondents and this could be supported by Peneau et al. (2013), who stated that a considerable number of people have recently been expressing environmental concerns, including those linked to dietary habits. In all three conditions, the most common response to an opinion of a global dietary change was positive and definite but, surprisingly, the results also depicted how the condition had no significant effect on that level of concern and/or knowledge. This means that the fifth hypothesis is rejected. This may have been an outcome of individual interpretation as opposed to processing the facts in a more equitable manner. Vicente-Molina et al. (2013, in Cleveland, Robertson and Volk, 2020) discovered that there was an undeniable link between how facts are defined by people and how one may behave, with a personal understanding of facts having a more significant effect on behaviour rather than what the facts are actually portraying. Thus, the interpretation of facts in a subjective fashion, as opposed to objective, could be a barrier to be taken into account when attempting to promote behaviour change via education.

A second explanation may be that especially younger people believe that technological intervention will be adequate in combating environmental issues over time (Casaló, Escario and Rodriguez-Sanchez, 2019), meaning that they are more unlikely to take the matters seriously and thus not change their dietary habits for sustainability. The consensus on this could be that despite the concern and desire for environmental conservation, peoples' behaviour seems to be consistently contradicting that statement (Ling and Xu, 2020).

5.3. Awareness of Cognitive Dissonance

In social psychology, there is a theory known as the Cognitive Dissonance Theory (CDT) (Van Veen et al., 2009), to which the theorist, Festinger (1957, in Ong, Frewer and Chan, 2017) formerly highlighted how in humans, there is a desire to live in alignment with personal values. Cognitive dissonance or being in a dissonant state is defined as acting in a way that contradicts those values and beliefs (Martinie et al., 2017), which triggers a feeling of discomfort that one wishes to be relieved from (Rothgerber, 2020). The actions that one engages in for that particular relief is what is known as dissonance reduction (Rothgerber, 2014).

For the respondents in the third condition, the intention of avoiding animal product consumption had a significant effect on the awareness of the cognitive dissonance experience but the intention on limiting their consumption had no such effect, so the final hypothesis is rejected. Indeed, when it comes to the environment, there seems to be a desire to disconnect from the environmental impacts of meat, with those who consume it experiencing the most cognitive dissonance (Šedová, Slovák and Ježková, 2016). This could show how there could be a refusal of accepting accountability on one's environmental impacts (Chwialkowska, Bhatti and Glowik, 2020), potentially out of fear of experiencing that mental discomfort, since it is the perspective on the extent of a person's impact that drives their underlying actions (Roczen et al., 2013).

Contradicting behaviour can be something that one is fully aware of (Šedová, Slovák and Ježková, 2016) and could be followed through with because meat-eaters seem to attempt to provide justifications for their behaviour through self-persuasion that firstly, meat is a main constitute to a healthy diet (Rothgerber, 2014). Many also believe that eating meat is natural behaviour as evolution provided humans with the physiological and morphological features to be able to do so (Horgan et al., 2019). Finally, meat is a pleasurable experience in the sense of taste (Dowsett et al., 2018) that was introduced from an early age and thus its consumption became socially conditional (Hartmann and Siegrist, 2020).

In Schösler, de Boer and Boersema's (2014) research, their results displayed how environmental factors can encourage meat consumption and inhibit the questioning of one's actions. Despite the fact that the consumption of different foodstuffs is a cognizant and deliberate action (Weibel et al., 2019), meat consumption is also an unconscious action due to the previously mentioned social conditioning aspect. In addition, due to food’s global societal status, decisions regarding lifestyle such as those of food choices are a universal form of expression of an individual's persona (Costa et al., 2019). For example, meat consumption in the male gender is linked to a higher expression of their manliness, while abstaining from it creates a sense of decreased masculinity and this opinion seems to be common in both genders, though this viewpoint does not apply to all men particularly (De Backer et al., 2020).

The above factors could make accepting the environmental responsibility that comes with food choices more challenging and Malek, Umberger and Goddard (2019), had found that knowledge on the food system had a lower impact on individuals even reducing their meat consumption when they considered themselves as "committed meat-eaters". Thus, the approach of using agricultural education in combination with raising awareness of the cognitive dissonance theory, may not be sufficient or the most effective approach in motivating the public to limit or avoid animal product consumption. Indeed, there have been studies where a feeling of guilt was triggered amongst the subjects and seemed to have had a stronger impact on behaviour change than a more educational approach (Carfora, Bertolotti and Catellani, 2019).

5.4. Improvements, Limitations and Future Study Recommendations

In the first condition, a question whose answers were going to be included in the “knowledge/concern” score and was supposed to have contained 3 answer options, instead contained 5, meaning the highest possible score was higher than the one in the other two conditions. Furthermore, in the third condition, the question that asked about the intention of limiting animal product consumption for sustainability did not include a “Not Applicable” option for those who did not consume animal products. Both instances were caused by human error and could have potentially affected the accuracy of the results, to which if the study were repeated, they would both be corrected for the purpose of consistency in the answer options for the scores and a simpler later analysis.

Finally, some of the respondents of the survey were individuals known to the principal investigator, which could have potentially led to some bias in the results and could be improved by each individual member of the target audience being unfamiliar to the researcher.

While this project adds to the literature of what determines effective motives for promoting limitation and avoidance of animal products, it too has its set of limitations. Firstly, avoiding meat consumption may not be feasible under certain circumstances, such as the lack of access to suitable alternatives in certain nations (Gómez-Luciano et al., 2019) or poor food affordability (Phan and Chambers IV, 2016), which are factors that the project did not consider. This study also excluded other animal products such as fish and eggs, however, this was due to meat and dairy having the largest environmental impact out of all animal products.

There seems to be a lot of literature on the environmental consequences of meat production and promoting reduction in its consumption but research on promoting behaviour change in terms of dairy product consumption is very limited. This could be a potential future research topic, as dairy production is estimated to rise by 58% within the next 30 years (Worden and Hailu, 2020) and currently accounts for 4% of total greenhouse gas emissions (Hagemann et al., 2011), which is a high contribution (Sulaiman et al., 2017).

6. Conclusion

Both limiting and avoiding animal product consumption have great potential in reducing the environmental impact of not only the individual's but also the entire human population's. Having environmental knowledge is an important trait and agricultural education appears to be a sufficient motivator for potentially limiting animal product consumption for sustainability, therefore, it could be considered an overall effective approach in that aspect. In opposition, other forms of action appear necessary to determine an effective approach for promoting a complete avoidance of animal products by virtue of a sustainable food system.

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es%2C+F&rft.au=Chianese%2C+D.S&rft.date=2010-03-01&rft.issn=0022-0302&rft.eissn=1525-3198&rft.volume=93&rft.issue=3&rft.spage=1266&rft.epage=1282&rft_id=info:doi/10.3168%2Fjds.2009-2162&rft.externalDBID=n%2Fa&rft.externalDocID=358432610&paramdict=en-UK [Accessed 22 Jul. 2019].

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9. Appendices

9.1. Appendix A

Fig. A.1: Ocean dead zone (Source: The Water Brothers, 2013).

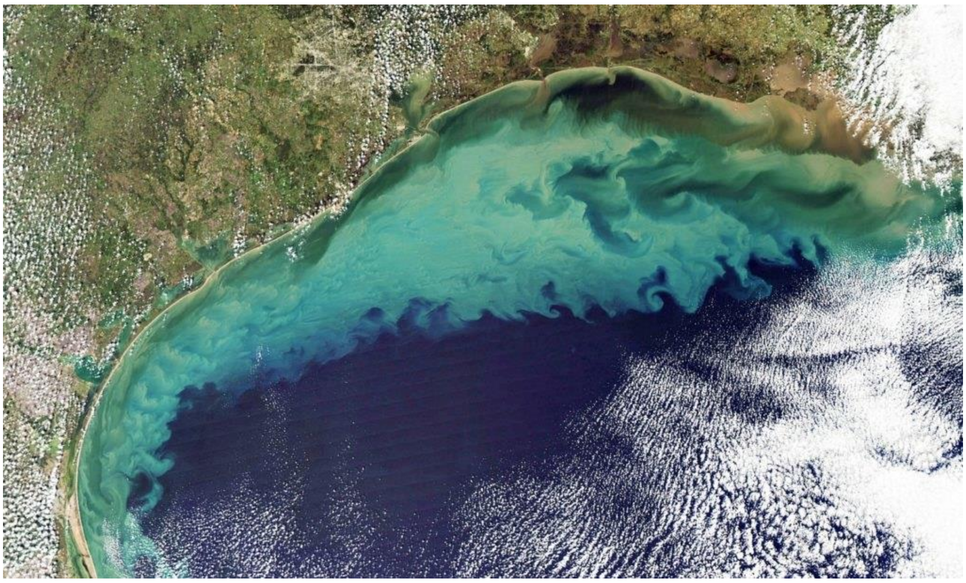

Fig. A.2: Dead zone in the Gulf of Mexico in 2017 (Source: InHabitat, 2017).

An example case of major eutrophication is the Gulf of Mexico, to which 90% of the nitrogen received by the gulf originate from agricultural waste (Goolsby et al., 2000). The nitrogen concentrations were deemed as a potential contributor to lower oxygen levels from algae population overgrowth in the lowermost water layer of the Gulf (ibid).

Fig. A.3: Coral Bleaching- Before and After (Source: New Haven Dive School, n.d).

Fig. A.4: Amazon Deforestation (Source: Loan Pride, 2018).

Goolsby, D., Battaglin, W., Aulenbach, B. and Hooper, R., 2000. Nitrogen flux and sources in the Mississippi River Basin. Science of the Total Environment, [e-journal] 248(2-3), pp.75-86. Available at: https://www.sciencedirect.com/science/article/pii/S004896979900532X [Accessed 5 April 2020].

Inhabitat, 2017. Dead Zone in The Gulf of Mexico in 2017. [image online] Available at: https://inhabitat.com/gulf-of-mexicos-dead-zone-in-2017-could-be-the-largest-on-record/ [Accessed 4 May 2020].

Loan Pride, 2018. Amazon Deforestation. [image online] Available at: https://loanpride.com/negativity-around-us-good-things-happened-2017/ [Accessed 3 May 2020].

New Heaven Dive School, n.d. Coral Bleaching - Before nd After. [image online] Available at: http://greenheartatwork.blogspot.com/2016/12/coral-reefs.html [Accessed 3 May 2020].

The Water Brothers, 2013. Ocean dead zone. [image online] Available at: https://www.huffingtonpost.ca/alex-mifflin/oceans-into-dead-zones_b_3961715.html?guce_referrer=aHR0cHM6Ly93d3cuZWNvc2lhLm9yZy8&guce_referrer_sig=AQAAAEbDeYKBZ68RIVOGGIEeGyan9NzEzMfpHkjOJxp2Z8APQpTUJSq1KcleJ7GB1hU61DygMZCDnKGD9PQXoSwnowZqAZltB_Y7R2khbkhlz1gl26kb8KlJLJeoWvqYDiA2lALI9Gky0MbR6e96Wn0ow1ZI3oomUGfVW9tfk5sfBhCv [Accessed 25 Nov. 2019].

9.2. Appendix B

Table B.1: "The Water Footprint of Selected Food Products from Animal and Vegetable Origin."

Food item	Water footprint per ton (m^3/ton)				Nutritional content			Water footprint per unit of nutritional value		
	Green	Blue	Grey	Total	Calorie (kcal/kg)	Protein (g/kg)	Fat (g/kg)	Calorie (liter/kcal)	Protein (liter/g protein)	Fat (liter/g fat)
Sugar crops	130	52	15	197	285	0.0	0.0	0.69	0.0	0.0
Vegetables	194	43	85	322	240	12	2.1	1.34	26	154
Starchy roots	327	16	43	387	827	13	1.7	0.47	31	226
Fruits	726	147	89	962	460	5.3	2.8	2.09	180	348
Cereals	1,232	228	184	1,644	3,208	80	15	0.51	21	112
Oil crops	2,023	220	121	2,364	2,908	146	209	0.81	16	11
Pulses	3,180	141	734	4,055	3,412	215	23	1.19	19	180
Nuts	7,016	1367	680	9,063	2,500	65	193	3.63	139	47
Milk	863	86	72	1,020	560	33	31	1.82	31	33
Eggs	2,592	244	429	3,265	1,425	111	100	2.29	29	33
Chicken meat	3,545	313	467	4,325	1,440	127	100	3.00	34	43
Butter	4,695	465	393	5,553	7,692	0.0	872	0.72	0.0	6.4
Pig meat	4,907	459	622	5,988	2,786	105	259	2.15	57	23
Sheep/goat meat	8,253	457	53	8,763	2,059	139	163	4.25	63	54
Beef	14,414	550	451	15,415	1,513	138	101	10.19	112	153

(Source: Mekonnen and Hoekstra, 2012).

Table B.2: The definition of each category of water in the Water Footprint Assessment Manual.

Water Footprint		
Blue	Green	Grey
Fresh or groundwater either stored in the soil, evaporated or utilised by the crops.	Rainwater either stored in the soil, evaporated or utilised by crops.	Fresh or groundwater required to accumulate toxic waste to the extent where their effect is neutralised.

(Source: Hoekstra et al., 2011)

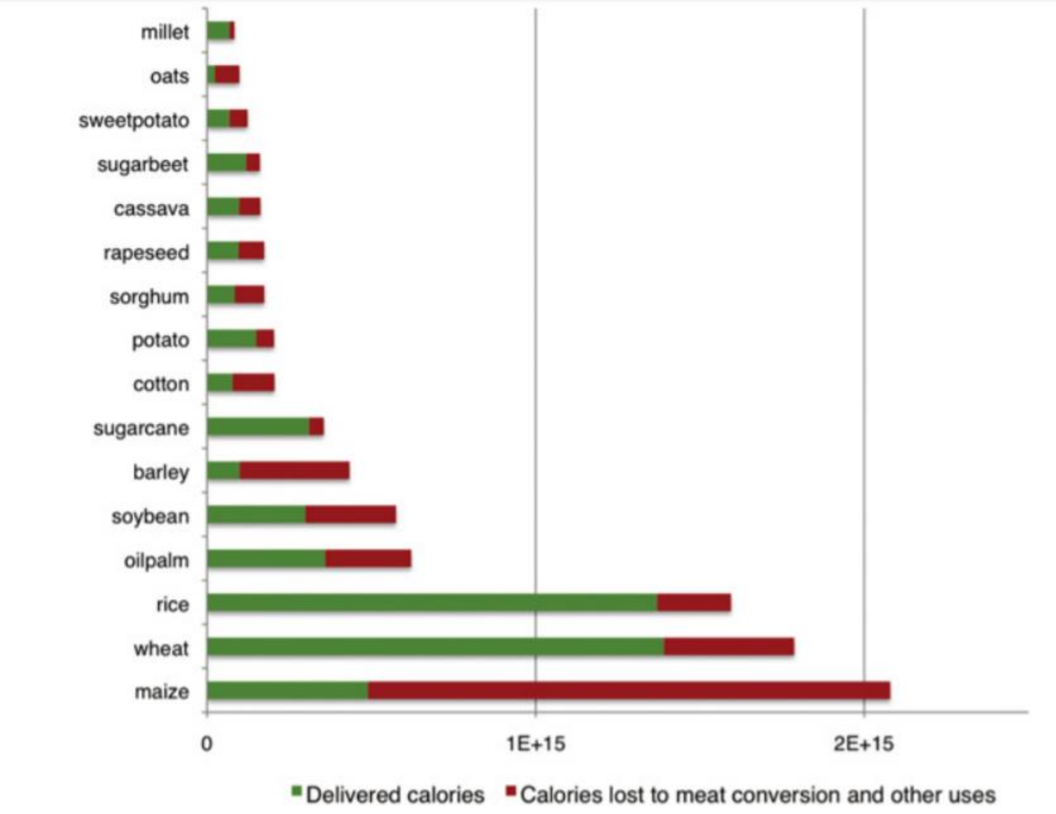

Figure B.3: “Calorie delivery and losses from major crops. Calories delivered are shown in green (this includes plant and animal calories) and calories that are lost to meat and dairy conversion as well as biofuels and other uses are shown in red.” (Source: Cassidy et al., 2013, p.5)

Hoekstra, A., Chapagain, A., Altaya, M. and Mekonnen, M., 2011. *The Water Footprint Assessment Manual: Setting The Global Standard*. [pdf] London: Earthscan Ltd. Available through: water footprint network <https://waterfootprint.org/media/downloads/TheWaterFootprintAssessmentManual_2.pdf> [Accessed 4 May 2020].

9.3. Appendix C

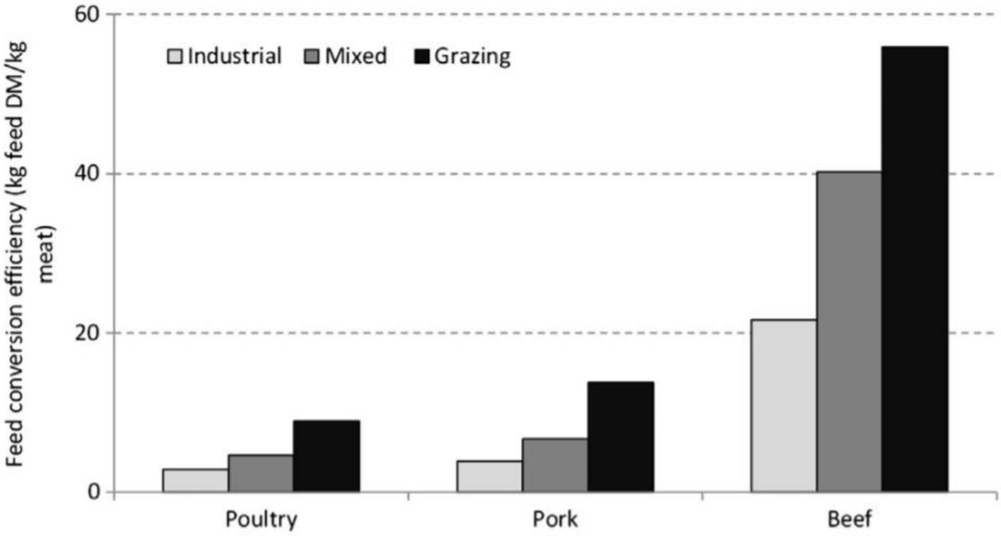

Fig. C.1: Feed conversion efficiencies for poultry, pork and beef averaged for China, Brazil, the Netherlands and the U.S. (Source: Mekonnen and Hoekstra, 2010, cited in Gerbens-Leenes, Mekonnen and Hoekstra, 2013, p. 29).

9.4. Appendix D

Chi-square test for association between AnimalConsumption and IntentionLimit

Message: some expected values less than 5, so probability may be unreliable. An alternative would be to do a permutation test (procedure CHIPERMTEST).

Pearson chi-square value is 194.91 with 90 d.f.

Probability level (under null hypothesis) p < 0.001

```
1696  CHIPERMTEST [PRINT=summary; PLOT=histogram; METHOD=pearson; NTIMES=4999; SEED=0] Table1
```

Contingency table permutation test

Message: Default seed for random number generator used with value 960747
19 × 6 contingency table Table1
Pearson chi-square 194.91
Range of values from 4999 permutations (51.06, 164.63)
Probability < 0.001

Fig. D.1: Genstat output for Chi-square 1.

Chi-square test for association between AnimalConsumption and IntentionAvoid

Message: some expected values less than 5, so probability may be unreliable. An alternative would be to do a permutation test (procedure CHIPERMTEST

Pearson chi-square value is 203.95 with 90 d.f.

Probability level (under null hypothesis) p < 0.001

```
2801  CHIPERMTEST [PRINT=summary; PLOT=histogram; METHOD=pearson; NTIMES=4999; SEED=0] table2
```

Contingency table permutation test

19 × 6 contingency table table2
Pearson chi-square 203.96
Range of values from 4999 permutations (56.78, 144.43)
Probability < 0.001

Fig. D.2: Genstat output for chi-square 2.

Chi-square test for association between Condition and IntentionLimit

Message: some expected values less than 5, so probability may be unreliable. An alternative would be to do a permutation test (procedure CHIPERMTEST)

Pearson chi-square value is 26.92 with 10 d.f.

Probability level (under null hypothesis) p = 0.003

```
2805  CHIPERMTEST [PRINT=summary; PLOT=histogram; METHOD=pearson; NTIMES=4999; SEED=0] table3
```

Contingency table permutation test

3 × 6 contingency table table3
Pearson chi-square 26.92
Range of values from 4999 permutations (0.92, 38.09)
Probability 0.002

Fig. D.3: Genstat output for chi-square 3.

Chi-square test for association between Condition and IntentionAvoid

Message: some expected values less than 5, so probability may be unreliable. An alternative would be to do a permutation test (procedure CHIPERMTEST)

Pearson chi-square value is 10.91 with 10 d.f.

Probability level (under null hypothesis) p = 0.364

```
 2809  CHIPERMTEST [PRINT=summary; PLOT=histogram; METHOD=pearson; NTIMES=4999; SEED=0] table4
```

Contingency table permutation test

3 × 6 contingency table table4
Pearson chi-square 10.91
Range of values from 4999 permutations (0.70, 47.66)
Probability 0.369

Fig. D.4: Genstat output for chi-square 4.

Analysis of variance

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Condition	2	47.34	23.67	0.53	0.590
Residual	155	6924.26	44.67		
Total	157	6971.59	44.41		

Fig. D.5: Genstat output for the one-way ANOVA.

Numerical variable: knowledge/concern score

Categorical variable: Condition

Analysis of variance

Source	d.f.	s.s.	m.s.	v.r.	F pr.
IntentionLimit ignoring IntentionAvoid	4	54.446	13.611	1.58	0.200
IntentionLimit eliminating IntentionAvoid	4	10.474	2.619	0.30	0.873
IntentionAvoid ignoring IntentionLimit	5	144.973	28.995	3.37	0.013
IntentionAvoid eliminating IntentionLimit	5	101.001	20.200	2.35	0.061
IntentionLimit.IntentionAvoid	6	33.634	5.606	0.65	0.689
Residual	36	309.745	8.604		
Total	51	498.827	9.781		

Fig. D.6: Genstat output for the two-way ANOVA.

Numerical Variable: ‘Dissonanceknowledge’ score

Categorical Variables: IntentionLimit, IntentionAvoid