Supplements to 'Farmers and Alternative Proteins'

Supplements A

A.1 Full Vignette and Attention Checks

There are a few concerns with factory farming (Section 1)

Most animal products that consumers buy, including meat, milk, and eggs, come from intensive farms or "factory farms". It is estimated that 70% of farmed animals in the UK are kept in factory farms (FAIRR, 2016).

There are a few concerns with factory farming:

- Animals are closely housed together and remain inside for the whole of their productive lives.
- Animals are selectively bred and fed artificial concentrated diets to maximise growth or milk yield.
- Animals are slaughtered at an age of 10-25% of their natural life expectancy.
- Factory farming has a large negative impact on the environment and greatly contributes to greenhouse gas emissions, water use, land use, and energy use.
- The use of chemical pesticides and fertilisers also greatly contribute to air, water, and soil pollution.

Alternatives to factory farming (Section 2)

There are several alternatives to factory farming that offer potential benefits. Alongside less intensive types of farming, these alternatives include:

1. **Plant-based products**
2. **Cultured animal products**

Plant-based products

Plant-based alternatives to animal products are created from sources of protein, including soya beans, and pea protein. Alternatives for meat and dairy are widely available.

Plant-based products have several advantageous qualities:

- They mimic the taste and appearance of animal products, such as sausages and burgers
- They are nutritionally similar to animal products, however, no animal slaughter is required
- They contain no cholesterol, however, can be lower in protein than traditional animal products
- They have seen a recent surge in popularity and can be used in many identical ways to traditional animal products
- They have a substantially smaller impact on the environment than factory farming as they produce less greenhouse gas emissions, use less water, and use less land to cultivate

Attention check 1. The production of plant-based alternatives generates more greenhouse gases compared to animal products.

- ○ True
- ○ False

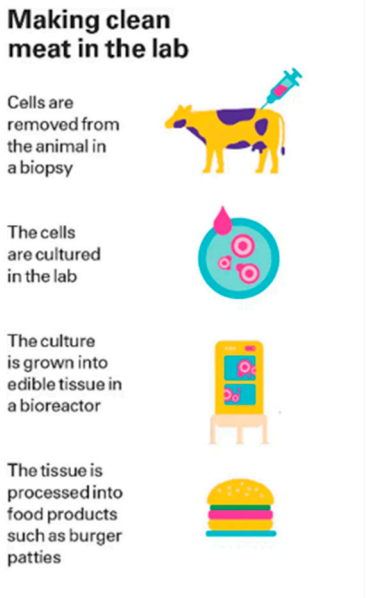
Answers for attention check 1

True – incorrect: the production of plant-based alternatives generates less greenhouse gases compared to animal products.

False – correct

Cultured animal products (Section 3)

Cell-culturing is an emerging process for producing animal-based products that does not require animal slaughter. These products are expected to reach the market by 2030. As shown in the figure below, cultured beef burgers have been created.



Cow's milk has also been created using a fermentation process similar to the production of beer or soy sauce. DNA is extracted from cow's milk and inserted into yeast cells, the yeast is fed sugar and converts into milk.

There are several expected advantageous qualities to cultured animal products:

- They have an identical taste, texture, and appearance to traditional animal products
- They are nutritionally identical to traditional animal products
- Animals are only required for the initial cell or DNA samples, then no further animals are needed for production
- They have been projected to have a substantially smaller impact on the environment than factory farming with fewer greenhouse gas emissions, less water use, and less land use

Attention check 2. Cultured animal products are made from animal cells and DNA.

○ True

○ False

Answers for Attention check 2. True – cultured animal products are made from animal cells and DNA.

Section 4

Below is a table that shows estimates from studies on how these alternatives could help reduce the environmental impact of factory farming.

Comparison of a 100g factory-farmed beef burger, plant-based soya burger, and cultured beef burger:

FEATURES	Plant-based soya burger	Cultured beef burger
Greenhouse gas emissions	**88% less**	**89% less**
Water use	**99% less**	**96% less**
Land use	**99% less**	**99% less**

Kustar & Patino-Echeverri (2021); Tuomisto & de Mattos (2011)

Finally, the table below provides a summary of these alternatives when compared with factory farming.

FEATURES	Factory farming	Plant-based alternative	Cultured alternative
Price	✓✓	✓	—
Heart disease risk	—	✓✓	✓
Animal welfare	—	✓✓	✓✓
Environmental impact	—	✓✓	✓✓
Zoonotic disease risk, such as, Avian flu, Swine flu	—	✓✓	✓✓
Supports local economy	—	✓	—

Attention check 3. Which of these alternatives to factory farming has the lowest risk of heart disease?

- ○ Plant-based alternatives
- ○ Cultured animal products

Answers for attention check 3.

Plant-based alternatives – correct

Cultured animal products – incorrect: plant-based alternatives have the lowest risk of heart disease (as they contain no cholesterol).

A.2 Sources and Empirical Findings Used to Build the Vignette

Descriptions of the treatment of animals within factory farming were created by combining information about the treatment of dairy cows (Viva, n.d.a), and beef cows (Viva, n.d.b) in intensive farming. Descriptions of the environmental impact of factory farming were from statistics of the environmental impact of animal products on greenhouse gas emissions, water use, and land use (Poore & Nemecek, 2018). The vignettes also included a description of cell-culturing and an image illustrating the process (New Scientist, 2020), and a description of the process of precision fermentation (Mendly-Zambo et al., 2021).

The environmental impact of a plant-based soya burger (Kustar & Patino-Echeverri, 2021) and the estimated impact of a cultured beef burger (Tuomisto & de Mattos, 2011) were compared against the environmental impact of a factory farmed beef burger (Poore & Nemecek, 2018). Although Poore and Nemecek did not mention the type of farming used to produce the beef, we used it for factory farming as this is the most common method of farming. Information about the price and nutritional content of a plant-based burger and 'factory farmed' beef burger was taken from Tesco's website (Tesco, 2022). The cheapest beef burger was selected, to represent factory farming, and the cheapest plant-based burger was selected as a fair comparison. Heart disease risk was based on the saturated fat content within the burgers.

References (used in and/or to create the vignette)

FAIRR. (2016, August 11). Factory Farming: Assessing investment risks. Retrieved from https://www.fairr.org/article/factory-farming-assessing-investment-risks/

Kustar, A., & Patino-Echeverri, D. (2021). A review of environmental life cycle assessments of diets: Plant-based solutions are truly sustainable, even in the form of fast foods. *Sustainability*, *13*(17), 9926. https://doi.org/10.3390/su13179926

Mendly-Zambo, Z., Powell, L. J., & Newman, L. L. (2021). Dairy 3.0: Cellular agriculture and the future of milk. *Food, Culture & Society*, *24*(5), 675-693. https://doi.org/10.1080/15528014.2021.1888411

New Scientist. (2020, May 20). Accelerating the cultured meat revolution. *New Scientist.* https://www.newscientist.com/article/mg24032080-400-accelerating-the-cultured-meat-revolution/

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, *360*(6392), 987-992. https://doi.org/10.1126/science.aaq0216

Tesco (2022). *Tesco Groceries*. Retrieved from https://www.tesco.com/groceries/?icid=dchp_groceriesshopgroceries

Tuomisto, H. L., & de Mattos, M. J. T. (2011). Environmental impacts of cultured meat production. *Environmental Science & Technology, 45*(14), 6117–23. https://doi.org/10.1021/es200130u

Viva. (n.d.a). *Beef Cattle.* Retrieved from https://viva.org.uk/animals/cows/beef/

Viva. (n.d.b). *Dairy Cows.* Retrieved from https://viva.org.uk/animals/cows/dairy-cows/

Table S1

Spearman's Rho Correlations between Age and Product Acceptance Ratings. PB = Plant-based. C = Cultured.

	1	2	3	4	5	6	7	8
1. Age	-							
2. PB Burger Appeal	-.03	-						
3. C Burger Appeal	-.28**	.59***	-					
4. PB Milk Alt. Appeal	-.15	.701***	.45***	-				
5. C Milk Appeal	-.16	.60***	.68***	.63***	-			
6. PB Burger Pos. Change	-.14	.83***	.60***	.64***	.54***	-		
7. C Burger Pos. Change	-.10	.72***	.72***	.51***	.62***	.72***	-	
8. PB Milk Alt. Pos. Change	-.07	.77***	.52***	.79***	.54***	.86***	.65***	-
9. C Milk Pos. Change	-.09	.69***	.68***	.57***	.77***	.73***	.83***	.68***

$N = 98$, ** $p < .01$, *** $p < .001$. PB= Plant-Based. C = Cultured. Pos. Change = Positive Change.

Supplements B

B.1 Farm Types and Sizes

The majority of farmers had experience working on small and medium sized farms, with only one farmer having experience of a very large farm, see Table S2. As the farmers can be considered small-scale producers, as opposed to intensive large-scale producers, they are likely to be highly invested in traditional animal agriculture. As expected, a large number of farmers had experience of working on dairy farms and with cattle, and are therefore directly involved in producing cow's milk and beef products.

Table S2

Farmer Demographic data for Farm Sizes and Types, using DEFRA 2014 Classification

Farmer Demographic	Definition	Count
Farm Size		
Very small	"Up to one FTE worker"	6
Small	"One to two FTE workers"	14
Medium	"Two to three FTE workers"	20
Large	"Three to five FTE workers"	9
Very large	"Five or more FTE workers"	1
Farm Type		
Cereals		18
General crops		8
Horticulture		4
Pigs		2

Poultry		3
Dairy		23
Grazing		22
Livestock		34
Mixed		14
Other	Shire horses	1

Note: Farmers selected more than one farm size and type. Farm size is based on the number of full-time equivalent (*FTE*) workers required to operate the farm.

B.2 Normality Tests and Statistics

Table S3

Shapiro-Wilk Values, Skewness, and Kurtosis for all Variables. PB = Plant-based. C = Cultured.

	Shapiro-Wilk			Skewness	*SE*	Kurtosis	*SE*
	W	df	*p*				
Age	.961	98	.000	.25	.24	-.82	0.48
PB Burger Appeal	.880	98	.000	-.28	.24	-1.33	0.48
C Burger Appeal	.895	98	.000	-.26	.24	-1.25	0.48
PB Milk Alt. Appeal	.877	98	.000	-.08	.24	-1.46	0.48
C Milk Appeal	.894	98	.000	-.12	.24	-1.35	0.48
PB Burger Pos. Change	.839	98	.000	-.97	.24	-.14	0.48
C Burger Pos. Change	.864	98	.000	-.76	.24	-.53	.48
PB Milk Alt. Pos. Change	.849	98	.000	-.91	.24	-.23	.48
C Milk Pos. Change	884	98	.000	-.75	.24	-.38	.48

B.3 Non-Parametric Descriptive Statistics

Table S4

Descriptive Statistics for the Variables for the Two Groups. PB = Plant-based. C = Cultured.

	Farmers			Non-Farmers		
Product	*Mdn*	*SD*	95% CI [LL, UL]	*Mdn*	*SD*	95% CI [LL, UL]
Appeal						
PB Burgers	4.00	2.20	[2.78, 4.11]	5.00	1.81	[4.12, 5.12]
C Burgers	3.00	2.08	[2.64, 3.89]	5.00	1.62	[3.95, 4.84]
PB Milk Alt.	3.00	2.34	[2.68, 4.08]	5.00	2.01	[4.05, 5.16]
C Milk	3.00	1.98	[2.54, 3.73]	4.00	1.74	[3.60, 4.56]
Pos. change						
PB Burgers	5.00	2.16	[3.75, 5.05]	6.00	1.36	[5.36, 6.11]
C Burgers	4.00	2.02	[3.10, 4.32]	5.00	1.45	[4.88, 5.68]
PB Milk Alt.	5.00	2.21	[3.76, 5.09]	6.00	1.39	[5.24, 6.01]
C Milk	5.00	1.91	[3.29, 4.44]	5.00	1.44	[4.83, 5.62]

Note. PB= Plant-Based. C = Cultured. Pos. Change = Positive Change.

B.4 Experience with Plant-based Alternatives and Purchase Behaviours

Table S5

Farmer and Non-Farmer Experience with Plant-based Products.

Plant-based Product	Farmer Count (%)	Non-farmer Count (%)
Burgers	11 (24)	18 (24)
Sausages	10 (22)	25 (47)
Mince	12 (27)	14 (26)
Chicken	8 (18)	19 (36)
Fish	1 (2)	2 (4)
Milk alt.	11 (24)	17 (32)
Dairy	6 (13)	10 (19)
None	11 (24)	8 (15)

Table S6

Farmer and Non-Farmer Purchase Behaviours and Intentions: Plant-based Alternatives.

Intention	Farmer Count (%)	Non-Farmer Count (%)
"No, I do not currently buy plant-based products and would never buy them"	15 (33)	11 (21)
"No, I do not currently buy plant-based products, but I intend to start buying them"	7 (16)	12 (23)
"Yes, I currently buy plant-based products occasionally"	13 (29)	25 (47)
"Yes, I currently buy plant-based products regularly"	7 (16)	5 (9)
Not stated	3 (7)	-

B.5 Product Comparisons by Group

Table S7

Wilcoxon Signed Rank Follow-Up Tests for Farmers: Comparison of Products on Product Appeal and Positive Change. PB = Plant-based. C = Cultured.

Comparison	Product 1 *Mdn*	Product 2 *Mdn*	*Z*	*r*	*p*
Product Appeal					
PB Burgers vs. C Burgers	4.00	3.00	-7.18	-1.07	.473
PB Burgers vs. PB Milk Alt.	4.00	3.00	-.09	-.01	.932
PB Burgers vs. C Milk	4.00	3.00	-.91	-.14	.364
C Burgers vs. PB Milk Alt.	3.00	3.00	-.01	-.00	.991
C Burgers vs. C Milk	3.00	3.00	-.45	-.07	.651
PB Milk Alt. vs. C Milk	3.00	3.00	-.72	-.11	.470
Positive Change					
PB Burgers vs. C Burgers	5.00	4.00	-3.06	-.46	.002*
PB Burgers vs. PB Milk Alt.	5.00	5.00	-.39	-.06	.698
PB Burgers vs. C Milk	5.00	5.00	-2.41	-.36	.016
C Burgers vs. PB Milk Alt.	4.00	5.00	-3.23	-.48	.001*
C Burgers vs. C Milk	4.00	5.00	-1.76	-.26	.078
PB Milk Alt. vs. C Milk	5.00	5.00	-2.91	-.43	.004*

Note. For *SD* and 95% CI see Table S4. * $p < .0083$. PB = Plant-based. C = Cultured.

Table S8

Wilcoxon Signed Rank Follow-Up Tests for Non-Farmers: Comparison of Products on Product Appeal and Positive Change. PB = Plant-based. C = Cultured.

Comparison	Product 1 *Mdn*	Product 2 *Mdn*	*Z*	*r*	*p*
Product Appeal					
PB Burgers vs. C Burgers	5.00	5.00	-1.03	-.14	.302
PB Burgers vs. PB Milk Alt.	5.00	5.00	-.26	-.04	.796
PB Burgers vs. C Milk	5.00	4.00	-2.46	-.34	.014
C Burgers vs. PB Milk Alt.	5.00	5.00	-.72	-.10	.474
C Burgers vs. C Milk	5.00	4.00	-1.92	-.26	.055
PB Milk Alt. vs. C Milk	5.00	4.00	-2.31	-.32	.021
Positive Change					
PB Burgers vs. C Burgers	6.00	5.00	-3.09	-.42	.002*
PB Burgers vs. PB Milk Alt.	6.00	6.00	-.94	-.13	.347
PB Burgers vs. C Milk	6.00	5.00	-3.39	-.47	.001*
C Burgers vs. PB Milk Alt.	5.00	6.00	-1.92	-.26	.055
C Burgers vs. C Milk	5.00	5.00	-.74	-.10	.462
PB Milk Alt. vs. C Milk	6.00	5.00	-2.36	-.32	.018

Note. For *SD* and 95% CI see Table S4. * $p < .0083$. PB = Plant-based. C = Cultured.

Supplements C

C1. Product Acceptance – Distribution of Responses by Farmer Type

Figure S1

Distribution of Farmers' Appeal Ratings

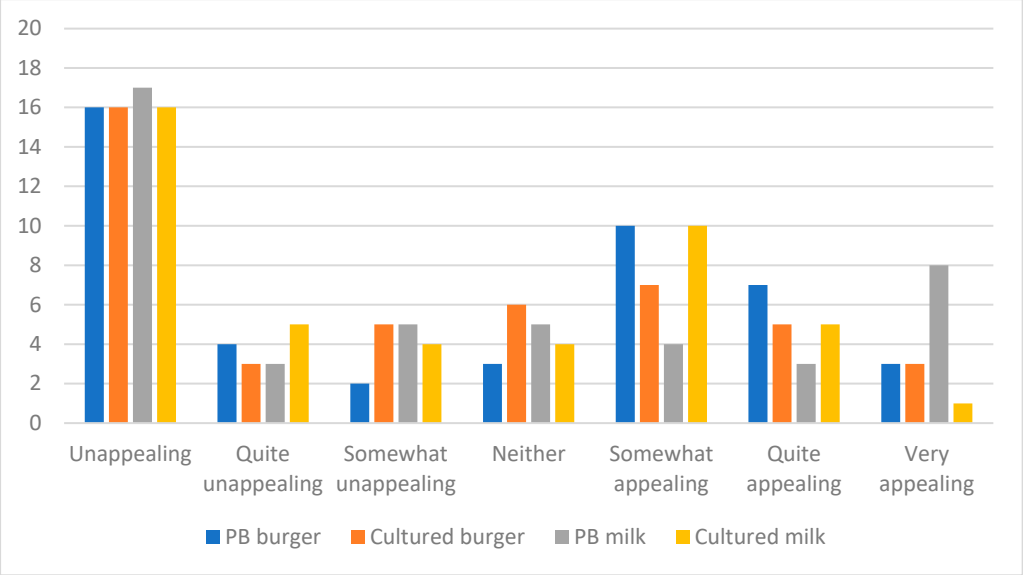


Figure S2

Distribution of Occupational Farmers' Appeal Ratings

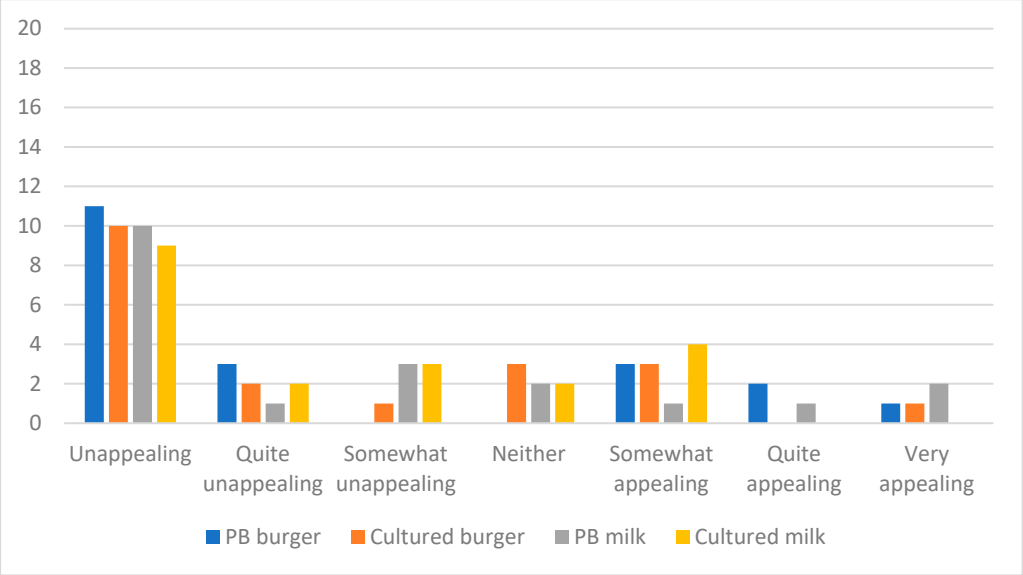


Figure S3

Distribution of Farming Family Members' Appeal Ratings

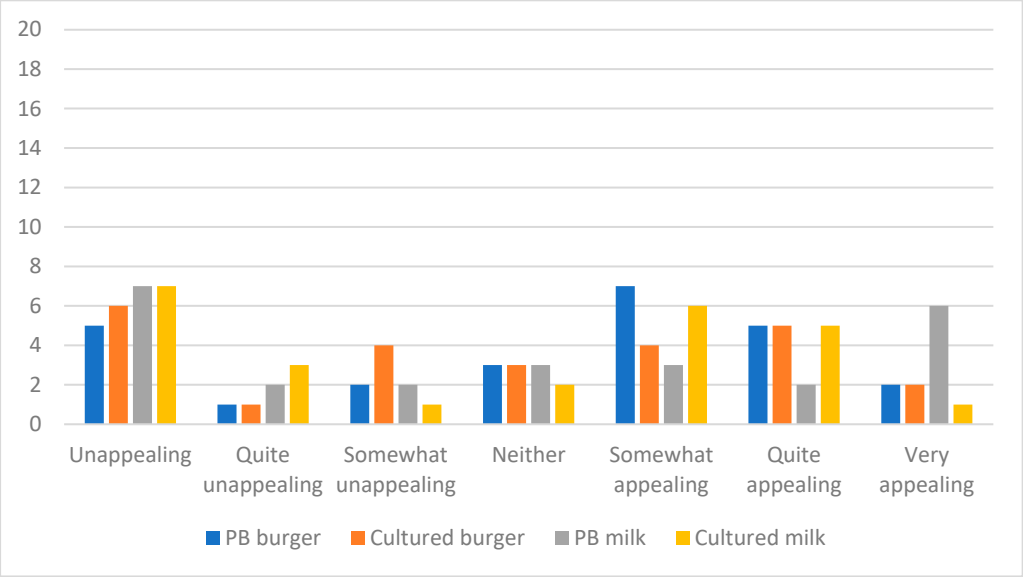


Figure S4

Distribution of Non-Farmers' Appeal Ratings

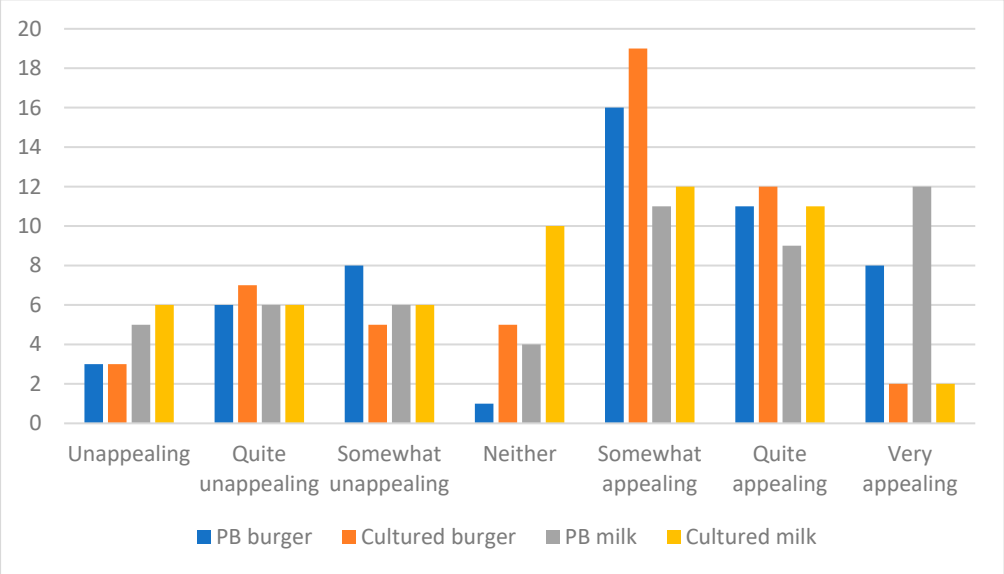


Figure S5

Distribution of Farmers' Positive Change Ratings

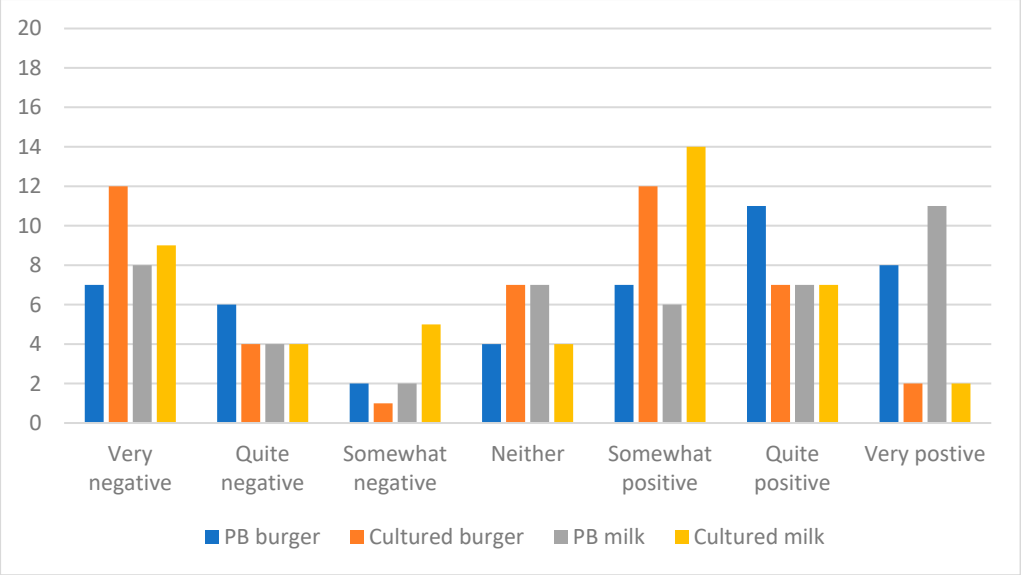


Figure S6

Distribution of Occupational Farmers' Positive Change Ratings

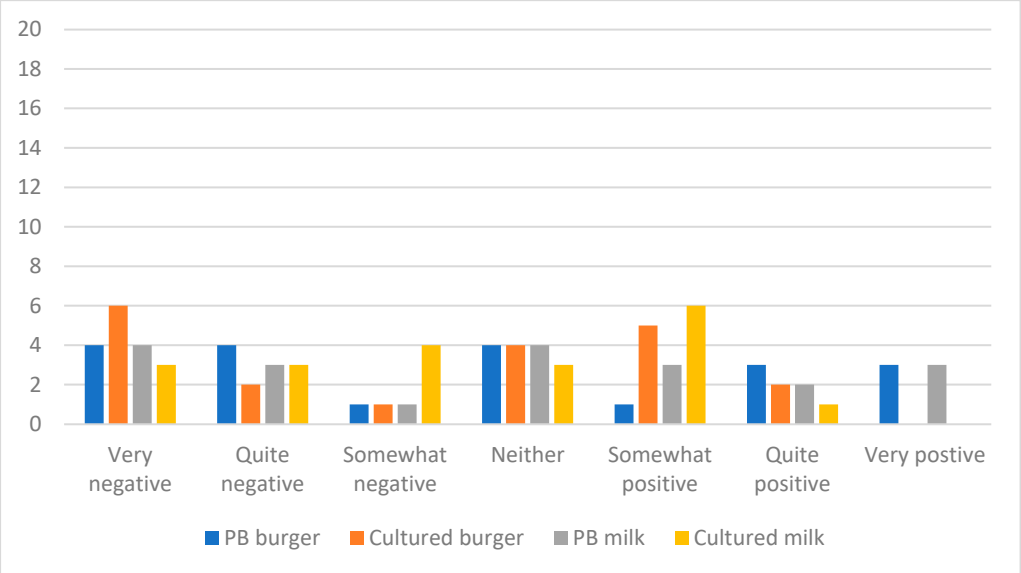


Figure S7

Distribution Farming Family Members' Positive Change Ratings

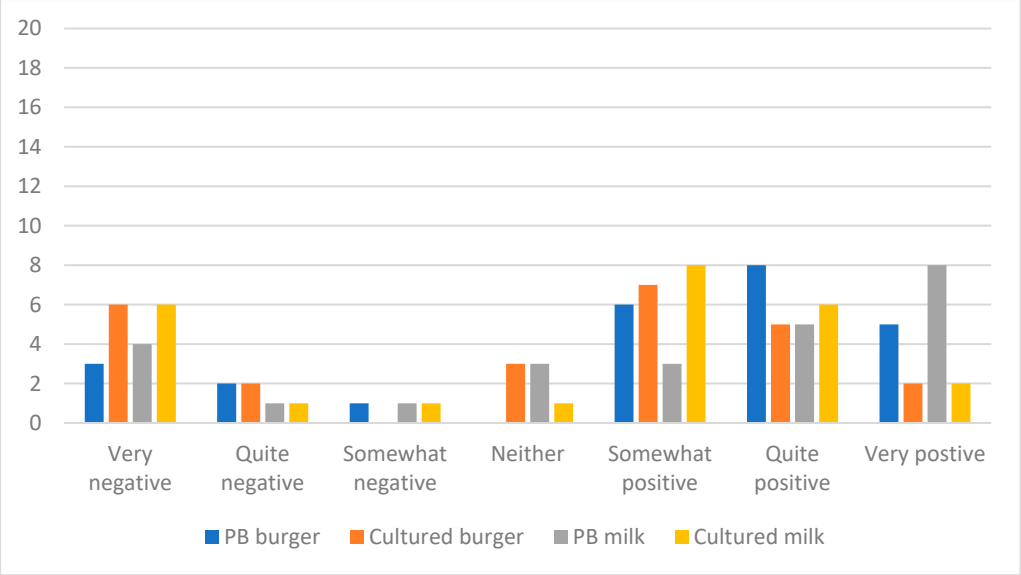


Figure S8

Distribution of Non-Farmers' Positive Change Ratings